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Outcomes of immediate full weight bearing protocol for incomplete intertrochanteric occult hip fractures

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ABSTRACT

Introduction: Occult hip fractures are femoral neck fractures diagnosed by MRI or CT scan following negative plain radiographs. Incomplete intertrochanteric occult hip fractures (IIOHFs) do not involve the medial cortex. These fractures can be isolated but can also occur in the presence of greater trochanter (GT) fractures. Many authors recommend further imaging to exclude IIOHFs in cases where a GT fracture is present on plain radiograph, in order to evaluate the intertrochanteric region fracture extension. There is no consensus on the optimal treatment for IIOHFs, with approaches ranging from surgical fixation to full weight bearing. At our institution a protocol of immediate full weight bearing for patients diagnosed with IIOHFs was implemented. This study retrospectively evaluates the outcomes of this treatment protocol.

Methods: The medical records of patients who underwent MRI for suspected occult hip fractures were retrospectively analyzed. Inclusion criteria included: (1) patients with no findings on plain radiographs who were diagnosed by MRI with intertrochanteric fractures not involving the medial cortex, and (2) patients with isolated GT fractures diagnosed by plain radiographs and fracture extension greater than one-third of the intertrochanteric width seen on MRI. Data regarding initial hospitalization, diagnostic timing and findings, and follow-up outcomes were collected.

Results: Of 196 MRI scans performed during the study period, 45 patients met the inclusion criteria. None of these patients experienced secondary displacement of the fracture despite immediate full weight bearing. The average age was 81.1 years, and 21(10.7%) patients were male. The mean time from admission to MRI was 30 h, and the average length of hospitalization was 6.3 days. The 45 intertrochanteric fractures that were included in this study include nine isolated incomplete intertrochanteric fractures and 36 GT fractures with extension greater than one third of the intertrochanteric width. None of the GT fractures had involvement of the medial cortex.

Conclusion: Our findings suggest that immediate full weight bearing is a safe treatment approach for IIOHFs. Operative fixation or immobilization may be unnecessary for these fractures. Our findings also challenge the clinical necessity of routine MRI scans in patients with GT fractures to assess for fracture progression.

Introduction

Occult intertrochanteric hip fractures are typically diagnosed by MRI or CT scan following negative plain radiographs in the elderly population [1]. A minority of these fractures are incomplete intertrochanteric occult hip fractures (IIOHF) where the fracture line does not involve the medial cortex. A well described form of IIOHF is apparently isolated GT fracture seen on plain radiographs but with fracture propagation into the intertrochanteric region on MRI [2]. For this reason, many authors recommend further imaging of apparently isolated GT to exclude occult intertrochanteric extension [3–8]. Despite the high prevalence of GT fractures there is no consensus regarding the necessity or modality of further imaging following plain radiographs. The second group of IIOHF are occult fractures with normal plain radiographs. A high level of suspicion together with a formal diagnostic protocol for patients with hip pain following trauma and negative radiographs is critical to avoid

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missing these fractures.

There is no consensus regarding the treatment of IIOHFs, with options ranging from surgical fixation to periods of non-weight bearing or even immediate mobilization with full weight bearing [2,4,5,8–11]. In our institution, we follow a strict diagnostic and treatment protocol for patients with IIOHFs.

We have previously described our diagnostic protocol for patients with pain around hip joint following traumatic event with no findings on plain radiographs. Our protocol includes initial CT scanning, followed by MRI in cases where scans are inconclusive [12]. For patients aged over 65 diagnosed with a GT fracture, we routinely performed MRI to assess for potential extension of the fracture line into the intertrochanteric region. The treatment protocol for IIOHFs in our institution is non-operative with immediate and full weight bearing.

In this article we aim to evaluate our assessment and treatment protocols for IIOHFs. Specifically, we explore the safety of immediate weight bearing in IIOHFs and the necessity of MRI in isolated GT fractures.

Outcome measures were progression of IIOHF to complete fracture requiring surgical intervention. We also assessed whether there were specific characteristics associated with patients diagnosed with IIOHF.

Methods

We retrospectively analyzed the medical records of 196 patients who underwent MRI for suspected OHFs in the period of January 2012 - December 2023. Ethical approval was obtained from the local institutional review board. Inclusion criteria were patients diagnosed by MRI with occult intertrochanteric fractures that did not involve the medial cortex. GT fractures with extension to the intertrochanteric region were included if the extension exceeded one third of the intertrochanteric line, as described by Park et al. [11]. Exclusion criteria included patients under 18 years of age, those with no history of trauma, pathological or stress fractures, and those with follow-up of less than three months.

Our diagnostic protocol was as follows: patients with suspected hip fractures and negative plain radiographs were assessed by an orthopedic surgeon. Suspicion was defined as persistent hip pain following trauma, inability to fully bear weight, or pain during straight leg raise, passive rotation, or axial loading. A CT scan was conducted and evaluated by a senior orthopedic surgeon. If no definitive diagnosis was made on CT, an MRI was performed.

The CT examinations were conducted using one of two multi-slice helical scanners (Siemens SOMATOM Definition Flash, Force Siemens Healthcare, Erlangen, Germany). A CT protocol was developed for these pelvic examinations in order to reduce radiation exposure. The protocol included a tube voltage of 120 kV and 100–190 effective mAs. Data reconstruction was performed by bone filter in axial, sagittal and coronal plane of 1 mm thickness with soft tissue filter of 2 mm thickness. The MRI examinations were conducted by using T1 weighted spin echo + STIR (Short Tau Inversion Recovery) axial and coronal scans, using a 3T or 1.5T scanner (Siemnes MAGNETOM Aera or Skyra, Siemens Healthcare, Erlangen, Germany)

Radiographic diagnoses obtained from each CT /MRI and reported by a senior musculoskeletal radiologist were retrospectively collected from the electronic hospital medical records. Fracture extension into the intertrochanteric line was measured independently by two of the authors (A.D, M.A) on MRI Images which were reviewed on PACS (picture archiving and communication system) as described by Park et al. [11]. The coronal and axial T1-weighted images were utilized to evaluate the extent of the fracture in relation to the intertrochanteric line. Fractures involving less than one-third of the area were classified as isolated GT fractures and excluded from this cohort. Disagreements were resolved by a third measurement done by the two evaluators together. The time from admission to achieving radiographic diagnosis via either CT or MRI was recorded.

Our treatment protocol for patients diagnosed with IIOHFs included admission to the orthopaedic department, analgesia was provided and rehabilitation was initiated by physiotherapists where weight bearing as tolerated was allowed immediately. Patients were discharged home or to a rehabilitation centre depending on their social and mobilization status. Follow-up visits were scheduled at six weeks and three months post-injury. Patients with less than 3 months of follow up were contacted by telephone and asked to answer a short questionnaire. In case the patient was not alive or not physically able to answer the questionnaire a close relative was contacted. Questions addressed were – 1) Did you suffer from a complete hip fracture after your admission to our medical centre? 2) Did you undergo surgery as a result of the incomplete hip fracture following your discharge form our hospital? 3) If one of these answers is yes on which hip- the right or left? 4) What is/was your walking status 3 months after your admission to our medical centre (walking unaided, walking with aids, non-ambulatory)

Medical comorbidities were noted according to the following categories:

1. Cardiac comorbidity – ischemic heart disease (IHD) or previous myocardial infraction; heart failure; arrhythmias and conduction disorders requiring use of antiarrhythmic drugs, anticoagulation or pacemaker placement.
2. Neurological comorbidity – dementia, history of stroke or transient ischemic attack (TIA), and acute stroke or TIA at time of admission.
3. Chronic lung disease – obstructive or restrictive lung disease and pulmonary hypertension.
4. Diabetes mellitus.
5. Active malignancy.

Several medical conditions under the same category, were considered as a single category.

Results

During the study period 196 Patients underwent MRI for suspected OHFs in our medical centre. A flow chart of patients who were assessed using our evaluation protocol is shown in Fig. 1. 51 patients underwent MRI due to GT fracture diagnosed on plain radiograph. The remaining 145 cases underwent MRI due to clinical suspicion of occult hip fracture following unremarkable radiographs and CT scan. The MRI findings of these patients are summarized in Table 1. Forty five patients met the inclusion criteria and were included in this study, nine had incomplete occult intertrochanteric fracture without GT fracture and 36 had GT fracture with extension of more than a third of the intertrochanteric line. Demographic and medical data of these 45 patients are presented in Table 2.

Average follow-up time for the patients included in this study was 3.2 months. Fourteen patients with shorter follow-up periods were contacted via telephone, in ten cases responses were obtained from a relative due to patient inability to respond.

There were no incidents of progression from IIOHF to a complete fracture in any of the patients included in this study. The walking status of 12 patients deteriorated from walking with no aids to walking with aids due to the IIOHF. In the remaining 33 patients there was no change in mobility status.

Table 3 shows data regarding the diagnostic test findings, the time from admission to the diagnostic tests and data regarding walking status before and after the IIOHFs.

Radiographic examples of GT fracture with incomplete extension are shown in Fig. 2 and examples of IIOHFs shown in Fig. 3.

Discussion

This study demonstrates the safety of immediate full weight bearing in patients with IIOHFs. None of the cases in our cohort progressed to complete fracture and none required surgical intervention. In addition,

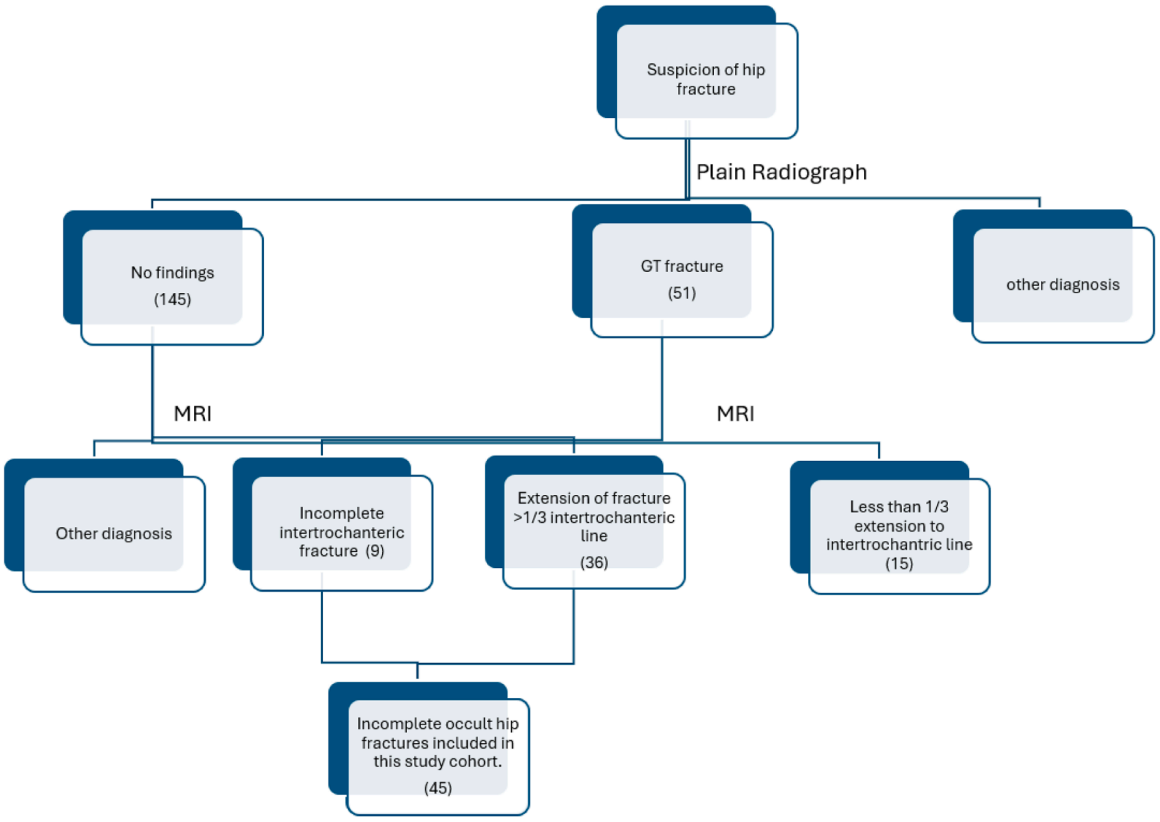

Fig. 1. Flow chart of study design. There are two pathways to have a diagnosis of incomplete intertrochanteric occult hip fracture and to be included in this study. Either as patient with GT fracture diagnosed by plain radiographs who completed MRI which demonstrated extension of the fracture the intertrochanteric line (more than 1/3), Or as patients with suspected hip fracture with negative radiographs which MRI demonstrated incomplete intertrochanteric fracture. Flow chart and numbers of patients in brackets are illustrated in this figure.

Table 1
. MRI diagnosis of patients with suspicion of occult hip fracture.

MRI results	196
Pubic rami fracture	26
Subcapital hip fractures	13
Intertrochantric hip fracture	6
Greater trochanter fractures	51
Isolated GT fractures	(15)
With more than 1/3 extension to IT region	(36)
Incomplete intertrochanteric fractures	9
Acetabular fractures	4
Sacral fractures	2
Pelvic fracture LC1	4
Iliopsoas muscle contusion	10
Gluteal muscle contusion	9
TFL muscle contusion	5
Rectos femoris muscle contusion	4
Adductor muscle contusion	6
Obturator internus muscle contusion	1
Intraarticular fluid	5
Severe Osteoarthritis	5
Hematoma	17
Nonspecific oedema	8
Normal exam	23

Table 2
Demographics data and patients' comorbidities for patients included in this study.

Number of patients		45
Age; years(SD)		81.1 (8.8)
Gender		Male-21
		Female-24
Comorbidities	Diabetes	18
	Cardio-vascular	27
	Neurological	10
	Malignancy	5
	Lung	3

none of the GT fractures showed medial cortex involvement which would necessitate surgery.

There is no consensus on the management of IIOHFs, and concerns remain about potential progression to complete fractures that may undergo displacement [2,7,13,14]. Proposed treatment varies form surgical treatment, to conservative management with differing weight bearing restrictions. Proposals to subcategorise this fracture according to the degree of progression through the intertrochanteric line have been made, advocating conservative treatment in cases where less than 50 % of the intertrochanteric region is involved [2,5]. We reason that the intact medial cortex as the primary weight bearing structure makes these fractures stable, therefore rendering fracture progression unlikely. Our uneventful 12-year experience with immediate full mobilization supports this concept.

Similar to our findings, other authors have reported successful nonoperative treatment of IIOHFs without secondary displacement of the fracture [4,5,15]. Katsuyama et al. compared surgical and non-surgical management of GT fractures with incomplete progression. Their nonoperative group included 21 patients, eight of whom had fracture extensions involving more than 50 % of the intertrochanteric line. Sixteen of these were allowed immediate weight bearing as tolerated, while five were only permitted full weight bearing after three weeks of bed rest. None of their patients had progression of the fracture. Caldwell et al. reviewed non-surgically treated occult hip fractures at their institution. Their cohort included six femoral neck and nine

Table 3
Diagnostic test findings for patients which included in the study. The time form admission to the diagnostic tests and data which was obtained in the follow up clinic or in the telephone questionnaire regarding walking status before and after the IIOHFs.

Diagnostic tests and mobility status	
Side of fracture	LT-20 RT-25
CT diagnosis	9- no fracture 36 – GT fracture, no extension
MRI diagnosis	
Isolated Incomplete intertrochanteric fractures	9
Greater trochanter fractures with more than 1/3 extension to IT region	36
MRI diagnosis of Greater trochanter fractures	Zone 2- 29 Zone 3 - 10
Time- admission to CT; hours (SD)	5.2(4.1)
Time -admission to MRI; hours (SD)	30.5(20.2)
Follow up; months (SD)	3.2 (2)
mobility status before injury	Walking −26 Walking with aids-13 Non-walker −0
mobility status at last follow up	Walking −14 Walking with aids-24 Non-walker-1

intertrochanteric fractures, all permitted weight bearing as tolerated. Two femoral neck fractures showed secondary displacement requiring surgical intervention, whereas none of the intertrochanteric fractures progressed to displacement [4]. Other authors have also reported on immediate weight bearing treatment of IIOHFs although their protocol included only patients with extension of the fracture to less than 50 % of the intertrochanteric line [7,10].

Regarding IIOHFs without GT fracture seen on radiographs, we report 9 cases which were treated non operatively with immediate weight bearing. This is one of the largest reports that we know of for this rare injury. A summary of reported data from other studies of IIOHFs without GT fracture is presented in Table 4. Our findings support our endorsement of non-operative treatment with immediate weight bearing rehabilitation protocol.

The results of this study should be approached cautiously. There are reports of occult fractures progressing to secondary displacement, requiring surgical intervention. Specifically, we identified three reports of GT fractures that progressed to displaced intertrochanteric fractures necessitating surgical treatment [11,13,16]. Park et al. described a case involving a GT fracture with two-thirds extension into the intertrochanteric line on MRI that subsequently progressed to a complete fracture requiring surgical intervention [11]. This remains the only reported case of an IIOHF diagnosed by MRI that demonstrated secondary displacement following conservative management that we know of. These reports lack detailed information on critical factors such as patient BMI, specific fracture characteristics, or whether secondary injury or falls contributed to displacement. Such data are essential for a deeper understanding of the risk factors associated with the progression of IIOHFs to fully displaced fractures.

When treating incomplete occult hip fractures, it is important to distinguish between fracture types. In contract to our recommendations for intertrochanteric fractures, we believe that incomplete fractures of the intracapsular femoral neck region should be managed operatively. As demonstrated by Caldwell et al., these fractures have significant potential to progress to complete fractures with displacement [4]. Moreover, intracapsular fractures that undergo secondary displacement often necessitate more extensive surgery, such as partial or total hip replacement. To mitigate this risk, we routinely perform prophylactic fixation of incomplete intracapsular fractures using cannulated screws. Further research is needed to evaluate the optimal management strategy for these fractures, which lies beyond the scope of this article.

There is no consensus regarding whether all GT fractures require further imaging to exclude occult intertrochanteric extension. There is also uncertainty regarding the optimal imaging modality (e.g., MRI, CT, dual-energy CT) [6,8,12,13,17,18]. Certain GT fracture patterns have been identified as being more prone to extension, and some authors recommend further imaging only in those specific cases [17]. In our study, none of the GT fractures demonstrated involvement of the medial cortex. Notably, we observed a relatively high number of patients (51) with GT fractures who underwent MRI to exclude medial cortex involvement. Our findings raise questions about the necessity of routine advanced imaging for all GT fractures.

With regards to imaging modality, MRI demonstrates high sensitivity for detecting IIOHFs, but it has limitations in accurately determining medial cortex involvement - a critical factor for treatment decisions. Some authors advocate for CT scans in such cases due to their superior bone visualization [6]. Advancements in imaging technologies, including modalities that enhance bone visualization in MRI [19], should be explored to address these issues.

Not much is known about the specific characteristics of the population suffering from IOHF, the mechanisms underlying these fractures, or their long-term outcomes. Analysis of patient demographics from our study demonstrate that elderly patients, often with significant comorbidities, are particularly prone to these fractures. IIOHF diagnosis and management in younger adults should be further explored as they can have different characteristics. Furthermore, the observed decline in mobility status following IIOHF in our patient cohort, even with aggressive rehabilitation, highlights the profound functional impact of this injury. These findings align with the conclusions of previous studies, highlighting the clinical significance of IIOHFs [20].

We recommend performing MRI in patients with suspected occult hip fractures when initial radiographs are inconclusive [12]. In contrast, patients diagnosed with isolated GT fractures do not routinely require additional imaging. However, specific fracture patterns may warrant further evaluation with CT [17]. Further research is necessary to establish definitive imaging guidelines and validate these recommendations. A limitation of this study is the relatively short follow-up period. However, we believe that the primary concern regarding the progression of IOHFs to a complete fracture is most relevant during the initial period following the injury, particularly when weight bearing begins immediately. The mobility status of the patient's before and after the injury was reported, patients form the cohort were treated by different rehabilitation programs (home, inpatient) this inconsistent rehabilitation treatment could affect patient's mobility status rather than fracture characteristics. Another limitation is that the telephone questionnaire was, in some cases, conducted long after the patient had been discharged and in some cases it was completed by a family member. These factors could introduce recall bias. Despite the implementation of strict protocols at our institution, patients were treated by a variety of physicians, which may have led to inconsistencies in diagnostic practices. Specifically, in cases of greater trochanter fractures, some patients did not undergo MRI for further investigation.

Conclusion

For patients diagnosed with incomplete intertrochanteric occult hip fractures we recommend rehabilitation with immediate full weight bearing. Our findings suggest that routine MRI scans to assess for fracture propagation in patients with GT fractures are likely unnecessary. Further studies are needed to refine imaging guidelines and treatment strategies for these injuries.

Ethical statement for solid state ionics

Hereby, I Amit Davidson, consciously assure that for the manuscript Outcomes of Immediate Full Weight Bearing Protocol for Incomplete Intertrochanteric Occult Hip Fractures. the following is fulfilled:

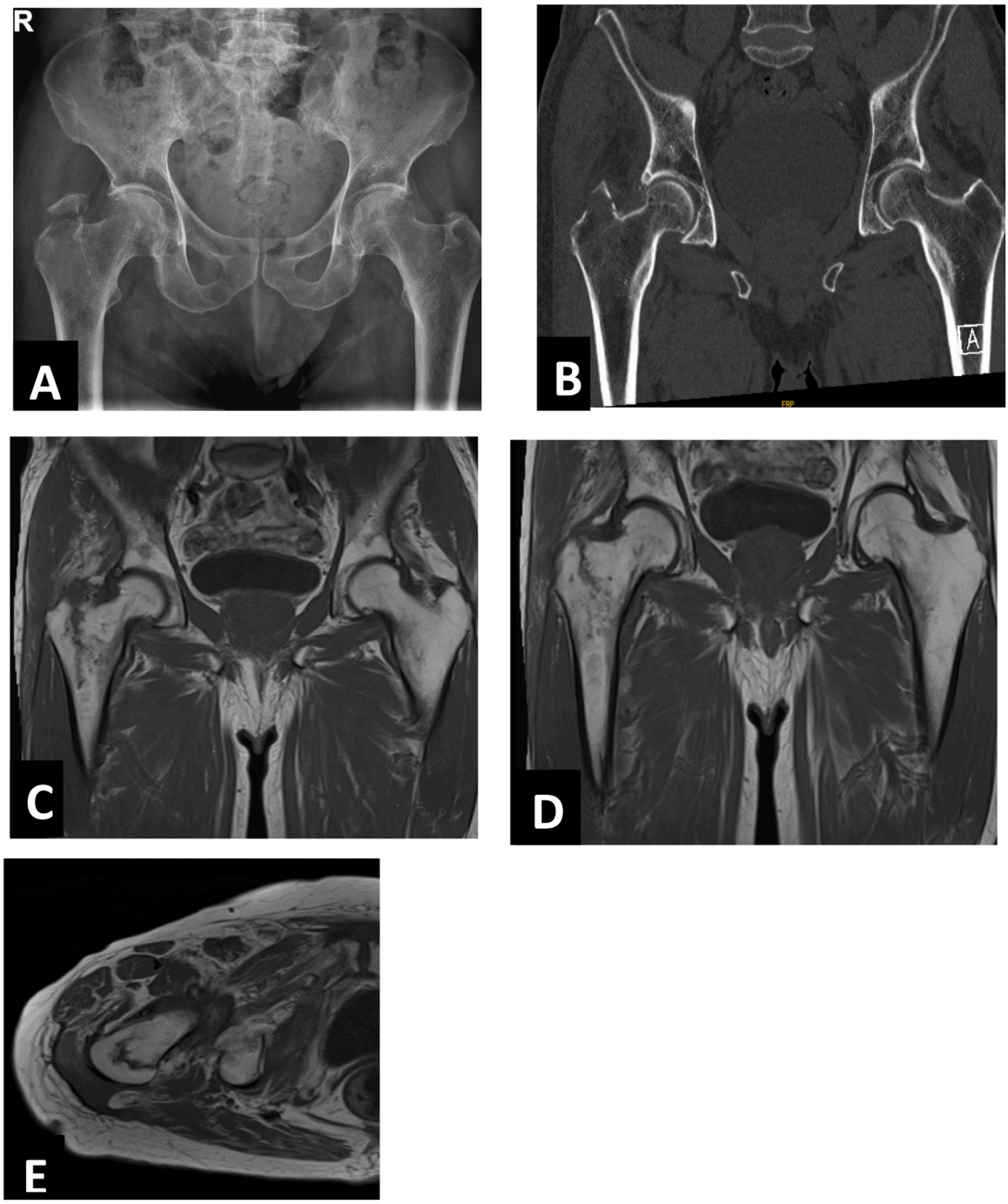

Fig. 2. (A–E) Images of 77 years male sustaining a fall on his right side. This patient was diagnosed with a right GT fracture on plain radiograph, CT and MRI were conducted as part of our diagnostic protocol. Fig. A- Plain radiograph showing GT fracture with no extension to the Intertrochanteric region. Fig. B- CT coronal cut showing the GT fracture with no visible extension to the intertrochanteric region. Fig. C- Coronal T1 sequences MRI image, showing a line with low signal extending from the fracture to the in the intertrochanteric region. Fig. D- Mid Coronal T1 sequences MRI image, showing a line with low signal extending from the fracture to the intertrochanteric region. Fig. E- Axial plane T1 sequences MRI image, showing a line with low signal extending to the anterior cortex.

1) This material is the authors' own original work, which has not been previously published elsewhere.
2) The paper is not currently being considered for publication elsewhere.
3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
5) The results are appropriately placed in the context of prior and existing research.
6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

The violation of the Ethical Statement rules may result in severe consequences.

I agree with the above statements and declare that this submission

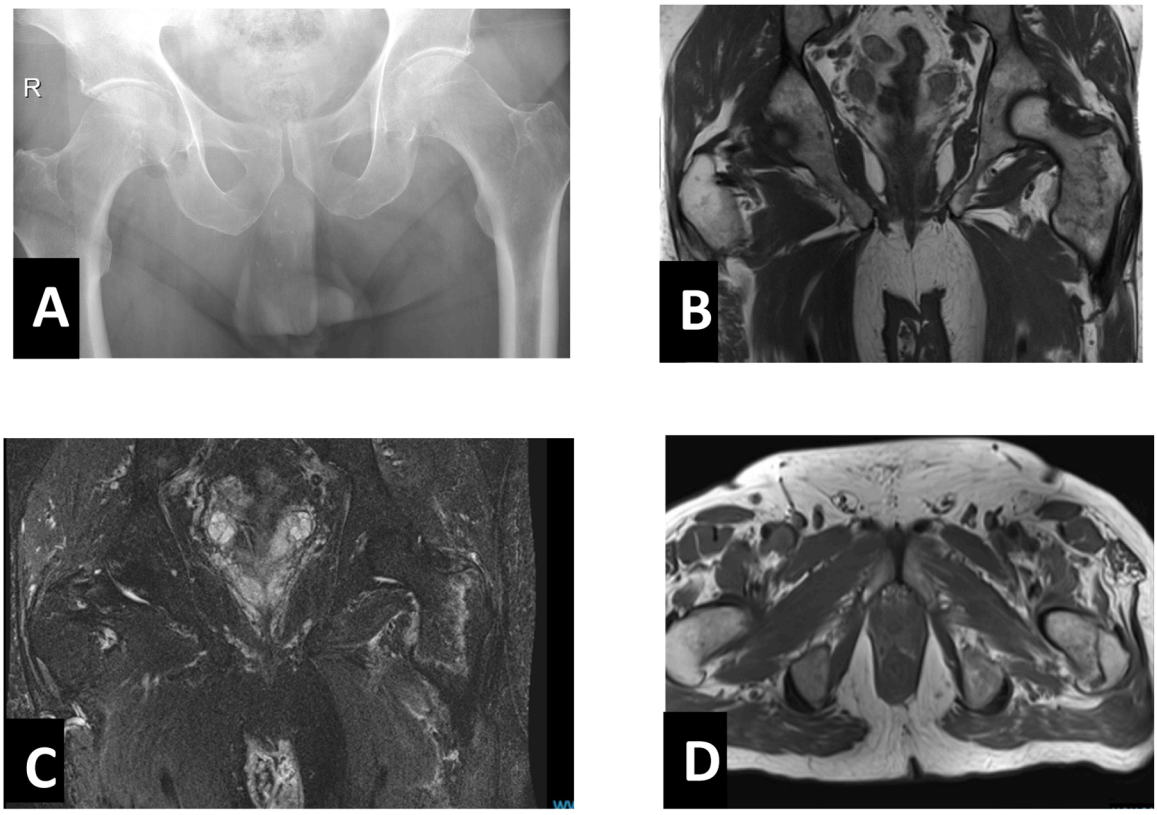

Fig. 3. (A–D) Images of 79 years male sustaining a fall on his left side. No findings on plain radiographs, MRI was conducted as part of our diagnostic protocol due to clinical suspicion of occult fracture. Fig. A- Plain pelvic radiograph no fracture was diagnosed Fig. B- Coronal T1 sequences MRI image, showing a fracture line with low signal in the intertrochanteric region. Fig. C- Mid Coronal T2 sequences MRI image, showing the fracture line. Fig. D- Axial plane T1 sequences MRI image, showing a line with low signal extending to the anterior cortex.

Table 4
Summery of reported literature on incomplete intertrochanteric occult hip fracture without a GT fracture.

Study	Imaging modality	Number of Occult Incomplete Intertrochanteric Fractures Without GT Fracture	Treatment	Outcome
Bogdan D. et al [21].	CT+MRI	13	Non-operative: bed rest initially, non-weight bearing on the affected leg no sooner than 3 weeks from trauma.	N/A
M. Haubro et al [22].	CT+MRI	2	Non-operative: bed rest initially, non-weight bearing on the affected leg.	N/A
Rehman H, et al [23].	CT+MRI	21	Operative	N/A
Eggenberger et al [24].	CT+MRI	2	No data	N/A
Alam A. et al [1].	MRI	8	3 Operative, 5 Non-operative	N/A
Hakkarinen D. et al [25].	MRI	1	Operative	N/A

follows the policies of Solid State Ionics as outlined in the Guide for Authors and in the Ethical Statement.

CRediT authorship contribution statement

Davidson Amit: Writing – original draft. **Silver Natan:** Data curation. **Abu Tair Mohammed:** Data curation. **Levy Yadin:** Investigation. **Katz Alan:** Writing – review & editing. **Yaakov Applbaum:** Formal analysis. **Peyser Amos:** Supervision.

Declaration of competing interest

None

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Natan Silver is recognized a shared first authorship due to his significant contributions to the writing of this paper.

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