
ORIGINAL ARTICLE

Occult Intertrochanteric Extension in Isolated Greater Trochanteric Fracture on Plain Radiographs

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ABSTRACT

Objectives: To review the prevalence of occult intertrochanteric extension and fracture pattern in patients with isolated greater trochanteric (GT) fracture on plain radiographs.

Methods: Between January 2010 and December 2013, patients with trochanteric hip fracture at a regional hospital in Hong Kong were retrospectively reviewed. Those with isolated GT fracture on plain radiographs were included. The demographic details, premorbid condition, computed tomography (CT) findings, fracture pattern, surgical intervention, outcome, and follow-up radiographs were analysed.

Results: Of 928 patients with trochanteric fracture, 58 (6.3%) showed isolated GT fracture on plain radiographs. CT was performed in 51 (87.9%) patients: 10 (17.2%) had intertrochanteric extension, and 7 of them were offered operative fixation. Dynamic hip screw was inserted in five, and surgery was avoided in two who were considered having a high anaesthetic risk. For the fracture pattern of greater trochanter on CT, 29 (56.9%) showed more than one facet involvement. Most involved the superoposterior facet (39/51, 76.5%), followed by anterior facet (25/51, 49.0%), lateral facet (15/51, 29.4%), and posterior facet (12/51, 23.5%). In the intertrochanteric extension group, there was a higher proportion of anterior facet involvement (Fisher's exact test, $p = 0.038$; odds ratio = 5.65 [95% confidence interval, 1.06-30.0]) and lower proportion of superoposterior facet involvement ($p = 0.042$; odds ratio = 0.21 [95% confidence interval, 0.047-0.91]). There was no statistically significant difference in the posterior and lateral facet involvement, or the age and gender in both groups.

Conclusion: In patients with isolated GT fracture on plain radiographs, 17% showed intertrochanteric extension on CT scans. Prompt and meticulous search for intertrochanteric extension is mandatory, particularly when CT scan reveals anterior facet involvement.

Key Words: Hip fractures; Tomography, X-ray computed

中文摘要

X光檢顯示孤立大轉子骨折並隱匿性股骨粗隆間擴展

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目的：從孤立大轉子骨折患者的X光片上探討隱匿性股骨粗隆間擴展的發生率和骨折形態。

方法：回顧2010年1月至2013年12月期間於香港一所分區醫院的股骨髓部骨折患者的病歷紀錄。孤立大轉子骨折患者列入研究範圍。分析以下資料：人口學數據、病前狀態、CT發現、骨折型態、手術干預、手術結果和隨訪過程中的X光片。

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Submitted: 1 Jun 2015; Accepted: 23 Sep 2015.

Disclosure of Conflicts of Interest: All authors have no relevant conflicts of interest to disclose.

結果：共928例轉子骨折，其中58例（6.3%）的X光片上顯示有孤立大轉子骨折。51例（87.9%）接受CT檢的患者中，10例（17.2%）有股骨粗隆間擴展，當中提供固定手術7例：5例進行動力髓螺釘內固定術，另2例因麻醉高風險而未接受手術。至於CT影像所見的大轉子骨折形態，29例（56.9%）牽涉多於一個小面；大多數牽涉上後小面（39/51，76.5%），其次為前小面（25/51，49.0%）、側小面（15/51，29.4%）和後小面（12/51，23.5%）。有股骨粗隆間擴展的患者中，牽涉前小面的較多（Fisher精確檢驗， $p=0.038$ ；比值比=5.65（95%置信區間：1.06-30.0）），牽涉上後小面的則較少（Fisher精確檢驗， $p=0.042$ ；比值比=0.21（95%置信區間：0.047-0.91））。兩組之間牽涉後小面和側小面，以及年齡和性別方面均無統計學顯著差異。

結論：X光片上發現有孤立大轉子骨折的患者中，CT顯示17%有股骨粗隆間擴展。當CT掃描顯示牽涉前小面時，需仔細檢查是否有股骨粗隆間擴展。

INTRODUCTION

Hip fracture is a major challenge in orthopaedic practice. In 2011, there were over 4500 new cases of hip fracture in Hong Kong, and the financial cost in acute and rehabilitation care accounted for more than HK\$300 million.¹ Nonetheless 2% to 10% of fractures may not be clearly visible on initial radiographs, and further imaging is required to make a definitive diagnosis.²

Hip radiographs have an estimated sensitivity of 90% to 98%，and the prevalence of occult hip fractures is approximately 3% to 4%，and in some series up to 9%.²

In the acute emergency setting, initial visualisation of hip fractures most often is on plain radiograph.³ According to the National Institute for Health and Care Excellence (NICE) guideline in the United Kingdom, computed tomography (CT) should be considered if hip fracture is suspected despite negative plain radiograph of the hips of an adequate standard, or if magnetic resonance imaging (MRI) is not available within 24 hours or is contraindicated.² In Hong Kong, CT has more often been used as the modality of choice, since it is more readily available with shorter examination time.

Among occult hip fractures, one entity that has not been widely studied is the occult trochanteric extension of isolated greater trochanteric (GT) fracture. Isolated GT fracture is relatively uncommon among all these hip fractures,⁴⁻⁷ and the pattern of GT fracture varies with age. In the elderly, most are due to a direct blow, while in adolescents, most are avulsion injuries.^{4,6,8,9} There are only a few reports in the literature about occult intertrochanteric extension in isolated GT fracture visible on plain radiographs. Although the preferred treatment for presumed isolated GT fracture has most often been

nonsurgical,^{3,4,10-15} treatment might be altered if the actual extent of the injury is known. In the presence of intertrochanteric extension, operative fixation may be needed to avoid further displacement and allow early rehabilitation, mobilisation, and weight bearing.

This study aimed to review the prevalence of occult intertrochanteric extension and the fracture pattern in patients with isolated GT fracture on plain radiographs.

METHODS

This was a 4-year retrospective review of patients with trochanteric fractures at a regional hospital in Hong Kong from January 2010 to December 2013. Data were retrieved from the Clinical Data Analysis and Reporting System (CDARS) of the Hospital Authority of Hong Kong. All patients who were admitted to the hospital between 1 January 2010 and 31 December 2013 with the diagnosis code of pectrochanteric fracture (ICD10 – S72.1) were shortlisted. The study was approved by New Territories West Cluster Ethics Committee.

Among the pectrochanteric hip fracture patients, only those with an isolated GT fracture on plain radiograph were included. The initial plain radiographs, consisting of both anteroposterior (AP) and lateral projection of the hips, were independently reviewed by two radiologists with 6 years of experience. Patients with a fracture other than isolated GT fracture (e.g. intertrochanteric fracture), or with obvious intertrochanteric extension or neck of femur extension, were excluded. If there was discrepancy between the two radiologists, the radiographs were reviewed again and discrepancies were resolved through consensus. Both radiologists were blinded to the history, clinical progress, outcome, and other imaging results, including CT scans and

subsequent plain radiographs.

The demographic details, premorbid condition, treatment received, length of hospital stay, outcome upon discharge, post-discharge clinical condition, and plain radiograph at follow-up were recorded.

Some patients underwent CT of the hip by a 16-multidetector CT machine (16 heads Brilliance 16; Philips Medical Systems, Best, Netherlands) with multiplanar reformation. Axial images were taken with slice thicknesses of 1.0 mm and increments of 0.8 mm. The CT findings of the fracture pattern, presence of intertrochanteric extension, and facet involvement were recorded and analysed. For patients in whom CT hip was not performed, all subsequent inpatient and post-discharge plain radiographs were reviewed for any evidence of intertrochanteric extension of fracture.

Patients with intertrochanteric extension and those without were compared. Statistical analysis was performed using the Statistical Package for the Social Sciences (Windows version 22.0; SPSS Inc, Chicago [IL], US). Fisher's exact test was applied for gender and facet involvement comparison. Mann-Whitney *U* test was applied for age and length of stay comparison. A *p* value of <0.05 was considered to be statistically significant.

RESULTS

Descriptive Results

Over the 4-year period, there were 2504 hip fracture cases retrieved from CDARS, among which 928 (37%) were trochanteric fractures. After radiological review of plain radiographs, 58 patients were deemed to have an isolated GT fracture (Figure 1). The mean age of the patients was 79.2 (range, 14-99) years. All patients had a history of low-energy trauma including fall. Regarding premorbid ambulatory status, 16 patients could walk unaided, 34 required walking aids, and 8 were bedbound or chairbound. Of the 58 patients, 24 were residents in an institution.

Of the 58 patients, CT hip was performed in 51 (87.9%). The mean time from hospital admission to CT was 23.4 hours. Of patients with isolated GT fracture, 10 (17.2%) had intertrochanteric extension, and the remaining 41 had no evidence of extension.

For the seven patients without CT hip, all had local tenderness at the greater trochanter but no tenderness

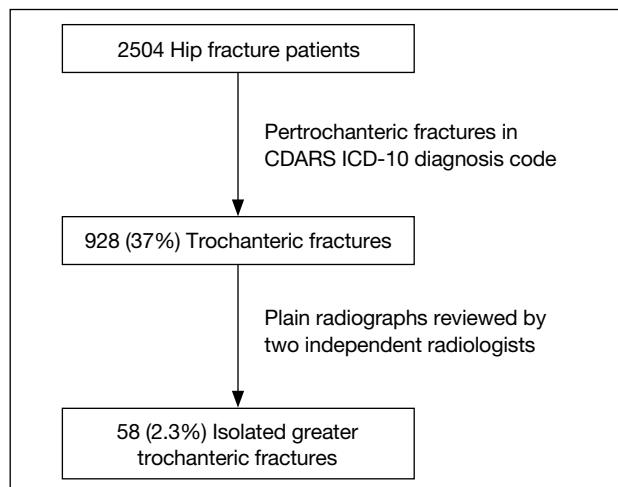


Figure 1. Patient inclusion.

Abbreviation: CDARS = Clinical Data Analysis and Reporting System.

on hip rocking or axial loading. The mean time to next plain radiograph was 52.6 (range, 9-90) days and none showed intertrochanteric extension. All patients were treated conservatively and were discharged after 1 to 20 days and followed up until a mean of 509 (range, 53-982) days post-injury. Clinically there was no increase in hip pain, no physical signs of rocking or axial loading tenderness, and no radiographic evidence of new fracture extension. All were regarded as having no intertrochanteric extension. Together with the 41 patients with CT, 48 (82.8%) patients had no intertrochanteric extension.

For the 10 patients who had intertrochanteric extension, seven were offered operative fixation. Dynamic hip screw was performed in five (Figure 2), and surgery was avoided in two who were considered having a high anaesthetic risk. For the three patients with intertrochanteric extension who were offered conservative treatment, one was wheelchair-bound, one was bed-bound, and one was given a course of rehabilitation and discharged with frame-walking. Fracture healing occurred in all 10 patients.

Regarding the fracture pattern of greater trochanter on CT, 56.9% showed more than one facet involvement. Most involved the superoposterior facet (76.5%), followed by anterior facet (49.0%), lateral facet (29.4%), and posterior facet (23.5%) [Table 1].

Analytical Results

Comparison of the groups with and without intertrochanteric extension revealed no statistically significant difference between gender (*p* = 0.737) and age (*p* = 0.112), although length of hospital stay of

Table 1. Greater trochanter facet involvement on computed tomography.

	Intertrochanteric extension		Total	p Value	Odds ratio (95% confidence interval)
	No (n=41)	Yes (n=10)			
Anterior facet	17 (41%)	8 (80%)	25 (49.0%)	0.038	5.65 (1.06-30.0)
Posterior facet	9 (22%)	3 (30%)	12 (23.5%)	0.682	-
Lateral facet	11 (27%)	4 (40%)	15 (29.4%)	0.454	-
Superoposterior facet	34 (83%)	5 (50%)	39 (76.5%)	0.042	0.21 (0.047-0.91)
Multifacet involvement	22 (54%)	7 (70%)	29 (56.9%)	0.483	-

Table 2. Greater trochanteric fracture with and without intertrochanteric extension.

	Intertrochanteric extension		Total (n = 58)	p Value
	No (n = 48)	Yes (n = 10)		
Male:female	23:25	4:6	27:31	0.737
Age (years)				0.112
Mean ± standard deviation	77.9 ± 16.4	85.3 ± 11.9	79.2 ± 15.9	
Median (range)	82.5 (14-93)	86.0 (58-99)	83.0 (14-99)	
Mean length of hospital stay (days)	12.2	28.7	15.0	0.005

**Figure 2.** An 86-year-old demented and blind female institutional resident was admitted with right hip pain following a fall. Physical examination showed right hip tenderness and rocking tenderness. (a) X-ray shows isolated greater trochanter fractures (arrows). (b) Computed tomography shows greater trochanteric fracture (anterior facet involvement) with intertrochanteric extension. Dynamic hip screw was performed.

the intertrochanteric extension group was significantly longer (28.7 days vs. 12.2 days; $p = 0.005$) [Table 2].

When the seven cases without CT were excluded, the results were similar with no statistically significant difference between gender ($p = 0.731$) and age ($p = 0.106$), although length of hospital stay in the intertrochanteric extension group remained longer (28.7

days vs. 13.3 days; $p = 0.011$).

For facet involvement, among the anterior, posterior, lateral and superoposterior facets, only anterior and superoposterior facets showed statistically significant difference between the two groups. In the intertrochanteric extension group, there was a higher proportion of anterior facet involvement ($p = 0.038$;

odds ratio = 5.65 [95% confidence interval, 1.06-30.0]) and a lower proportion of superoposterior facet involvement ($p = 0.042$; odds ratio = 0.21 [95% confidence interval, 0.047-0.91]). There was no statistically significant difference in the posterior and lateral facet involvement, or presence of multifacet involvement between the groups (Table 1).

DISCUSSION

Occult Intertrochanteric Extension in Isolated Greater Trochanteric Fracture

‘Occult fracture’ is a term typically used to refer to a fracture that is either imperceptible radiographically or manifests with such subtle findings that it is not identified at the time of initial interpretation.^{16,17} The standard for the detection of occult hip fractures has long been a combination of clinical history, physical examination, and radiography. Clinically, pain may be focal, minimal, or initially absent. Ecchymosis and leg length discrepancy may or may not be evident.^{3,4,7}

Radiographically documented isolated GT fractures are thought to be uncommon. This is confirmed by a paucity of orthopaedic reports or textbook coverage of the subject.^{3,4,5,7,8,13-15,18} The greater trochanter is most vulnerable at the tip and upper portion, yet the fracture mechanism varies.^{3,4,8,18} In children and adolescents, GT avulsion with physeal separation is more common than in adults.^{3,4,7,8,9} In adults, direct blows or falls are more likely than muscle action alone to be the cause for GT injury.^{3,4,8}

Weight bearing and motion of the hip joint may cause an incomplete trochanteric fracture to progress to a complete fracture,^{3,11} or an undisplaced fracture to a displaced fracture, thereby changing management from conservative to operative, increasing length of hospital stay, and prolonging rehabilitation. A delay in surgical treatment for an acute hip fracture by 2 days doubles the mortality.¹⁹ Earlier diagnosis, and thereby earlier surgical intervention, results in earlier mobilisation and multidisciplinary rehabilitation, and lower hospital and social costs.²⁰

Imaging Modality: Plain Radiography

According to American College of Radiology (ACR) Appropriateness Criteria, plain radiograph is the established initial imaging study of choice for acute hip pain with suspected fracture.²¹ Hip AP and cross-table lateral views should be performed.² Despite properly taken plain radiographs, their sensitivity ranges from 90% to 98%.²

Bone resorption around the fracture site, or cortical displacement, will render most occult hip fractures visible if plain radiographs are repeated after a few days. This is due to bone resorption occurring along the fracture line that makes it radiographically more obvious, but displacement or impaction may occur during this interval due to walking with the fracture or hip motion. Delay in surgery due to delayed diagnosis is associated with prolonged suffering and poorer health outcomes for patients, and exposes clinicians to the risk of litigation.²

Imaging Modality: Magnetic Resonance Imaging

MRI had been suggested as the investigation of choice in occult hip fracture. MRI is more sensitive than CT (99% vs. 53%) in detecting insufficiency fractures.²² Although MRI is regarded as the best available secondary imaging modality to detect an occult hip fracture, it may not always be feasible.²³⁻²⁵ Anxious or restless patients, or patients in pain, may find it impossible to lie still for the entire duration of an MRI examination. Also, MRI may not be widely available both during and outside office hours, or may be contraindicated, for example in patients with a pacemaker, metallic implant, or in those who are claustrophobic.²⁶

Imaging Modality: Computed Tomography

CT has been used to detect hip fracture since the 1980s.²⁷ It is widely available, rapid, and easily tolerated, especially in patients with potential hip injuries.²¹ The diagnosis of a fracture extending into the intertrochanteric region with CT relies on either disruption of the cortical line of the intertrochanteric crest (posterior) or the intertrochanteric line (anterior). Occasionally sclerosis from compressed trabeculae can also be seen.¹⁶

In a retrospective study of 193 patients with suspected missed hip fracture and equivocal or negative plain radiographs who underwent CT imaging, CT sensitivity was 95%.²⁶ The observer agreement in CT of occult hip fracture was near-perfect or close to that of MRI.²⁸

Multiplanar reformation CT is more useful than MRI when deciding the indication of surgical treatment in patients with GT fracture and intertrochanteric extension.²⁹

Our Study

In this study, among the 2504 hip fractures collected over 4 years in a regional hospital, isolated GT fracture

accounted for 58 (2.3%) cases. With about 4500 new cases of hip fracture in Hong Kong in 2011,¹ there are roughly 100 cases of isolated GT fracture per year by extrapolation.

There was no statistically significant difference between the groups with and without intertrochanteric extension, in terms of age or gender. Length of hospital stay, however, was significantly longer for the intertrochanteric extension group. This was to be expected since half of the intertrochanteric extension group required operation. Even with conservative treatment, a longer period of immobilisation would be required when compared with the group without intertrochanteric extension.

In our study, among the seemingly isolated GT fracture, 17% had confirmed diagnosis of intertrochanteric fracture. If the seven patients without CT were excluded, the percentage increased to 19.6%. Our literature review found that the percentage varied widely due to differences in inclusion criteria, different standards (some using MRI, bone scan, or CT), and different scale of study.

In Feldman and Staron's study using MRI as standard,³ 35 (95%) out of 37 patients with isolated GT fracture on plain radiograph had intertrochanteric extension. Regarding fracture pattern, 21 extended from the superolateral to inferomedial cortices of the intertrochanteric region; two had incomplete intertrochanteric extension; 11 had additional extension to diaphysis and one had additional superior extension to the base of the femoral neck. Surgery was performed in 30 patients although the inclusion and exclusion criteria were not described in detail. Bone scintigraphy was performed in 5 of the 37 patients and CT in 5. It is unknown how many patients with plain radiograph negative of intertrochanteric extension underwent bone scintigraphy or CT who were subsequently proven to be extension positive nor how many were excluded from the study.

In a study by Lee et al,⁶ 20 (80%) out of 25 patients with an isolated GT fracture on plain radiograph had intertrochanteric extension on MRI, of whom 15 underwent surgery. In Craig et al's study,¹² the rate was three (23%) out of 13 on MRI. In the Alam et al's study,³⁰ eight (12%) out of 68 patients with a normal plain radiograph showed intertrochanteric extension on MRI.

For facet involvement, we adopted the four-facet

divisions from anatomical studies by Pfirrmann et al.³¹ We could not identify any previous studies that had tried to delineate the relationship of facet involvement and intertrochanteric extension. Feldman and Staron's study³ only analysed the intertrochanteric extension pattern and superior or inferior extension of fracture. In our study, we noticed a higher proportion of anterior facet involvement in the intertrochanteric extension group, with an odds ratio of 5.65 (confidence interval, 1.06-30.0). More large-scale studies are required to confirm the relationship and significance.

Limitations of Our Study

Due to the retrospective nature of the study, selection bias might be present. Since the accuracy of data for the study patients depended on the integrity and accuracy of the diagnosis code entered into the Clinical Management System, cases could have been under-reported if the fracture diagnosis code was not entered and thus not retrievable by CDARS.

With CT as the chosen modality to confirm intertrochanteric extension, and without benchmarking with MRI which is less widely available in the local setting, minimal intertrochanteric extension might have been missed.

Despite being followed up for a mean of 509 (range, 53-982) days post-injury, fracture healing was documented solely on radiographs and by clinical orthopaedic evaluation, not on CT or MRI. A follow-up CT / MRI scan may be preferable if the healing status of the fracture is a major concern of the study.

The Way Forward

Dual-energy CT (DECT), also known as spectral imaging, was first designed to identify uric acid deposition in the kidneys. With two X-ray tubes allowing simultaneous acquisition at two different energy levels (e.g. 80 or 100 and 140 kVp), it is superior to the present single-energy CT. Through the DECT virtual non-calcium subtraction technique, bone marrow oedema, for example in traumatic cases, can be detected analogous to MRI.^{16,32} Pache et al³³ reported a sensitivity of 86.4% and high specificities of 94.4% and 95.5% for the two observers. With colour-coded virtual non-calcium-subtracted images, attenuation changes in the bone marrow could be even better visually detected. The Guideline Development Group of NICE Guideline 2014 suggested further research on whether CT can have similar reliability and accuracy to MRI.³⁴ If DECT

has comparable sensitivity and specificity to MRI, it could be a modality of choice in future.

CONCLUSION

In our patients with isolated GT fracture on plain radiograph, 17% showed intertrochanteric extension on CT scan. There was a statistically significant higher proportion of anterior facet involvement in the intertrochanteric extension group. Prompt and meticulous search for intertrochanteric extension is mandatory, particularly when anterior facet involvement is evident on CT scan.

ACKNOWLEDGEMENT

Authors would like to acknowledge New Territories West Cluster Quality & Safety Division Statistical Officer Mr Jaden Lam for his suggestion and advice on statistical methodology.

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