



# Distribution of occult fractures detected in emergency orthopedic patient trauma with computerized tomography

Acil ortopedik travma hastalarında bilgisayarlı tomografi ile tanınan gizli kırıkların dağılımı

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## BACKGROUND

Computerized tomography (CT) is a very useful diagnostic method in orthopedic emergency cases where fractures are suspected but cannot be detected through direct radiography, or when the fracture is detected in direct radiography but better evaluation of the anatomical structure is necessary. In this study, we analyzed occurrences of missed fractures in radiographs that were subsequently diagnosed in CT scans.

## METHODS

This was a retrospective study. We examined the medical records of all orthopedic trauma patients who visited our hospital's emergency room due to orthopedic trauma between January 2010 and January 2011 and whose spine, pelvis and extremity CTs were taken.

## RESULTS

Occult fractures were detected using CT in 12 (6.6%) of the children and 102 (6.8%) of the adults. We detected cervical vertebra fractures in 23 patients, femoral neck fractures in 6 patients, and tibia plato fractures in 5 patients, which can cause complications unless immediately acted upon in the emergency room.

## CONCLUSION

CT revealed most missed diagnoses and proved that direct radiography is less capable of detecting fractures of some critical regions. Where there is clinical suspicion, we recommend that before conservative treatment of patients, especially in cases of possible cervical spine and pelvic region fractures, CT should be requested, even if the radiography is normal.

**Key Words:** Computed tomography; emergency orthopedic trauma; missed diagnosis; occult fracture; radiography.

## AMAÇ

Bilgisayarlı tomografi (BT) acil ortopedik travma hastalarında kıraktan şüphelendiğimizde, direkt grafi ile tanınmayan veya direkt grafi ile tanınan ama anatomik yapılar hakkında daha iyi değerlendirme imkanı sağlayan çok yararlı bir tanı yöntemidir. Bu çalışmada radyografi ile atlanmış sonrasında BT ile tanı almış kırıklar ile ilgili deneyimlerimizi sunduk.

## GEREÇ VE YÖNTEM

Bu geriye dönük çalışmada, Ocak 2010 ile Ocak 2011 tarihleri arasında ortopedik travma nedeniyle hastanemize acil servisine başvuran, omurga, pelvis ve ekstremitelerde BT'si çekilen bütün ortopedik travmalı hastaların tıbbi kayıtları gözden geçirildi.

## BULGULAR

Sonuç olarak erişkinde 102 (%6,8) ve çocuklarda 12 hastada (%6,6) BT kullanılarak gizli kırık saptandı. Acil serviste müdahale edilmediği takdirde komplikasyonlara neden olan ve kötü prognoza sahip servikal vertebra kırığı 23, femur boyun kırığı 6 ve tibia plato kırığı 5 hastada saptandı.

## SONUÇ

Ortopedik travması olan hastalarda, atlanmış tanılarının ortaya çıkarılması seyrekdir. BT atlanmış tanılarının çoğunu ortaya çıkarmış ve radyografinin bazı önemli bölgelerin kırıklarının saptanmasında düşük bir yeteneğe sahip olduğunu ortaya koymuştur. Klinik şüphenin olduğu durumlarda, radyografi normal olsa bile, özellikle servikal omurga ve pelvik bölge travmalı hastaların konservatif tedavisinden önce BT çekilmesini öneriyoruz.

**Anahtar Sözcükler:** Bilgisayarlı tomografi; acil ortopedik travma; atlanmış tanılar; gizli kırık; radyografi.

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Direct radiography has a key role in detecting fractures and dislocation in extremity and pelvis traumas. Radiography is still one of the most frequently used examinations in emergency departments (EDs) despite many new generation imaging methods because of its accessibility, relative cheapness, and high potential to help diagnosis. Of all patients examined in EDs, 35-61% were subjected to radiological evaluation.<sup>[1]</sup> Optimum benefit from radiography depends on technically proper imaging and accurate evaluation. Computerized tomography (CT) is one of the imaging methods used in EDs.<sup>[2]</sup>

CT is not only used to better understand the fracture anatomy and make a surgical plan for both adult and child patients, but also to investigate the occult pelvis, extremity, and vertebral fractures for which direct radiography revealed negative results.<sup>[2,3]</sup> CT should be considered for patients with suspected spine, knee, pelvis, and hip traumas which can cause catastrophic consequences if not detected early because direct radiography is inadequate.<sup>[2,4-10]</sup>

Trauma surgeons need to understand the types of injuries that might be missed by direct radiography, and whether these missed diagnoses might influence the management and the prognosis of the patients. The missed diagnoses could be discovered using a CT scan or other diagnostic tools. Accordingly, we conducted a retrospective study to determine the frequency and character of missed diagnoses after radiography in orthopedic trauma patients.

## MATERIALS AND METHODS

The number of patients examined in the adult and child ED of our hospital between January 1, 2010 - January 1, 2011 was 183.552 and 171.450 respectively. The records for the application of CT on children (aged 0-14) and adults (aged 14+) visiting the emergency trauma section in 2010 were analyzed. During this analysis, we used emergency examination cards, computer-based hospital registration system, and pre-CT direct radiographies and CT images taken from computer archive (PACS). The analyses were done by one orthopedist and one radiologist. The reasons for demanding a tomography and findings of the physical examination were recorded. Occult fractures, injuries that have no radiographic indicators that occur following trauma or without any trauma, are characterized by pain and detected by CT. Those fractures, which appear normal in direct radiography but can be detected by CT, were evaluated as occult fractures. The CTs were grouped as extremity, pelvic, cervical, thoracic, and lumbar spine. Iliac bone, sacrum, acetabulum, and hip joint CTs were classified as pelvis CT in general. All data were also classified as child (aged 0-14) and adult (aged 14+). All patients in this study were ex-

amined and had CTs requested by the same team of doctors.

The data were analyzed using SPSS version 15.00 pack program. Chi-square and two sided analyses were used where appropriate and the alpha value was accepted as 0.05.

## RESULTS

Out of 32.685 patients examined in child and adult emergency trauma units over one year, 1.664 were asked for an extremity, pelvis, and spine CT (7.02%). The mean age of the patients was 38.6 (2-94).

Occult fractures were detected in 37 of the 493 extremity CTs of adults, and in 2 of the 56 extremity CTs of children. Occult fractures were detected in 14 of the 169 adult pelvis CTs and 2 of the 6 child pelvis CTs. Occult fractures were detected in 16 of the 504 adult cervical CTs and 7 of the 107 child pelvis CTs. Occult fractures were detected in 3 of the 44 adult thoracic vertebra CTs and 1 of the 4 child thoracic vertebra CTs. Occult fractures were detected in 32 of the 273 adult lumbar vertebra CTs and none of the 8 children lumbar vertebra CTs (Table 1). The most frequent occult spine fractures were detected as lamina fracture in 12 cases, transverse process fractures in 8 cases, and spinous process fractures in 7 cases (Table 2).

A total of 12 (6.6%) occult fractures were detected in children, and 102 (6.8%) in adults. We also observed that there was a significant difference in favor of children between two groups in detecting occult fractures ( $p<0.004$ ). However, significantly more occult fractures were seen in the cervical area of children ( $p=0.033$ ). In adults, significantly more occult fractures were seen in the lumbar area ( $p<0.001$ ), and occult fractures were seen the least in the cervical area ( $p<0.001$ ). No significant difference was found in detecting the fractures in all areas in total ( $p=0.427$ ).

## DISCUSSION

An analysis of the rates of occult fracture detection as a result of the retrospective analysis of CT examinations requested by trauma units in child and adult EDs revealed that CTs can change treatment significantly.

**Table 1.** The distribution of occult fractures detected in emergency trauma patients with computerized tomography

Occult fracture	Adults (%)	Child (%)	Total (%)
Extremity CT	37 (7.5)	2 (3.5)	39
Pelvis CT	14 (8.2)	2 (33.3)	16
Cervical CT	16 (3.1)	7 (6.5)	23
Thoracic CT	3 (6.8)	1 (25)	4
Lumbar CT	32 (11.7)	–	32
Total CT	102 (6.8)	12 (6.6)	114 (6.8)

**Table 2.** The distribution of occult fractures detected in extremity and pelvis patients with computerized tomography

Upper extremity	n	Lower extremity	n
Scapula fracture	2	Sacrum fracture	7
Proximal humerus fracture	2	Pubic rami fracture	1
Radial head fracture	6	Collum femoris fracture	6
Coronoid proces fracture	1	Patella fracture	4
Radius distal fissure	1	Tibia plato fracture	5
Scaphoid fracture	2	Fibular head fissure	1
Capitatum fracture	1	Posterior malleolus fracture	3
Lunatum fracture	1	Tuber calcanei fracture	6
		Fibular sesamoid fracture	1
		Navicular fissure	1

The frequent locations of these fractures include collum femoris, spine, pelvis, scaphoid, sacrum, coccyx, sternum, tarsometatarsal region, patella, and sesamoid bone.<sup>[11]</sup> In case the occult fractures in these bones are unclear, further examination is needed in patients whose direct radiographies are normal.<sup>[2,12-14]</sup> In the present study the most common occult fractures observed were sacrum fractures (n=7), collum femoris fractures (n=6), and radius head fractures (n=6).

Emergency and orthopedic doctors should apply radiographic requests based on a plan that utilizes resources wisely.<sup>[2]</sup> CT is a reliable, noninvasive, painless, easy-to-apply examination method and quite sensitive in detecting the pathologies in bone structure. It is especially important to request CTs based on true justifications and to minimize dosage while obtaining the diagnostic information using the due examination method.<sup>[15,16]</sup>

### Cervical

In the ED, physical examination of the cervical spine is difficult because movement of this area in patients with possible spinal injury is prohibited, and the ability of the physician to predict such injury on the basis of history and physical examination is poor.<sup>[17-19]</sup> Conventional radiography remains an excellent screening test when the probability of injury is high and the consequences of missing a fracture could be catastrophic.<sup>[20-22]</sup> Conventional tomography has advantages when nondisplaced dens fractures or facet fractures are being evaluated. CT is particularly useful in assessing fractures of the occipital condyles, Jefferson fractures, atlantoaxial rotatory dislocations, burst fractures with retropulsed fragments, and injuries to the cervicothoracic junction.<sup>[20,23-25]</sup>

Acheson et al.<sup>[11]</sup> revealed that though radiographs suggested fractures in vertebrae, most so-called occult fractures (i.e., fractures detected on CT scans but not on conventional radiographs) were located in different parts of the vertebrae, such as in the pedicle, than

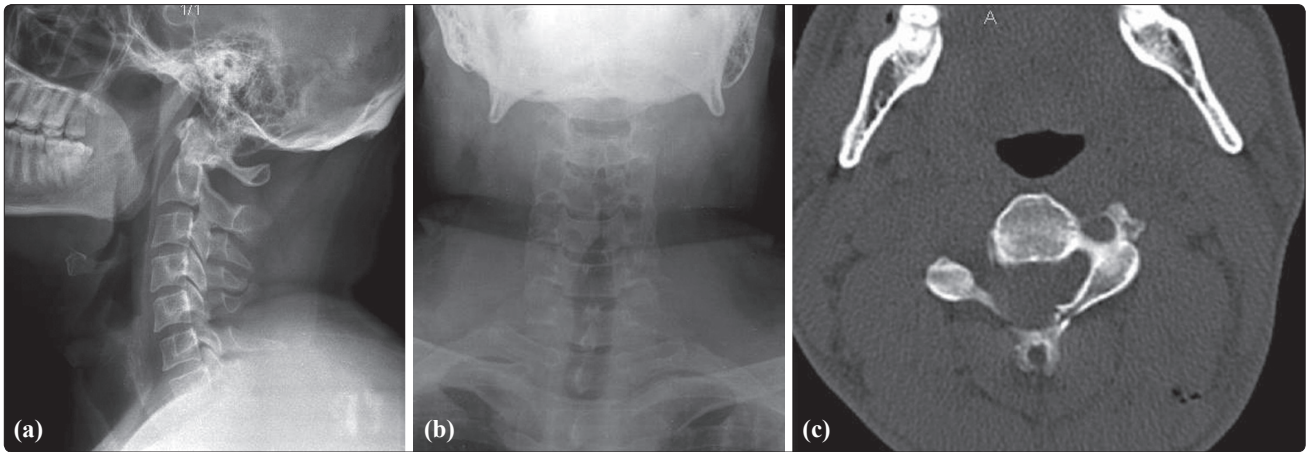
those found in radiographs. Fractures of the occipital condyles are difficult to diagnose because findings on plain radiographs are frequently normal.<sup>[20]</sup> In 1996, Nuñez et al.<sup>[15]</sup> reported that nearly 40% of cervical spine fractures are missed on conventional radiography but are later revealed on CT. Delays in diagnoses of clinically significant cervical spine injuries have been reported in approximately 5% to 23% of patients in various series, most of which used plain radiography as the initial screening modality. Neurologic deterioration (possibly secondary to mismanagement) occurred in 10% to 50% of these patients.<sup>[26,27]</sup> In contrast, development of a secondary neurologic deficit occurred in only 1.4% of patients whose injuries were detected on initial screening in Reid and coworkers' cohort.<sup>[28]</sup>

Generally, it has been accepted that 10-20% of all significant cervical spine injuries are missed by standard radiographs.<sup>[18,22]</sup> Of note, all the cervical spine injuries missed by plain films required some form of treatment, and 13 of these were unstable injuries requiring surgical stabilization.<sup>[5]</sup> A total of 23 cervical occult fractures were detected in our study. Six of the 16 occult fractures detected in adults were surgically stabilized, and 7 occult fractures detected in children were traced conservatively (Fig. 1a-c).

### Thoracic and lumbar spine

The options for thoracic and lumbar spine radiographs are far less complicated than those for the cervical spine.<sup>[26,27]</sup> AP and lateral films are adequate to rule out thoracic or lumbar spine injuries in most cases. As stated previously, the upper thoracic spine can be difficult to visualize with plain films and should be included as part of a cervical CT scan if indicated. Obscuring soft-tissue shadows in obese patients can make interpretation of plain radiographs difficult; this may prompt CT evaluation for spinal clearance. A CT also should be obtained in those patients with continued pain and tenderness or a neurologic deficit despite negative plain radiographs.<sup>[21,29]</sup> In most cases,





**Fig. 1.** (a) The normal appearance of the lateral cervical radiography. (b) The normal appearance of the AP cervical radiography. (c) Lamina fracture of third cervical vertebra in axial CT.

a CT is obtained to evaluate an injury identified by plain radiographs. Incidental injuries, such as spinous process and transverse process fractures, often are coincidentally detected on chest or abdominal CT scans obtained for non-spine reasons.<sup>[21,26]</sup>

### Sacrum

Dedicated sacral images are usually not a routine component of the spine evaluation and in fact lie more within the auspices of pelvic fracture evaluation. However, dedicated pelvic views should be obtained in patients with fractures or dislocations of the lumbosacral junction. This includes an AP pelvis (which is usually obtained as part of the initial trauma series) and pelvic inlet and outlet views. Pelvic ring fractures that include the sacrum are routinely evaluated by CT.<sup>[21,30]</sup> In our study occult sacrum fractures were detected in 7 patients, and 2 patients had neurological deficiency. If the sacrum fracture is not immobilized, it causes or deteriorates the neurological damage. While this is a medicolegal threat for the doctor who relies solely on direct radiography, it means destruction for the patient. As neurological damage can develop in sacral area fractures, routine pelvis CT is quite useful in early diagnosis.

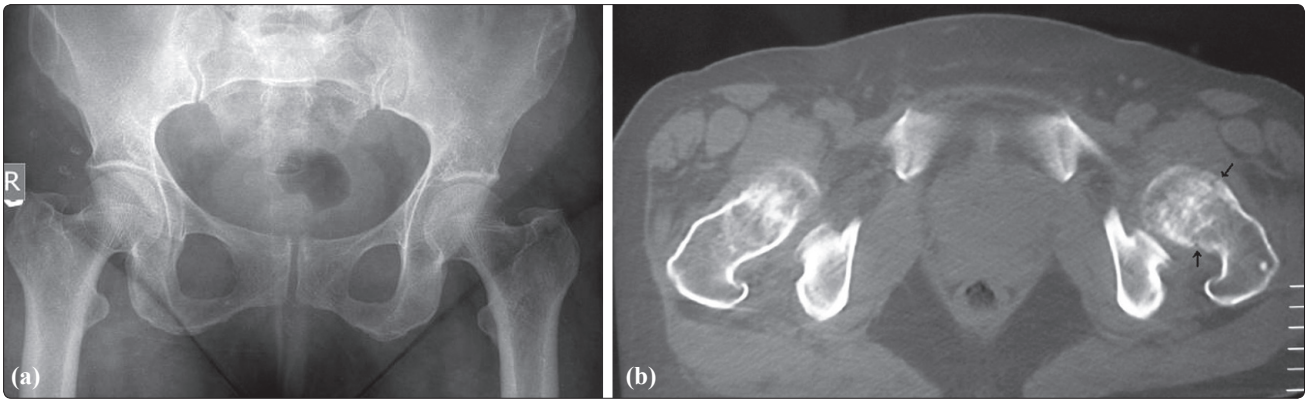
### Extremity and pelvis

*Occult scaphoid fracture:* If no fracture is visible on radiographs six weeks after trauma, it is considered safe to discontinue immobilization. This strategy, however, includes weeks-long unnecessary immobilization in some patients, which results in both a reduction in the quality of life and an increase in health care costs.<sup>[31]</sup> In cases of negative or equivocal findings, additional projections (i.e., scaphoid views and/or magnification views) have been reported to increase sensitivity.<sup>[31,32]</sup> However, immediately after injury, up to 65% of scaphoid fractures remain radiographically occult.<sup>[32]</sup> In our study occult scaphoid fractures were

detected in two patients, and such patients should be subjected to CT alternatively as most scaphoid fractures are missed in direct radiographies.

*Occult hip and pelvic fracture:* The challenge for emergency physicians is to diagnose this subset of patients at the point of care, because significant morbidity can result when a patient ambulates on an unrecognized hip fracture.<sup>[8]</sup> Surprisingly, there are limited data as to the overall incidence of hip fracture that is not radiographically apparent on plain radiographs, particularly with respect to patients presenting to the ED with hip injury.<sup>[8,10,33]</sup> Of the pelvic and hip fractures, 8% were not identified by plain radiograph as compared with 6.8% in their population.<sup>[10]</sup> Dominguez et al.<sup>[10]</sup> found that the most common fractures identified by magnetic resonance imaging after negative plain radiographs included the pubic rami (34.5%), the sacrum (27.6%), the femoral neck (13.8%), and the intertrochanteric region (6.9%). We found that 4.4% of the ED patients with hip pain who had negative plain radiographs were subsequently diagnosed as having fractures.<sup>[33]</sup> Further studies are warranted to identify characteristics of patients requiring advanced hip imaging studies. Immediate *in situ* nailing was used in six patients with detected femoral neck fracture (Fig. 2a, b). Occult posterior pelvic ring fractures are easily missed in geriatric patients with pubic rami fractures following a simple fall.<sup>[8]</sup> Occult pubic rami fracture was detected in one of our patients.

In our study occult plateau fractures were detected in five patients. Three of them were schatzker type 1; two were type 2 (Fig. 3a-c). If these fractures, which are treated conservatively, cannot be detected early and the patient applies load early, the collapse in the joint accelerates and requires surgical treatment. In a similar vein, the early diagnosis of the patellar fractures and immobilization of the knee in the early phase is important. During the flexion of the immobilized



**Fig. 2.** (a) The normal appearance of the Pelvic AP radiograph. (b) Left collum femoris fracture (black sign) in pelvic CT (black arrow).

knee, the fracture line is separated and causes tendons to stick to the patella, which may need surgical treatment.<sup>[7]</sup> In our study we found transverse patellar fractures in three patients and vertical patellar fracture in one patient, which healed with conservative treatment.

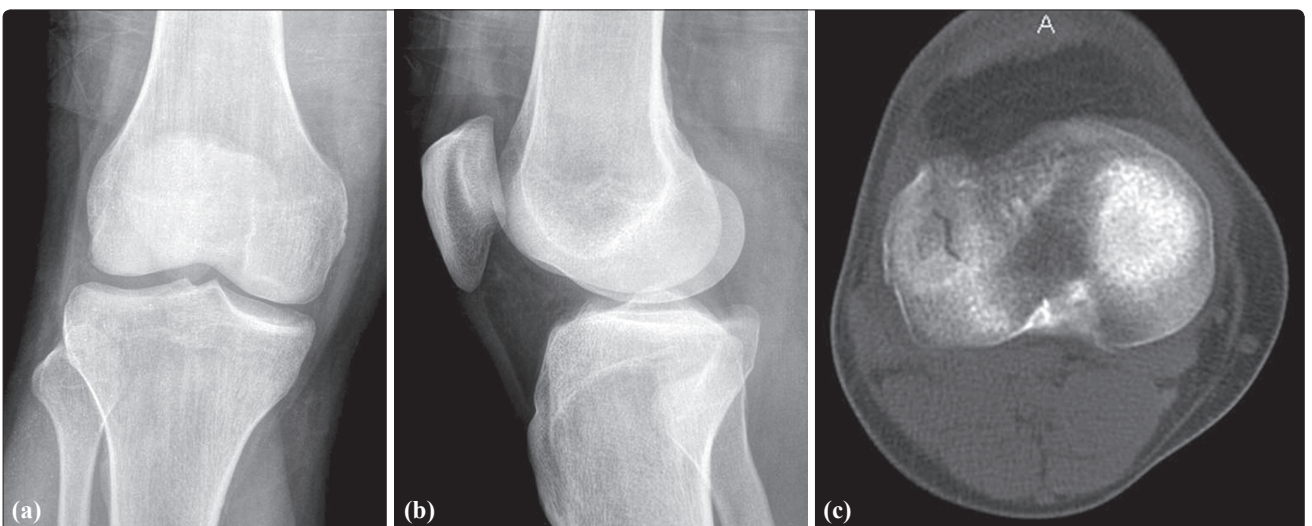
A large number of patients from almost all age groups were involved in this study. The results are significant when considering patients whose radiographies revealed no fractures after proper anamnesis and regular physical examination in the orthopedical emergencies but who revealed occult fractures in the following CTs and were treated starting from the first day. The occult fractures missed in the CT imaging become more complicated to treat, cost more, and the rates of disability increase. Therefore, detecting these occult fractures CTs is a very useful diagnostic tool.

### Child

The term ‘occult fracture’ is used for a fracture that is either radiographically undetectable or demonstrating subtle abnormalities that were missed on the initial

prospective interpretation, even if the fracture is visualized retrospectively or confirmed by other imaging tests.<sup>[9,14]</sup> Injuries to the physis can occur at any age before physeal closure, but are most common during periods of rapid skeletal growth. Although problems after injury to the physis are uncommon, missed injuries to this area can lead to premature closure with resultant focal bone growth arrest. Fortunately, fractures across the physis usually occur in a predictable pattern. Knowledge of these patterns is key for the emergency physician to avoid this potential orthopedic pitfall.<sup>[9,34,35]</sup> The incidence of pediatric cases of occult fractures occurs in about 2-18% of reviewed cases.<sup>[3,9]</sup> In our study occult fractures were detected using CT in 12 (6.6%) of the children.

The absence of early management in these children may increase the complication rate. Thus, immobilization is critical for improving healing time, preventing potential growth arrest and fracture deformity, and to avoid discomfort.<sup>[3,13]</sup> However, the major limitation of this strategy is the undesirable overtreatment, resulting



**Fig. 3.** (a) The normal appearance of the AP knee radiography. (b) The normal appearance of the lateral knee radiography. (c) Occult tibia plateau fracture in knee axial CT.



in unnecessary limitation of extremity motion, and a 1-2 week follow-up that is imposed on children without a fracture, as well as unnecessary visits for parents or guardians. As a result, about half of the children without fractures can be over treated, and nearly one-third of children with a fracture can be undertreated.<sup>[9,13]</sup>

The limitation of our study is in its retrospective design. The second limitation was our failure to classify fracture types and to evaluate the trauma mechanism because we were concerned about the presence of an occult fracture.

In conclusion, missing the diagnosis of patients with femoral neck fractures, which need immediate surgical treatment, and vertebral fracture, which can cause neurological damage, means destruction for patient and a medicolegal threat for the doctor who relies only on physical examination and direct radiography. As orthopedic surgeons, we should train ourselves about destructive outcomes caused by the risk of missing occult fractures not seen in direct radiography and delay diagnosis, act based on proofed protocols, and request for proper examinations immediately when necessary.

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