Research Article

The Role of Multi Detector Computerized Tomography (MDCT) In Evaluation of Ankle Joint Fractures

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Abstract
Fractures of the ankle joint are among the commonest fractures in adults. For a good long-term functional outcome to be achieved, reliable early evaluation is crucial. CT is the modality of choice for ankle joint fracture, axial and coronal views are essential for diagnosis. MDCT has revolutionized our understanding and characterization of these fractures and their management. Fracture characterization is essential to guide the management of these injuries. The use of MDCT with MPR and 3D reformatted images allow better visualization of fracture lines, dislocation and comminuted fractures and optimal evaluation of the injury .Ankle fractures are classified according to the part affected. If the fibular part affected it is classified according to the Weber classification, which is the most common and the simplest. If the calcaneal part is affected, it is classified in to extra articular fractures and intra articular fractures which also further classified according to Sander's classification. If the tibial part is affected it is classified according to the "The Rüedi-Allgwer" classification. Associated soft tissue injury and tendon injury and muscle injury are important to be evaluated before treatment of the fracture.
Keywords: Ankle Joint Fractures, Multi Detector Computerized Tomography

Introduction
Fractures of the ankle joint are among the commonest fractures in adults, with an incidence of up to 174 cases per 100 000 persons per year. For a good long-term functional outcome to be achieved, reliable early evaluation is crucial so that it can be determined whether the problem is a distortion (sprain), ligament rupture, bony ligament avulsion, or fracture of the joint**.**[(1)]

The proper treatment is chosen on the basis of the mechanism of the accident and the correct classification of the injury and accompanying soft-tissue damage. The goal of treatment is to enable the patient to put his or her full weight on the joint once again without pain and to prevent permanent damage.[(1)]

The ankle joint is formed by the tibia and fibula of the leg, and the talus and calcaneus of the foot. The tibia and fibula are bound together by strong tibiofibular ligaments. Together, they form a bracket shaped socket, covered in hyaline cartilage. This socket is known as a mortise. The articulating part of the talus is broad anteriorly, and narrows posteriorly. [(1)]

Clues to a probable ankle fracture include swelling, hematoma formation, and tenderness to pressure over the medial and/or lateral malleolus or over the proximal head of the fibula .The presence of an ankle effusion on plain radiographs following acute ankle trauma is suggestive of an underlying fracture. [(2)]

Occult fractures of ankle joint cannot be detected by primary radiography .MDCT reveal the extent of the fractures and the position of the dislocated bone better than conventional radiography, especially in cases of complex intra-articular fracture patterns. [(3)]The overall sensitivity of radiography in the
Detection of foot and ankle fractures is only moderate to poor in patients with multiple injuries from high-energy trauma and in patients with complex fracture patterns. [(3&4)]

The ankle fracture classifications:
I- Weber classification:
- **Type A**: below the level of the talar dome usually transverse (infra syndesmotic)
- **Type B**: distal extent at the level of the talar dome, may extend some distance proximally usually spiral (Trans syndesmotic)

- **Type C**: above the level of the ankle joint (supra-syndesmotic) [5-6-7]

II- The Lauge-Hansen classification: It focuses on the trauma mechanism
- It describes the position of the foot at the time of injury (i.e. supination or pronation)
- The deforming force direction (i.e. abduction, adduction, or external rotation) [8-9]

Aim of the work

The aim of this study is to assess the role of multi detector CT (MDCT) in evaluation of ankle fractures

Patients and Methods

This study included 30 Patients of adult age groups referred from the department of Radiology at El-Minia University Hospital during the period from February 2018 to December 2018. They presented with ankle trauma and suspect ankle fractures. Their ages ranged from 20 to 69 years with mean age of 34 years. Seventeen cases were males and thirteen cases were females.

All patients were subjected to:
1- Full history taking.
2- full clinical examination.
3- Plain radiography.
4- MDCT of the ankle joint.

Plain radiology Recommended views included
1- An anteroposterior view of the ankle joint. Lateral view. Oblique view in some cases.

MDCT of the ankle joint: The standard protocol performed for all patients was as follows:
Using 16 slice MDCT machine (GE Bright Speed, General Electric Medical Systems. Milwaukee. W1) **Imaging the hind foot with the following parameters:** 0,625-mm collimation, apish of 0,5625,120 KVP, and 200m A,512x512 array field of view (FOV) and 1 pitch factor.

Preparation of the patient:
- No patient preparation as no contrast media is indicated in the study.
- Removal of metallic objects to avoid metallic artifact

Technique for MDCT of the ankle joint:
Patient lying in the supine position. Feet first**.** Imaging of both sides is indicated for comparison. Lateral scanogram view from above the ankle joint superiorly to the planter pad of fat inferiorly was performed while the planter surface of foot is perpendicular to the table with mild dorsiflexion.

For axial imaging:
Using a plane parallel to the planter surface of the foot obtaining 1.5mm thickness sections from above the ankle joint to the planter fat pad, with 1.5mm spacing in the area of the subtalar joint and 2.5 mm spacing above and below it. The ankle joint on the axial images used as a reference to obtain true sagittal and coronal planes of the hind foot.

Images were done in both:
- **Bone window** for fracture classification and associated other bony injuries.
- **Soft tissue window** for tendon entrapment or any soft tissue abnormalities.
- Scanning time ranged from 8 to12s
- The data were reconstructed into 1.25mm slice images, resulting in a total of 300-400 slices. The threshold value for voxels was selected by threshold segmentation (-600 to 1500 **HU**) that was appropriate to differentiate muscles, tendons and bones

Post processing:
The acquired images were transferred to a workstation for post processing (advantage workstation, AW) with manufacturer-provided software that allows generation of 2D and3D images, 2D multiplanner reconstruction (MPR) in the sagittal and coronal planes by 1.6mm slices thickness.
Sagittal reformatted images of the ankle joint areprescribed off the axial images.

Coronal images are reformatted perpendicular to the sagittal images.
- 3D volume rendered images for further evaluation as:-
- full extent of the fracture is recognized in 3D images.
- Relationship of the fracture to the articular surfaces
- Displaced fragments …etc.

ResultsThis study included thirty patients referred from orthopedic emergency department to the radiology department of El-Minia university hospital. Patients were presented with ankle joint trauma and suspected fractures. They presented during the period from February 2018 to December 2018.Twenty nine cases were presented with one side ankle joint injury and one case had bilateral ankle joint injury so this study included 31 ankle joint injuries.

Regarding the age of the patients: (Table I)
Table 1: Representation of age of the patients

Age of patient	Number of cases	percentage
20-30	16	53.3%
31-40	4	13-3%
41-50	7	23.3%
51-60	2	6.7%
61-70	1	3.3
Total	30	100%

The patient's age ranged from 20 to 69 years with mean age of 34year. There were sixteen cases were below the age of 20 yrs / old (53%), four patients from 31 to 30 yrs / old (13.3%), seven patients from 40 to 50 yrs / old (23%) and three cases from 50 to70 yrs / old (10%), so that ankle fractures are more common in middle aged patients than the old aged patients.

Regarding the gender of the patients: (Table II)

Table II: Representation of the gender of the patients:

Gender of patients	Number of patients	percentage
Male	17	56.7 %
female	13	43.3 %
Total	30	100

There were seventeen (57%) males and thirteen (43%) females (Seen in table (II)) .The ankle fractures are more common in males than in females.

Regarding the affected bone fractures: (Table III)
Table 111: Representation of the fracture type according to the affected bone

The affected bone	Number of cases	percentage
Calcaneus	16	51.6%
Fibula	4	12.9%
Tibia	2	6.5%
tibiofibular	9	29%
Total	31	100%

Fractures of calcaneal bone were detected in 16 cases (51.6%), nine cases showed fractures of both fibula and tibia (29%), four cases showed fibular fracture (12.9%), while two cases showed tibial fracture only (6.5). This is presented in table III

Fracture according to the ankle joint parts:

A) Fibular part:

Fibular fractures are classified according to the Weber classification ,which is based on the position of the fibular fracture in relation to the tibiotalar joint space and the associated level of syndesmosic disruption

Weber classification: (Table IV)

- **Weber A:** below level of syndesmosis.
- **Weber B**: at level of syndesmosis.
- **Weber C:** above level of syndesmosis.

Table IV: Representation of fibular fracture:

Type of classification	Number of cases	percentage
Weber A	1	3.2%
Weber B	4	12.9%
Weber C	8	25.8%
Total	13	41.9%

According to Weber classification there were eight cases presented as type, four cases has been classified as type B and one case as type A.

Calcaneal part: Sander's classified the intra articular fractureS of calcaneus into four types which is based on number of the articular pieces as a result of the trauma (Table V).

Table V: Calcaneal fracture according to Sander's classification:

Type of classification	Number of cases	percentage
Type I	0	0
Type II	8	25.8%
Type III	3	9.6%
Type IV	2	6.4%
Total	13	41.8%

According to Sander's classification, there eight cases presented as type II, three cases had been classified as type III, and two cases had Sander's type IV.
NB) there were three cases showed extra articular calcaneal fracture.

B) **According to tibial part:** The Rüedi-Allgwer (1969) classification of distal tibial fractures is based on the degree of displacement of the articular fragments**.**

Table VI: Representation of tibial fracture

Type of classification	Number of cases	percentage
Type I	1	3,2%%
Type II	0	0%
Type III	10	32.2%
Total	11	35,4%

According to the The Rüedi-Allgwer classification there were ten cases of the type III and one case of the type I , no cases of the type II .This is presented in the table VI **Regarding the affected lower limb or limbs of the patients:**

Table VII: Representation of the affected side

Affected limb	Number of cases	percentage
Right limb	15	48.3%
Left limb	14	45%
Bilateral	1 (2 limbs)	6.5%
Total	31	100%

The right side was affected in fifteen patients (48.3%), while the left was affected in fourteen patients (45%) and it was bilateral in 1 patient (6.5%).The right side more affected in this study .This is shown in table VII.

Regarding the causes of trauma:
Table VI: Representation of cause of trauma

Cause of trauma	Number of cases	percentage
Car accident	14	46.7%
Fall from height	16	53.3 %
Total	30	100%

Sixteen cases were due to fall from height (53%) and fourteen cases were due to motor car accident. (47%). The usual cause for ankle fracture was fall from height .This is presented in table VIII

Regarding the associated injury and complications of ankle joint fractures:

Table IX: Representation of complications of the fracture.

Associated injury	Number of cases	Percentage
Soft tissue injury	15	50%
Muscle injury	12	40%
Tendon injury	3	10%
Total	30	100%

Fifteen cases were presented with soft tissue edema (43%), twelve cases were presented with muscle injury (40%), three cases were presented with tendon injury two of them were peroneal tendon and the third was Achilles tendon (7%). This is showing in table IX

Discussion

Over the last 10-15 years, there has been dramatic improvement in CT technology. Current MDCT scanners allow extremely rapid imaging with very thin sections ,for example anatomic regions of acutely injured patients Thin section data provide voxels that are essentially, which allows for high resolution MPR. Image reformation allows trauma patients to be scanned while they are in more comfortable, non anatomic positions without compromising image quality .MPR images from data acquired on state- of the -art scanners provide image quality that is superior to or at least equal to that of directly acquired images produced 10-15 years ago[(10)] This advancement encourages the use of thin MDCT technology in evaluation of ankle joint fractures, as these fractures are common and major cause of disability. Accurate delineation of the type of fracture, extension and associated injuries help the orthopedic surgeon to get the right way of treatment of these patients.[(11)] In this study, the patient's age ranged from 20 to 69 years with mean age 40 year. Twenty out of thirty (66,6%) were from 20-40 years. The result concludes that ankle fractures are more common in middle aged patients than in the old aged. This is agreed with the study of Van Staa, T., E.et al., (2001), who stated that these fractures typically occur because of axial loading in middle aged people and usually have poor outcome.[(12)] Regarding the gender of the patients included in the study, there were seventeen males (57%) and thirteen females (43%). The ankle fracture more common in males than in females. This agrees with the study of[(14)] B Hintermann, et al., (2000) who stated that ankle joint fractures were more common among male patients. They studied 288 patients with 148 (51,5%) of whom were males and 140(48,5%) were females. This is explained because the life style and work of males is harder and subjects them to trauma more than females. [(15)] Regarding the affected side in this study ,unilateral ankle joint fractures were recorded in 29 out of 30 ,but bilateral in only 1 case, thus unilateral ankle joint fracture are more common than bilateral fractures.

Regarding cause of the trauma, this study results revealed that fall from height was the common cause of ankle joint fracture and motor car accidents was the less common cause. Sixteen cases were due to fall from height (53%) and fourteen cases were due to motor car accident. (47%).

This agrees with Stoller and Bredella et al., 2004 regarding fracture mechanisms .They stated that an increased axial load caused by falling from a height (FFH) and landing on the feet is the most common cause of ankle joint fracture . Motor car accident, in which a seated passenger feet are pressed hard against the floor of the car, are another commonly encountered cause, however, less frequent than fall from height.

The current protocol for imaging acutely injured patients with suspected ankle fractures include a portable lateral radiograph obtained in the trauma room. If ankle joint fracture or equivocal finding are found, a CT scan of the ankle joint is obtained. All patients were examined by a 16-channel MDCT scanner (GE Bright Speed, GE healthcare, Waukesha, WI and Toshiba Aquilion S16 CFX) to enable us to make good quality 3D reformatted images which are complementary for full evaluation. Regarding type of fracture, the present study revealed that fibular fractures account (for 42%) ,calcaneal fractures account for (51,6%) and tibial fractures account for (35,4%). Regarding fibular fracture in this study Weber type C was more common than other types and that is not agree with the study of B Hintermann, et al., (2000)' which stated that Weber type B the commonest then type c then type A in the last.· Regarding calcaneal fracture the intraarticular fractures were more common than the extra-aticular fracture this agrees with Schepers and Lieshout et al., 2009 in which the intraarticular calcaneal fractures represent 75% of all calcaneal fractures in adults. Regarding tibial fractures Rüedi-Allgower type III present in ten patients and type one only in one case.

Summary and conclusion

Fractures of the ankle joint are among the commonest fractures in adults. For a good long-term functional outcome to be achieved, reliable early evaluation is crucial.

CT is the modality of choice for ankle joint fracture, axial and coronal views are essential for diagnosis.

MDCT has revolutionized our understanding and characterization of these fractures and their management.

Fracture characterization is essential to guide the management of these injuries. The use of MDCT with MPR and 3D reformatted images allow better visualization of fracture lines, dislocation and comminuted fractures and optimal evaluation of the injury .Ankle fractures are classified according to the part affected.

If the fibular part affected it is classified according to the Weber classification, which is the most common and the simplest.

If the calcaneal part is affected, it is classified in to extra articular fractures and intra articular fractures which also further classified according to Sander's classification.

If the tibial part is affected it is classified according to the "The Rüedi-Allgwer" classification.

Associated soft tissue injury and tendon injury and muscle injury are important to be evaluated before treatment of the fracture .

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