The Egyptian Journal of Radiology and Nuclear Medicine (2015) **46**, 423–433

Egyptian Society of Radiology and Nuclear Medicine

**The Egyptian Journal of Radiology and Nuclear Medicine**

www.elsevier.com/locate/ejrnm
www.sciencedirect.com

ORIGINAL ARTICLE

# Evaluation of benign and malignant vertebral lesions with diffusion weighted magnetic resonance imaging and apparent diffusion coefficient measurements

**Khaled Abdel Wahab Abo Dewan [a], Alsiagy A. Salama [a,*], Hassan Mostafa Saber El habashy [a], Ayman El Sayed Khalil [b]**

[a] *Radiodiagnosis and Imaging Department, Faculty of Medicine, Tanta University, Tanta, Egypt*
[b] *Orthopedic Surgery Department, Faculty of Medicine, Tanta University, Tanta, Egypt*

Received 27 October 2014; accepted 11 January 2015
Available online 14 February 2015

**KEYWORDS**

Vertebral bone marrow lesions;
Diffusion-weighted MRI;
Apparent diffusion coefficient

**Abstract** *Aim of the work:* The aim of this study was to assess the utility of apparent diffusion coefficient obtained in diffusion-weighted MR imaging for the differentiation between benign and malignant vertebral lesions, and to determine the sensitivity and the specificity in differentiating benign and malignant vertebral lesions according to the optimal cutoff ADC value.
*Patients and methods:* In 50 patients, 96 vertebral lesions were included and underwent DW MR Imaging. The mean ADC values of normal and abnormal vertebrae were calculated. The optimal cutoff ADC value was determined for the differentiation of benign and malignant lesions. The results were correlated with histopathological and surgical findings.
*Results:* The mean ADC value of benign lesions was significantly higher than that of malignant ones ($P < 0.05$). There was an overlap between the mean ADC values of malignant and tuberculous lesions. According to the optimal cutoff value of $1.21 \times 10^{-3}$ $mm^2/s$, determined for the differentiation of benign and malignant vertebral lesions, sensitivity was 95.12%, specificity 92.73%, positive predictive value 90.70%, and negative predictive value 96.23%.

*Abbreviations*: MRI, magnetic resonance imaging; CF, compression fracture; ADC, apparent diffusion coefficient; SI, signal intensity; S1, sacral 1; D, dorsal; DWMRI, diffusion-weighted magnetic resonance imaging; ROI, region of interest; ROC, receiver operating characteristic

* Corresponding author at: Lecturer of Radiodiagnosis, Tanta Faculty of Medicine, Tanta University, Egypt. Tel.: +20 1113558503; fax: +20 2 40 3407734.
E-mail address: siagyali33@yahoo.com (A.A. Salama).

Peer review under responsibility of Egyptian Society of Radiology and Nuclear Medicine.

http://dx.doi.org/10.1016/j.ejrnm.2015.01.002

*Conclusion:* Vertebral lesions were differentiated as benign or malignant with high sensitivity and specificity with the aid of ADC values calculated from maps obtained by DWI.



## 1. Introduction

Invasion of the fatty bone marrow by primary malignant tumors, metastatic malignancies, acute benign and malignant compression fractures, and infectious conditions causes similar signal changes in routine magnetic resonance imaging (MRI) studies (1).

Although MRI has a high sensitivity in delineating the pathology, its specificity is low. Osteoporotic and metastatic compression fractures may be mistaken for each other in the acute phase. Edema in the acute phase of benign fractures may replace normal bone marrow and cause hypointense signal changes in T1-weighted images and hyperintense signal changes in T2-weighted images, at the same time taking contrast material. These changes are also typical for metastasis and cause confusion in diagnosis when only one lesion is present (2).

It is quite important to determine whether a compression fracture has a malignant or a benign cause, especially in patients with a primary malignancy. This is because compression fractures depending on osteopenia develop in these patients at a rate of one-third (3).

Pyogenic bacteria and tuberculosis infections are the most common causes of spondylodiscitis (4). Infections can sometimes be difficult to diagnose, especially when there is isolated vertebral body involvement without any soft tissue component, and adjacent disk involvement (5). Therefore, in order to plan appropriate therapy according to the precise diagnosis, the patients are exposed to invasive interventions such as biopsy (1).

Diffusion-weighted imaging (DWI) has recently appeared as a new method of screening in characterizing lesions without necessitating contrast material and in evaluating the vertebrae quantitatively (6,7).

Diffusion-weighted-imaging (DWI) provides microscopic information from water protons which is not possible using conventional magnetic resonance imaging (MRI). DWI measures the random (Brownian) extra, intra and transcellular motion of water molecules (8).

A loss of signals on DWI occurs as a result of the microscopic movements of the molecules in the diffusion-sensitivity sequences, and this loss is measured by calculating the ADC. The ADC depicts the specific diffusion capacity, microscopic structure, and organization of a biological tissue (6,9).

Apparent-diffusion-coefficient (ADC) is a quantitative parameter calculated from DWI that combines the effects of capillary perfusion and water diffusion (10). ADC value is calculated for each pixel of the image and is displayed as a parametric map. By drawing regions of interests on these maps, the ADCs of different tissues can be derived (11).

Some studies have been able to differentiate acute benign compression fractures from malignant induced compression fractures according to ADC values (2,3,12–15). In a comparatively small number of surveys, ADC values have been studied in discriminating the infectious lesions from the malign lesions (3,4,16). So the purpose of this study was to assess the utility of apparent diffusion coefficient obtained in diffusion-weighted MR imaging for the differentiation between benign and malignant vertebral lesions, and to determine the sensitivity and the specificity in differentiating benign and malignant vertebral lesions according to the optimal cutoff ADC value.

## 2. Patients and methods

### 2.1. Patients

From July 2013 to September 2014, 50 patients (31 males and 19 females, with mean age of 58.45 years and the age ranged from 22 to 87 years) presenting with vertebral collapse in one or more vertebral body on conventional MR sequences were included.

The study protocol was approved by the ethics committee of Tanta University. Written consent was obtained from all the patients to participate in the study.

A total of 50 patients found to have 96 vertebral lesions were included in this study. The vertebral CFs were classified according to the etiology into three groups as acute benign CFs (Group 1), infectious CFs (Group 2) and malignant CFs (Group 3), and the number of lesions in each group was 33, 22 and 41, respectively. Compression fractures were considered acute if they occurred within 4 weeks prior to presentation. Of the acute benign CFs, 13 were osteoporotic (diagnosed by bone densitometry and none of the osteoporotic patients had a history of serious trauma or malignancy) and 20 were acute traumatic (with a history of serious trauma and no history of osteoporosis or malignancy), of the infectious group, 17 were pyogenic spondylodiscitis and 5 lesions were tuberculous (diagnosed by history, imaging methods and confirmed by laboratory findings). The malignant group was composed of 41 lesions, of them 31 were metastatic vertebral fractures. The primary neoplasms included breast carcinoma in 14 lesions, lung carcinoma in 10 lesions, renal cell carcinoma in 4 lesions, prostate carcinoma in 2 lesions and thyroid carcinoma in 1 lesion. 10 lesions were due to primary neoplasms of the spine (chordoma in 4 lesions, myeloma in 3 lesions, lymphoma in 2 lesions and plasmacytoma in 1 lesion).

The primary focus of all metastases and primary malignant tumors were histopathologically proven with biopsies. Dense sclerotic vertebrae were excluded from the study module. Also in 45 patients, one vertebral body without pathologic SI on MR images was examined, and it served as an internal control. Overall, 96 vertebral lesions and 45 normal vertebrae were evaluated.

### 2.2. Methodology

All patients were subjected to the following: