Open Journal of Clinical Diagnostics, 2011, 1, 22-25 **OJCD**
doi:10.4236/ojcd.2011.13005 Published Online December 2011 (http://www.SciRP.org/journal/ojcd/).

Differentiation of malignant and benign lesions of the osseous spinal axis with three dimensional computed tomography image appearences: dirty interface sign

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Received 20 September 2011; revised 22 November 2011; accepted 30 November 2011.

ABSTRACT

Purpose: We aimed to make a fast and accurate distinction of malignant and benign lesions in cases with predominantly solitary or multifocal involvement using latest technology software and hardware systems in computed tomography. Materials and Methods: 53 cases were included in the study. Primary (n = 42, 31 benign, 11 malignant) or metastatic (n = 11) tumors were detected at various locations in the bone structure of the cervical to coccygeal vertebrae in all cases. 3D CT images taken using the same system and biopsy or post-operative histopathology findings were available for all cases. Thin section images taken retrospectively from the archives were converted to 3D images using the same program and parameters, which were then recorded in the same window settings by two radiologists. Only 3D images were then analyzed to investigate the presence or absence of the dirty interface sign. Results: Dirty interface sign was present in 17 malignant lesions and absent in the remaining 5 lesions. As for benign lesions, the sign was present in only two lesions and the remaining 29 were negative for the sign. There was a high level of consistency between the two radiologists. In conclusion, malignant and benign lesions affecting the bone spinal axis were distinguished based on the presence or absence of the dirty interface sign with 77.3% sensitivity, 93.5% specificity and 86.8% accuracy. Conclusion: When evaluated with standard bone window views, 3D views can be used successfully for the distinction of malignant and benign bone tumors. At least, 3D views generated using low dose regimes in highly developed systems can be used with similar purpose to that of diffusion weighted MRI sequences that give roughly outlined but fast and accurate information about the lesion.

Keywords: Three-Dimensional CT; Differentiation; Malignant-Benign; Bone Tumor

1. INTRODUCTION

With using of latest technology software and hardware systems in CT, perfect and high quality three dimensional images can be obtained even at low doses. 3D analyses can be done in the form of both 3D maximum intensity projection (MIP) and volume weighted colored surface imaging. The views can be assessed step by step using the fly around method by turning them around themselves in the right-left, up-down direction or randomly. Objects in the large gravity fields can be evaluated with only one examination using these 3D views. In this way, it will be possible to be oriented to the anatomy and the pathology at least at the level of bone skeleton. In this study, we assessed the benefits of this development in the CT technology for the evaluation of tumor lesions. By using surface weighted volume rendered 3D views, we investigated the efficiency of using only 3D viewing for the distinction of malignant and benign lesions.

2. MATERIALS AND METHODS

53 cases were included in the study. Primary (n = 42, 31 benign, 11 malignant) or metastatic (n = 11) tumors were detected at various locations in the bone structure of the cervical to coccygeal vertebrae in all cases. 3D CT images taken using the same system and biopsy or post-operative histopathology findings were available for all cases. Reconstruction images of the thin section views (Siemens 64 × 2 slice, dual source CT) taken retrospectively from the archives were generated using the

same parameters (B30-medium soft tissue, ≤2 mm section thickness). These reconstruction images were converted to 3D images in the workstation (Leonardo Running Space) using one of the automated bone algorithms (same window for all cases). These 3D images were then recorded in the same window settings by two radiologists. Whole evaluation time for these images were no more longer than 5 minutes in all cases (mean 4.2 mins). Only 3D images were then analyzed to investigate the presence or absence of the dirty interface sign and the findings were indicated in separate tables. If the surface color is homogenous and bright, the sign accepted as negative. Otherwise, in the existence of a heterogenous, cloudy, dirty surface appearences of the vertebral lesion, dirty interface sign was accepted as positive (and supportive for malignancy).

3. RESULTS

Dirty interface sign was present in 17 malignant lesions and absent in the remaining 5 lesions. As for benign lesions, the sign was present in only two lesions and the remaining 29 were negative for the sign (**Table 1**). In cases for which the view of the entire spinal column was available, highly objective distinction of malignant and benign lesions was possible for malignant focuses (**Figure 1**) and malignant or benign pathologies affecting the vertebral corpus or the posterior elements (**Figure 2**).

There was a significant level of consistency between the two radiologists (**Table 2**) ($P < 0.05$). Malignant and benign lesions affecting the bone spinal axis were distinguished based only on the presence or absence of the dirty interface sign with 77.3% sensitivity, 93.5% specificity and 86.8% accuracy (**Table 3**). Furthermore, views

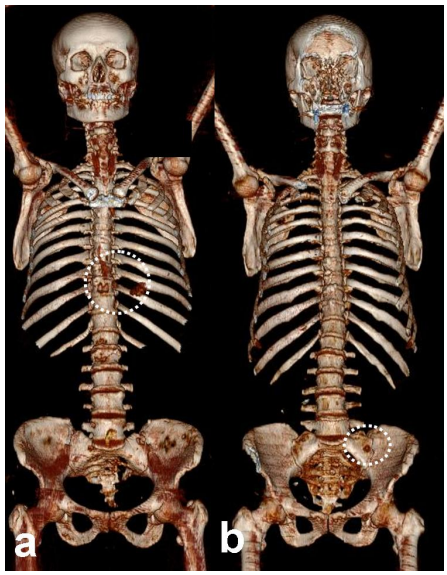

Figure 1. (a) Non-hodgkin lymphoma (large cell lymphoma), areas with heterogenous bold colored changes represent the involvement of the distal dorsal vertebrae and related ribs (encircled area) (b) Focal heterogeneous lower density similar focus of the left lateral sacral mass (encircled area) was also associated with malignity (metastasis of the left breast lobular carcinoma).

Table 1. The presence (+) or absence (–) of the dirty interface sign in all lesion groups and malignant-benign group.

Benign Sign (–)	Benign Sign (+)	Malignant Sign (–)	Malignant Sign (+)
Aneurysmal bone cyst (n = 9)	Giant cell tumor (GCT)	Metastasis (n = 2)	Ewing sarcoma
Histiocytosis (n = 2)	Osteomyelitis	Lymphoma (n = 2)	Metastasis (n = 10)
Dyscitis		Chondrosarcoma	Lymphoma
Neurogenic tumor			Osteosarcoma
Osseous anomaly (n = 2)			Chordoma
Neurofibroma + hemangioma (n = 2)			Osteosarcoma
Paget's disease			Rhabdomyosarcoma+
Osteoblastoma (n = 2)			Multiple myeloma +
Porotic vertebral collapse (n = 4)			
Osteomyelitis			
Spondylodiscitis			
Fibrous dysplaisa (n = 2)			
Paget's disease			

Table 2. Consistency between the two readers for the distinction of malignant and benign lesions shown in numbers.

Lesions and the sign / Readers	Benign –	Benign +	Malign –	Malign +
Reader-I	29	2	5	17
Reader-II	27	4	4	18

Table 3. Analysis of the data into a 2 × 2 table separately.

		Histopathology	
		+	–
Malignity	+	17	2
	–	5	29

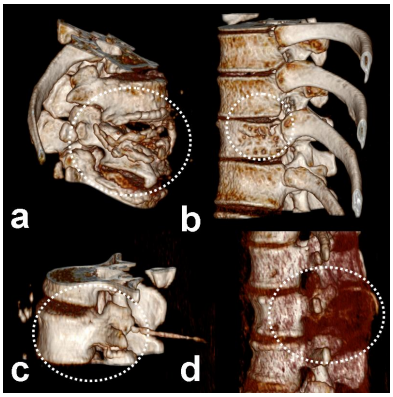

Figure 2. Miscalleneous lesion of the spine. Lesions are pointed by circles. (a) Porotic collapse fractures and (b) In Paget's disease cases, vertebra corpus densities had homogenous surface properties. In these pathologies 3D surface brightness was homogenous like in another case with porotic sompression fracture in (c) However, (d) soft tissue mass (multiple myeloma) destructing posterior elements of the dorsal vertebra was dense heterogeneous and had a remarkable heterogenous surface color change which represents the malignant interface sign.

leading to false positive or negative interpretation were displayed also exampled in a figure (**Figure 3**).

4. DISCUSSION

Approximately 2000 malignant bone tumors are diagnosed every year in the USA [1]. And greater than 5% of them is related only to axial skeleton As expected, the number of benign tumor cases will be much higher than this. For the management of malignant bone tumors,

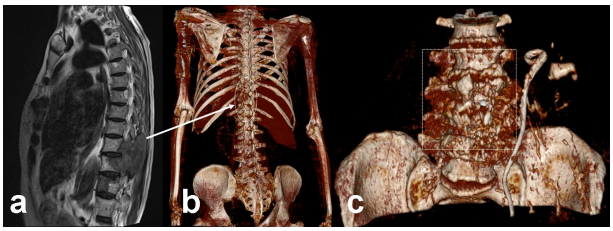

Figure 3. A case with renal cell carcinoma: (a) MRI, sagittal T1A view of a tumor lesion affecting the multiple compartments thorough the anterio-posterior segments of the lower dorsal axis. (b) as a false negative case; 3D reconstructing image of the same lesion (arrow) is faint and cannot be neatly distinguished (circled area) (c) Heterogeneous irregular 3D views of the affected lower dorsal segments in another osteomyelitis case, leading to a false positive finding by mimicking the malignancy (squared area).

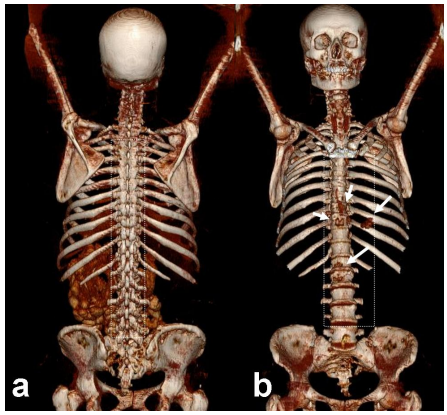

Figure 4. Involvement of the dorsolumbar spinal colon in a patient with non-Hodgkin lymphoma. a) Posterior aspect of the colon shows faint surface regularity and homogenous colour pattern. b) But in anterior projection, the same case's 3D-colored, volume rendered CT image reveals the lytic, involved sites as confirmatory for malignant changes.

moderate treatment regimens replaced radical excisions, such as radical amputation [2]. Thus, early diagnosis became important in terms of life quality. A large number of studies are available on the advantages and superiority of CT and MRI for the local staging of the musculoskeletal neoplasms. Despite the high soft tissue resolution, MRI is insensitive to calcifications, susceptible to artifacts especially in primary bone neoplasia., and have been replaced by CT The general opinion is that CT is superior for demonstrating the destruction of bone cortex and displaying the osseous or calcific component. Also, CT is also superior for displaying lung metastasis. The presence of thin cross sections contributed in the increase in resolution in both 2D and 3D.The developments in multidedector CT and multiplanar reformatte (MPR) technology have equalized CT and MRI. With

sensitivity weighted or diffusion weighted like specific sequences, MRI can differentiate calcification or benign versus malignant compression fractures. MRI can compensate its inadequacy against CT [4-6]. Without comparing the two methods, we evaluated 3D-CT views of the osseous spinal column and attempted to detect lesions that affect the bony cortico-medullary area and cause surface anomaly. By this method, we have tried to evaluate the entire area included in the field of view, similar to diffusion weighted MRI. Studies have shown that 39% of metastatic bone lesions are localized in axial skeleton and causes compression in time. The majority of spinal malign tumors are metastatic tumors, lymphoma and myeloma. Because the clinical presentation of vertebral tumors, whether primary or secondary are non specific, differential diagnosis is crucial. Recent studies have used different criteria (convex posterior border of the vertebral body, abnormal signal intensity of the pedicle or posterior element, an epidural mass, a focal paraspinal mass, and other spinal metastases, *i.e.*) with MRI and diffusion weighted MR imaging to distinguish porotic compression fractures from pathologic vertebral fractures [7-10]. Generally overall diagnostic accuracy in these studies was as following: sensitivity, specificity, and accuracy were 85% - 100%, 79% - 100%, and 86% - 95%, respectively [7-10]. Our aim was to show that it is possible to make a fast and accurate distinction of malignant and benign lesions in cases with predominantly solitary or multifocal involvement. And our results were acceptable when compared the mentioned large scaled MRI studies.

5. CONCLUSIONS

When evaluated with standard bone window views, 3D views can be used successfully for the distinction of malignant and benign bone tumors. At least, 3D views generated using low dose regimes in the highly developed systems can be used with similar purpose to that of whole body diffusion weighted MRI sequences that give roughly outlined but fast and accurate (86.8%) information about the lesion's hystology.

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