By Dr G Bier

Unfolded rib images: a promising software tool for the evaluation of malignant rib lesions

Multiple myeloma (plasma cell myeloma, plasmacytic myeloma, Kahler disease) is a serious plasma cell malignancy, which comes along with bone marrow and bone destruction. It accounts for approximately 1% of all types of malignancy and more than 10% of all hematologic malignancies. More than 90% of patients with multiple myeloma develop osteolytic or, to a smaller amount (< 3%), sclerotic bone lesions, known as myeloma bone disease [1, 2].

The underlying pathological mechanism for this malignant osteo-destruction is believed to be a tumor-cell-induced dysregulation of local factors, especially the receptor activator of NF-κB ligand (RANKL)/ osteoprotegerin (OPG) system with consecutive overstimulation of osteoclasts [3].

The occurrence of bone lesions is known to be an early event in the course of the disease and the osteolytic lesion load correlates with the entire tumor burden.

For these reasons, the extent of myeloma bone disease has been added to the multiple myeloma classification by Durie & Salmon, which has been widely accepted as the standard for predicting the prognosis of multiple myeloma patients [4]. According to this classification and in addition to serological parameters, patients are classified as stage I if normal bone structure or a solitary bone plasmocytoma is detected radiologically, whereas stage III is defined by ≥ 2 lesions. Here, accurate bone imaging is crucial, because patients with myeloma bone disease generally undergo therapy and the identification of new osseous lesions as a correlate for disease progression may induce a therapy change. In addition, fractures, especially of the spine, are common and represent a particular hazard; up to 20% of the patients suffer malignant spinal cord compression due to fractures during the course of the disease [5].

Initially, the radiological assessment of multiple myeloma was carried out by a sophisticated x-ray survey. This has now largely been superseded by computed tomography (CT) and magnetic resonance imaging (MRI), with their increased capability to detect tiniest bone and bone marrow defects [6]. As a result both imaging modalities have found their way into the new Durie & Salmon PLUS classification [7]. Using CT protocols with reduced dose, fast and reliable diagnosis and follow-up imaging of myeloma bone disease are now possible [8].

Myeloma bone disease occurs particularly at medullary sites that still contain hematopoietic, red bone marrow, which — in adults—is predominantly located in the axial skeleton and the ribs [9]. Even with modern imaging techniques, these latter are difficult to assess due to their vaulted shape and also to respiratory motion, which reduces the diagnostic accuracy of both CT and MRI in this particular body region [10].

Stimulated by a recent publication which showed a significant enhancement of diagnostic accuracy in the detection of malignant rib lesions in patients with lung cancer and which used a commercially available software application called CT Bone Reading (syngo.via from Siemens Healthcare) [11], we recently evaluated the performance of the same software for the evaluation of myeloma bone disease.

The software generates unfolded rib images through use of a learning-based deformable template matching method for automated rib centreline extraction. This centreline serves as rotation axis for curved planar reformats (CPRs), which are finally attached to the spinal centreline. The result is an unfolded visualization of all ribs (19 images with a 10° angle between each CPR image), which are rotatable along the centreline by mouse-scrolling [Figure 1].

Our retrospective study included 116 representative patients with multiple myeloma or monoclonal gammopathy of undetermined significance (MGUS) and who had undergone whole-body reduced-dose multidetector CT [12],. Unfolded rib visualizations were generated from CT images with a slice thickness of 1 mm; the diagnostic performance in terms of sensitivity and specificity were evaluated in a 2-reader setting and in comparison to 5mm and 1mm CT slices. The reference standard was a consensus-reading including follow-up CT examinations of each patient. At the same time, the reading time for each CT-analysis was recorded. With a total number of 6727 myeloma-related rib lesions, the unfolded rib reading yielded on a per-lesion basis a sensitivity of 96.5%, which was significantly higher than the transversal slice approach (5mm: 69.7% and 1mm: 79.8%) with a specificity of 89.7% (5mm: 87.2% and 1mm: 55.9%). The diagnostic accuracy was also significantly higher (96.1%) for the unfolded rib reading than with 5mm slice thickness (70.5%) and 1mm slice thickness (78.0%). The increased sensitivity in the unfolded rib reading occurred both with medullary as well as for cortical lesions. An example is given in Figure 2.

The reading time was significantly shorter for the unfolded rib display, with a mean reading time of 90.8 ± 49.9 secs compared to 178.7 ± 47.4 secs with 5mm slices and 215.1 ± 55.9 secs with 1mm slices. Using the Durie & Salmon classification system, the isolated reading of transverse images would have resulted in an erroneous upstaging in four cases and in an erroneous downstaging in one case, whereas the unfolded rib evaluation yielded one case with potentially false-positive upstaging.

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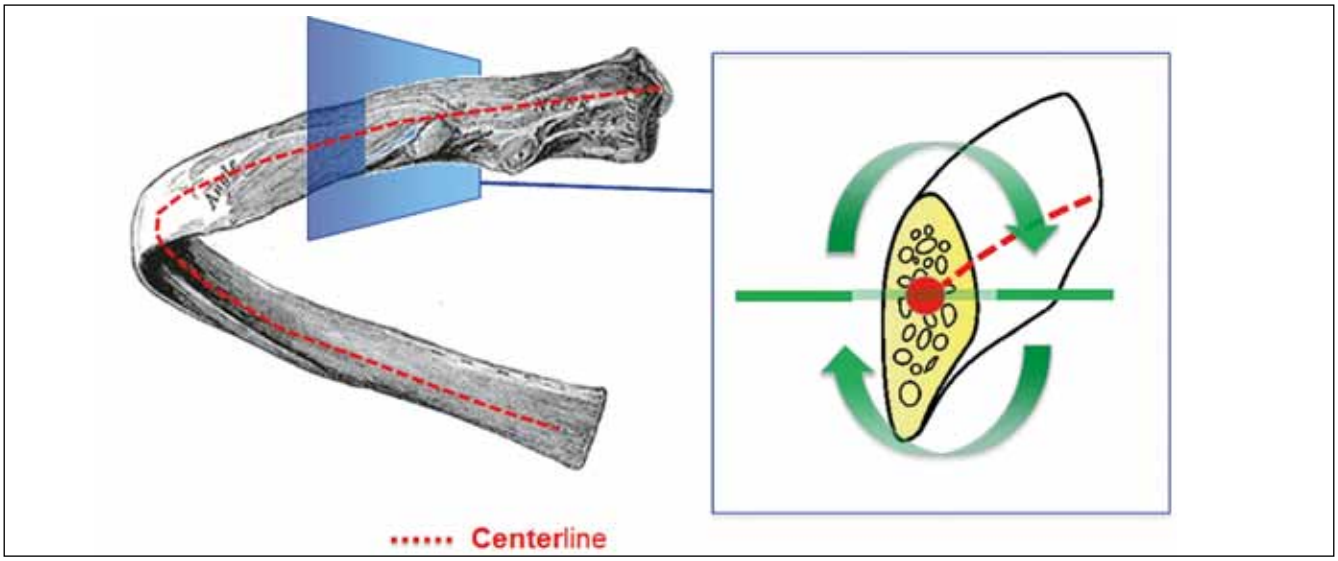

FIGURE 1. Schematic representation of the workflow of the CT Bone Reading software application. Curved planar reformats (CPRs) are generated along an automatically assigned centreline of each rib, which allow a rotatable, detailed view of each rib's cross-section..

CONCLUSION

The results of our study show that advanced multiple myeloma imaging using this new software application may increase sensitivity and accuracy for the detection of myeloma bone disease of the ribs, with a significant reduction in the reading time. The software has also been shown to be useful in the detection of rib fractures without loss of diagnostic accuracy [13].

Overall, the software-mediated unfolding of CT rib images not only improves the diagnosis of malignant involvement of the ribs but also the accuracy of therapy monitoring and follow-up .

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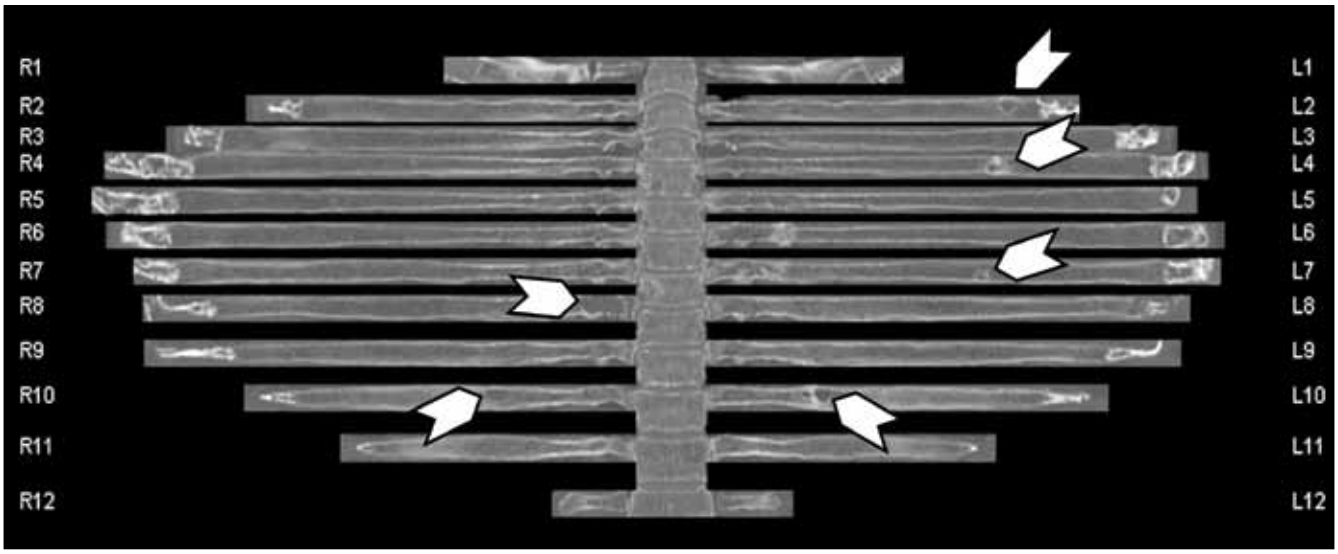

FIGURE 2. Image example of a patient with multiple myeloma (Durie & Salmon stage III) showing multiple osteolytic lesions of the ribs (arrows) as well as a fracture of the posterior part of the left 6th rib..