Predicting Osteoporosis from T1-weighted MR Images

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Introduction: T1-weighted sagittal MRI imaging forms part of routine examination of the lumbar spine. One of the limitations of MRI is that it does not provide information on bone mineral density (BMD). Such information would be helpful in alerting the clinician to the possibility of osteoporosis. T1-signal intensity of the marrow cavity is dependent on the amount of fatty marrow, red marrow and mineral bone content. Marrow fat content increases as BMD decreases. The purpose of this study was to investigate whether a simple normalized T1-value of the lumbar vertebrae can be used to isolate patients with osteoporosis.

Methods: The study cohort comprised 177 subjects (82 males, 95 females, age 72.6±4.6 years). Relative T1-signal intensity was measured on T1-weighted (TR/TE, 450/11 ms; 4 mm thick) mid-sagittal images (1.5T MR unit). Two regions of interest (ROI) were drawn manually encompassing (i) the cancellous bone within the vertebral body and (ii) the immediate prevertebral soft tissue. The latter tissue was used as a reference site for normalizing T1 signal intensity within bone marrow. Relative T1 signal intensity was calculated as the T1 signal intensity of L3 vertebral body relative to the T1-signal of the reference site (Fig.1). Lumbar spine BMD was measured by dual x-ray absorptiometry (DXA). Subjects were divided into three groups (normal, low bone mass, and osteoporosis) according to T-score and WHO criteria. ANOVA was used to compare relative T1-signal intensity among groups. The optimal cut-off value was determined by summating sensitivity and specificity on receiver operating characteristics (ROC) (Fig.2). The area under the curve (AUC) quantified the accuracy of the test. A level of 5% indicated statistical significance.

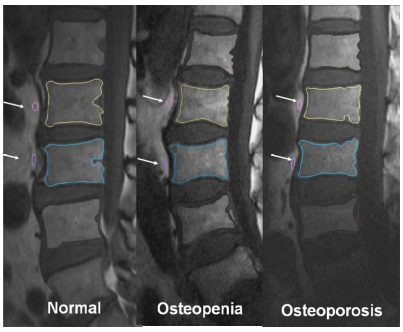

Fig.1. ROIs on T1-weighted sagittal image. Prevertebral tissue ROI's (arrows)

Results: For both male and females, relative T1-signal intensity n L3 showed significant differences ($p<0.001$) between the three groups (Table 1).

Table 1: Relative signal intensity (RSI) among three BMD groups for male and female subjects

	Group	Age (yrs)	L3 BMD (g/cm^2)	RSI_L3
Male	Normal (n=48)	72.9±4.3	1.10±0.14	0.85±0.13
	Low bone mass (n=21)	75.1±9.1	0.84±0.08	0.97±0.16
	Osteoporosis (n=13)	74.1±5.3	0.62±0.07	1.135±0.3
	P value (for trend)	=0.46	<0.001	<0.001
Female	Normal (n=17)	73.7±3.5	1.01±0.10	0.91±0.1
	Low bone mass (n=29)	71.4±2.9	0.84±0.07	0.99±0.13
	Osteoporosis (n=48)	72.2±3.7	0.66±0.07	1.10±0.14
	P value (for trend)	=0.1	<0.001	=0.006

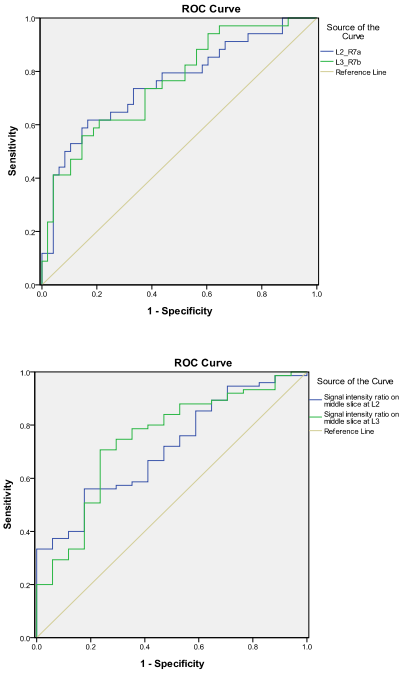

Fig.2. ROC curves of relative T1-signal intensity with cut-points at 0.95 and 1.016 for (a) male and (b) female subjects

The cut-off point for relative T1-signal intensity (RSI) was 0.95 for males and 1.016 for females. These cut-off values yielded a success rate of 84% and 66% for male and female subjects respectively in predicting osteoporosis.

Discussion: Relative T1-signal intensity of lumbar spine seems is a reasonably accurate parameter for estimating BMD subgroup (normal, low bone mass or osteoporosis). This parameter, if further refined, has the potential of being a simple method for radiologists to apply considering the likelihood of osteoporosis. Its potential clinical value lies in enabling selection of those patients most likely to benefit from follow-on densitometry (by DXA or quantitative CT) to determine actual BMD status. Before this is recommended, further study is needed to fine tune this parameter though evaluate of younger subjects, determination of optimal reference sites, and collaboration with trabecular rather than integrated BMD.

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