Intra- and Inter-Reader Reproducibility of a New Clinical Tool for Quantitative Vertebral Morphometry

D. Diacinti 1, R. Del Fiacco 2, N. Steiger 3, D. Diacinti 1, J. Staal 4, P. Steiger 4, E. D’Erasmo 2, S. Minisola 2, R. Passariello 1

1Dept. of Radiology, University “SAPIENZA” Rome, Italy; 2Dept. of Internal Medicine and Medical Specializations, University “SAPIENZA” Rome, Italy; 3Boston University Medical School, Boston, MA, USA; 4Optasia Medical Ltd., Cheddle, Cheshire, UK.

Objective
Quantitative Vertebral Morphometry (QM) provides important information in support of vertebral fracture diagnosis. However, QM is time-consuming with existing clinical tools. The purpose of this study is to evaluate intra- and inter-reader reproducibility of SpineAnalyzer, a new clinical tool, for QM on lumbar and thoracic X-ray images of the lateral spine.

Introduction
We have developed a software tool based on a previously reported novel method for the automated annotation of vertebral shape on lateral radiographs. This tool guides an operator through the process of generating outlines of vertebral shapes from T4 to L4. The workflow is as follows (see Figure on the right):
1. Select an image.
2. Place a single point at the approximate centre of each vertebra to be analysed.
3. Label anatomy and initialise vertebral outline search.
4. Review and, if necessary, correct outlines and morphometry points.

Methods
Twenty subjects (18 women, 2 men, aged 34-82 yrs, mean 66 yrs) presented for evaluation of osteoporosis were included in the study. QM was performed twice using SpineAnalyzer (Optasia Medical), a novel semi-automated clinical workflow tool, by three different readers: two experienced radiologists and one first year medical student with no prior experience in QM. All readers were trained on the use of the software using a different set of subjects. The readers analyzed the images independently without knowledge of their own previous or other readers’ results in two sessions, separated by 5 days or more. Intra- and inter-reader reproducibility was evaluated by using the root mean squared error of coefficients of variation (RMS CV) of all heights (anterior: \( h_a \), mid: \( h_m \), and posterior: \( h_p \)) and RMS standard deviations (RMS SD) of height ratios (\( h_a/h_p, h_m/h_p \)). Vertebrae that were inconsistently labeled on one of the 6 reads were excluded from analysis, resulting in the inclusion of 239 of the possible 260 vertebrae analyzed. 34 vertebrae (14%) of the vertebrae were deformed as defined by one of the height ratios being lower than 0.8 (or 20% deformed).

Results
Intra- and inter-reader reproducibility of vertebral heights and ratios are summarized in the tables on the left. The first table shows the ranges of RMS estimates across the three readers. The second table shows intra-reader results and the last table inter-reader results (first read and second read).

Discussion
Reproducibility was twofold better in normal versus deformed vertebrae. Intra- and inter-reader reproducibility in this study are consistent with those observed in previously published studies. Rea et al. showed intra-reader reproducibility was 3.3% for heights and 0.031 for height ratios. For inter-reader the values were 4.1% and 0.034, respectively. Closer review reveals that our results were slightly better for inter-reader reproducibility and slightly worse on deformed vertebrae than those observed by Rea.

Comprehensive QM on X-rays has not been feasible in clinical practice because of special training needed and the time required to perform the measurements. Therefore, QM is not routinely used in clinical practice despite its recognized diagnostic value. Our results demonstrate that after brief training an inexperienced operator using SpineAnalyzer can obtain QM results that are consistent with those of more experienced readers, while using a workflow that makes QM feasible in clinical practice.

References