Quantitative Morphometry on Spinal X-rays: Initial Evaluation of a New Workflow Tool for Point Placement

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INTRODUCTION

Vertebral height assessed by 6-point quantitative morphometry (QM) provides useful information for the diagnosis of both prevalent and incident vertebral fractures. However, reliable QM requires specially trained technicians and is tedious, making it impractical in clinical routine. The aim of this study was the initial evaluation of a new QM tool developed for clinical use (SpineAnalyzer, Optasia Medical Ltd, Cheadle, UK).

METHODS

Using SpineAnalyzer on lateral spine x-rays in the standard clinical routine, the reader initiates analysis by placing a point in the approximate center of each vertebra between T4 and L4. Based on active shape and appearance models, SpineAnalyzer suggests default placements of 6 points needed to measure posterior, mid and anterior heights of the vertebrae. The reader would then make adjustments, if necessary, allowing the algorithm to re-fit the contours or manually placing the contours. The computer then determines the placement of the QM standard 6 points on the contours allowing calculation of the anterior, middle and posterior heights.

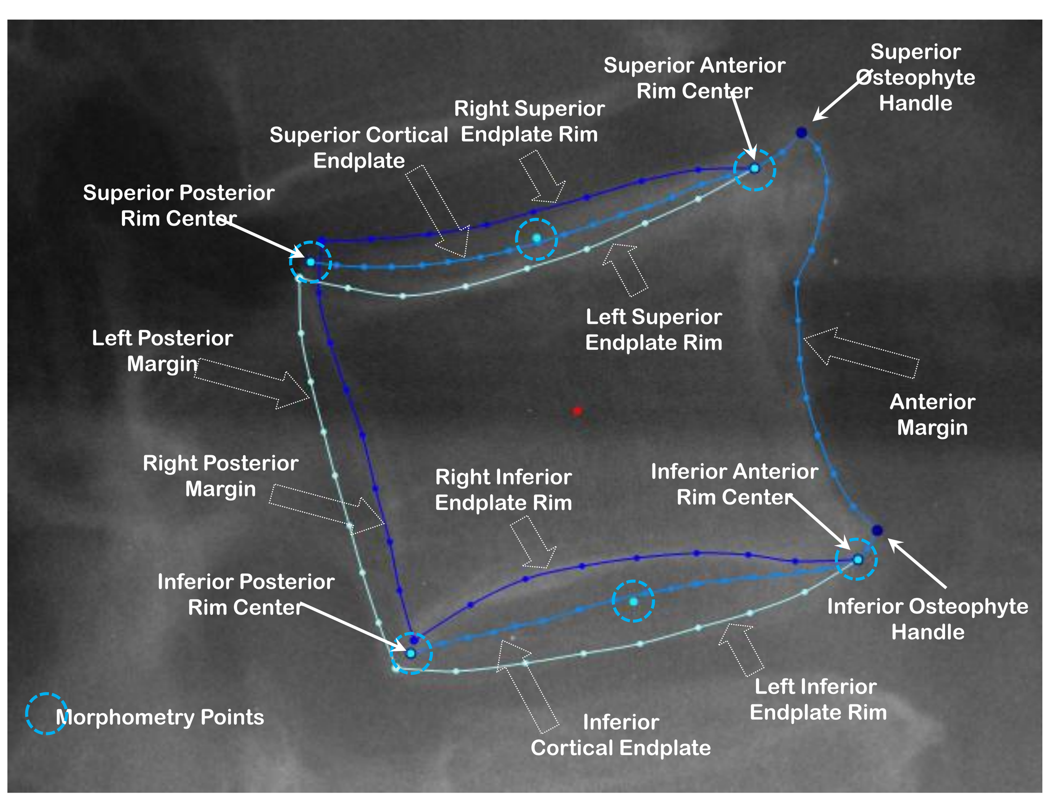


Figure 1. Vertebral body contours identified by SpineAnalyzer are shown. Triple contours are used for the endplates, double contours for the posterior margin and a single contour for the anterior margin. QM standard 6 points are shown along the endplates.

In this study a standard QM 6-point results determined by manual placement were compared with the default placement provided by SpineAnalyzer. Thus, to test the performance of the model and in contrast to clinical routine, default placements were not corrected by the reader even if they were obviously incorrect.

Lateral lumbar and thoracic x-rays from three groups of postmenopausal women (73.7 ± 5 y) with femoral neck T-score < -2.5 and were used:

- 100 subjects without vertebral fractures (Gr1)
- 50 subjects with milder fractures (deformed >20% but <30%) (Gr2)
- 50 subjects with more severe fractures (>30%) (Gr3)

Anterior, middle and posterior heights were calculated from the 6 points using standard algorithms.

The coefficient of variation was computed between the manual height measurement and those obtained by SpineAnalyzer default results. Results were summarized by vertebra by height.

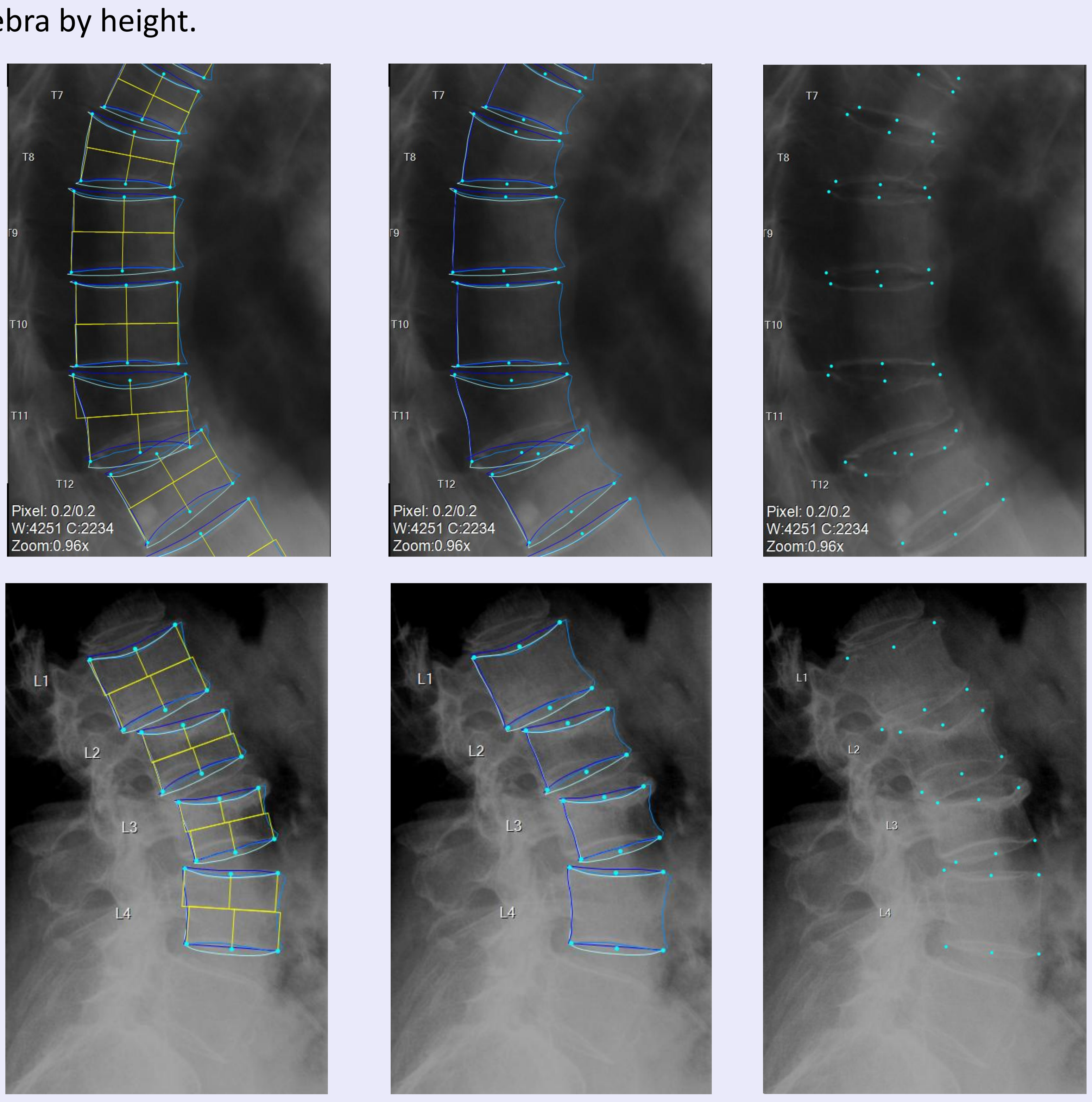
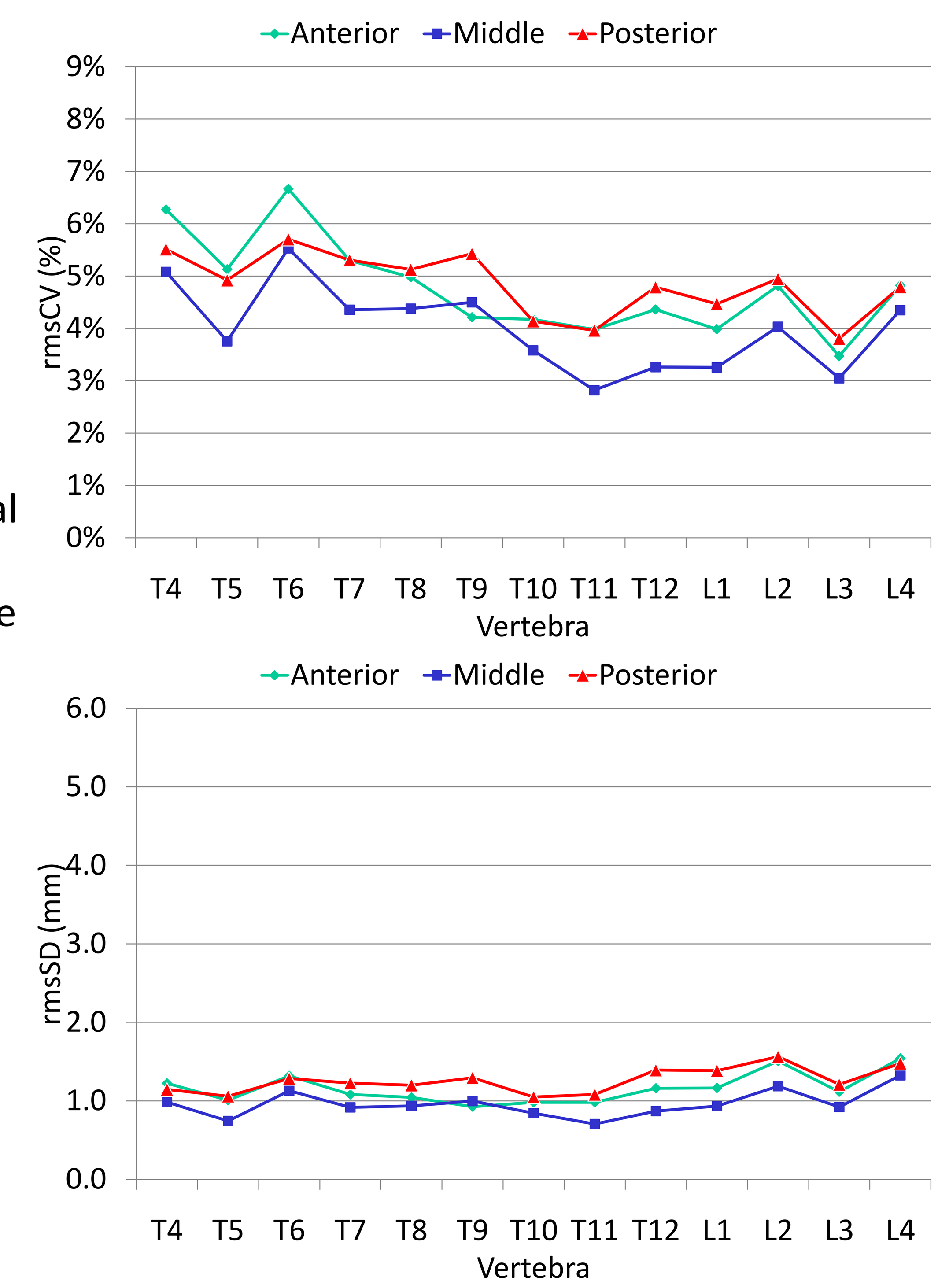


Figure 2. Two subjects from Gr3. While default placement for normal and mildly deformed vertebrae is acceptable, manual correction for more severely deformed vertebrae is clearly needed.

RESULTS

In all 200 subjects results were obtained from T4 to L4. In Gr1 8 vertebrae were judged unreadable due to low image quality. Results in Fig. 3 are based on the remaining 1,292 vertebrae. Fig. 4 shows the results for 61 fractured vertebrae of Gr.2 and Fig. 5 the results for 143 fractured vertebrae of Gr.3. Results for the unfractured vertebrae of Gr2 and Gr3 were comparable to those for Gr1 shown in Fig. 3

Figure 3: Gr1 Percentage (rmsCV%) and absolute (rmsSD) deviation between manual QM and SpineAnalyzer vertebral body heights are plotted by vertebra. The rmsCV% was largest in the upper spine while rmsSD showed a slight trend toward larger values in the lumbar spine. Middle heights agreed better with manual QM than anterior or posterior. Overall mean rmsSD = 1.13 mm.



On a percentage basis, in the unfractured vertebrae the deviation (rmsCV%) between manual and SpineAnalyzer heights was largest in the upper thoracic spine where vertebrae have smaller heights. However in absolute terms, the deviation (rmsSD) was nearly constant from T4 to L4 with slightly larger deviation in the lumbar spine.

Figure 4. Gr2 Absolute (rmsSD) deviation between manual QM and SpineAnalyzer vertebral body heights are plotted by vertebra. Error rates are elevated by uncorrected fractured vertebrae and most noticeable below T8. Overall mean rmsSD = 1.83 mm.

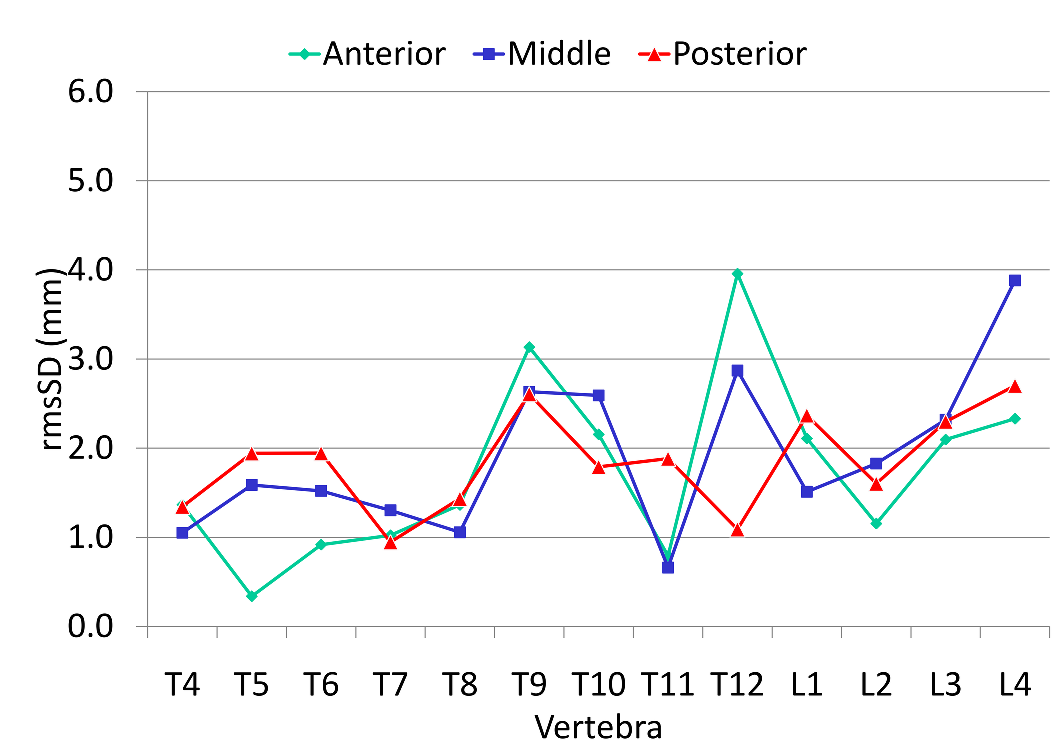
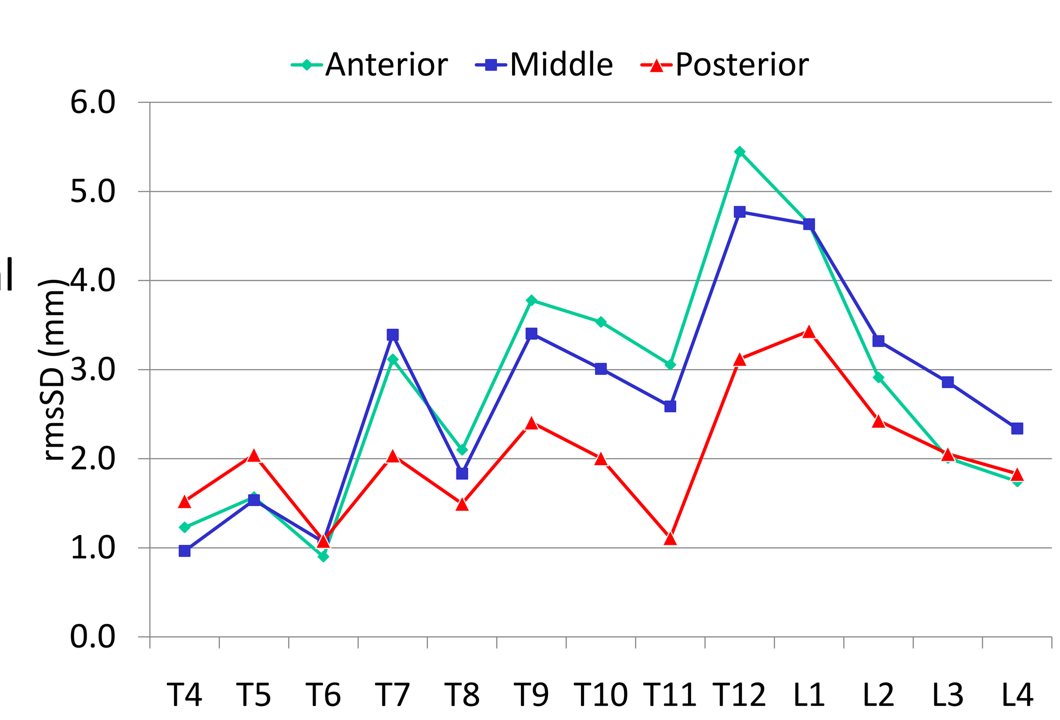


Figure 5. Gr3 Absolute (rmsSD) deviation between manual QM and SpineAnalyzer vertebral body heights. Again, error rates are elevated by uncorrected fractured vertebrae. Posterior height measurements are less affected. Overall mean rmsSD = 2.52 mm.



CONCLUSIONS

Overall in the unfractured but not in the fractured vertebrae the performance of the automatic point placement algorithm compared very well with manual QM analysis, which has rmsCV values about 3-4% among readers and 2-3% within readers. The results from SpineAnalyzer were slightly higher. However, inspection of images reveals instances where the default SpineAnalyzer results were clearly incorrect. Therefore, operator review and adjustment is required, as is recommended for standard clinical use. While relatively good agreement was shown here, we expect further improvements with operator adjustment.