Quantifying changes in 3D surface topography after surgical correction of adolescent idiopathic scoliosis

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INTRODUCTION

Adolescent Idiopathic Scoliosis (AIS) is the most common spinal disorder in children, occurring in around 2% of the population of otherwise healthy teenagers.

A plethora of measurements are available to characterise scoliosis, but a mismatch remains between cosmesis (visual appearance), radiological parameters (Cobb angle) and patient functional outcomes (SRS-22 Satisfaction scores). Better assessment of cosmesis, through quantitative techniques, may help address this mismatch.

We propose a new method of quantifying external scoliotic deformity, using 3D photography.

METHODS

Six AIS patients (Mean age: 14.2±1.6 years, Lenke: 1A, 3C, 5C) from the local children's hospital spine deformity clinic were assessed. Patients underwent two 3D surface scans (Artec Eva, Artec Group Inc., Luxembourg), pre-operatively and at their post-operative review. Participants were scanned in a relaxed standing position.

Using the surface scan data, 3D virtual representations of the patient's standing body shape were created(Fig 1B and Fig 2). From these reconstructions, transverse cross-sectional profiles of the outer torso skin surface were created at 10% intervals between their pelvis and C7 prominence (Fig 1C).

A line of symmetry was determined, that defined the angle of rotation of each profile (positive: right). An asymmetry comparison of the mirror image torso was conducted. This process included mirroring the model about the sagittal plane, and then performing a best fit registration, before calculating the linear deviations between the model surfaces (Fig 1D).

Each parameter was compared pre to post operatively for all patients. An example case is shown below.

RESULTS

Pre Op
Cobb 55°

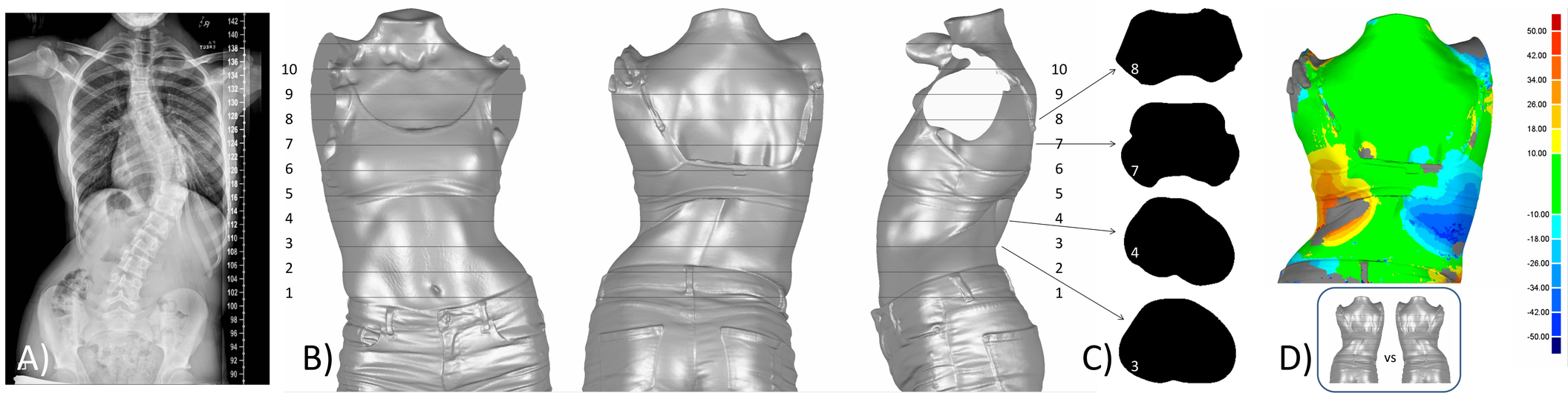
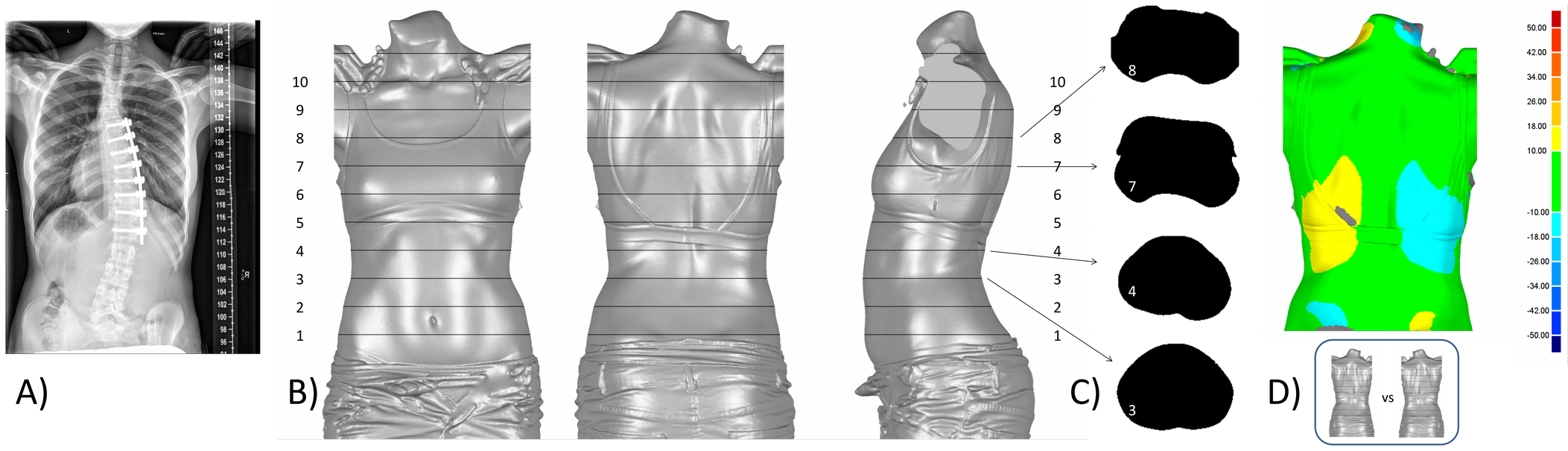


Figure 1: Pre operative (above) and Post operative (below) imaging showing, A) PA X-ray; B) 3D photography reconstructions: anterior, posterior and lateral views; C) Slices 3, 4, 7 and 8 through the torso; D) Asymmetry deviation map, comparing the original vs the sagittal mirror image, as shown in inset

Post Op
Cobb 20°



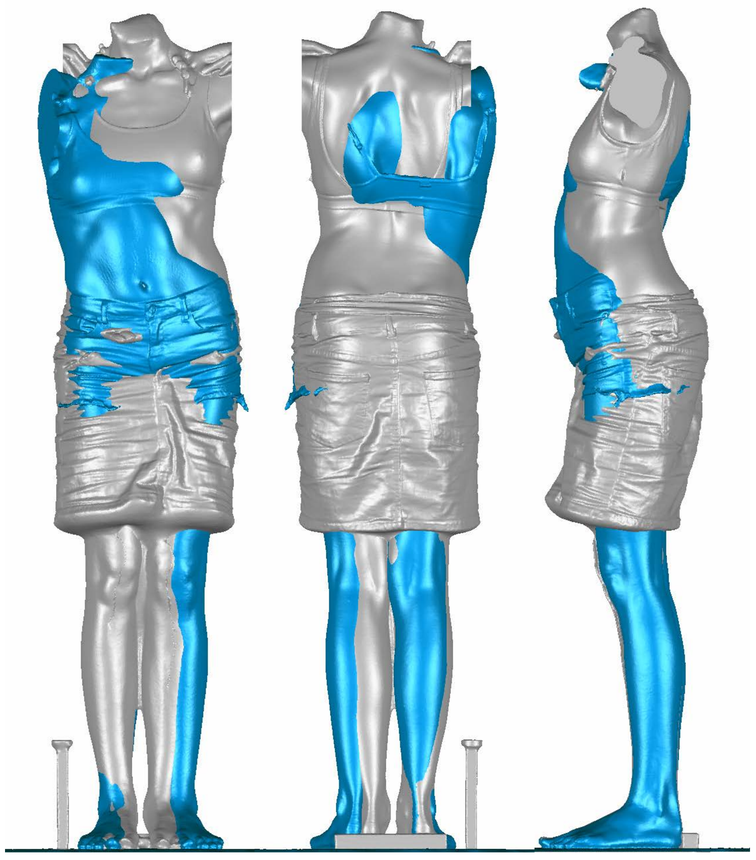


Figure 2: Full body reconstructions from 3D photography, Pre-operative shown in blue, Post-operative in Silver

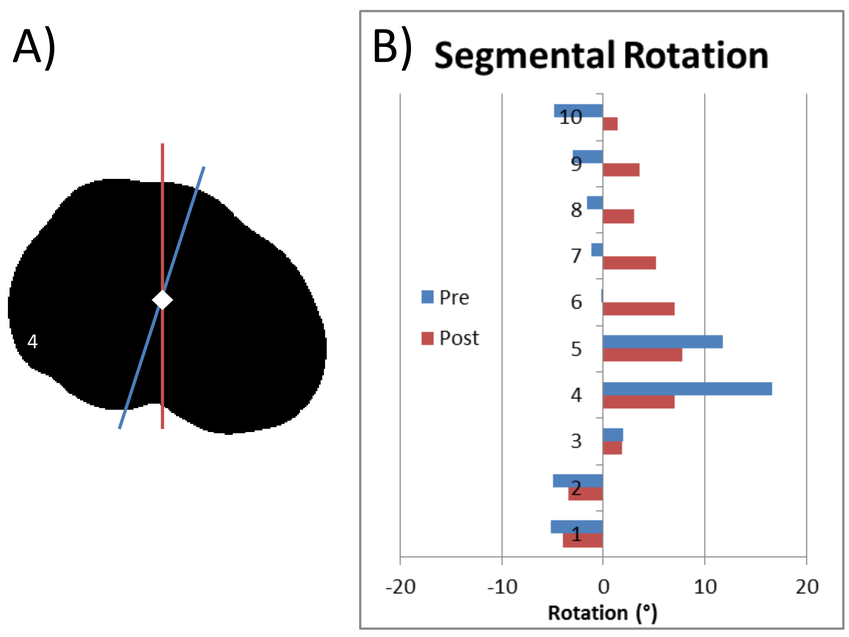


Figure 3: A) Torso segment (no 4), showing calculated rotation vector (blue), passing through the geometric centre of the segment (white diamond), with the angle reported against the sagittal plane shown in red B) Segmental rotations pre and post operatively

Due to the diversity of curve types and severity, it is best to look at the results individually, so a single patient has been shown as an example of the technique.

For a reduction in Cobb angle of 35°, this patient showed a marked improvement in cosmesis. The asymmetry analysis (Fig 1D) shows deviations of up to 42-50mm pre-operatively, that have decreased to less than 18mm post-operatively.

Segmental rotations (Fig 3B), show a reduction in peak rotations, and a smoothing of rotations along the length of the torso, and a return to values within the normal range.

CONCLUSIONS

With further development, this technique has the potential to provide a useful quantitative and qualitative tool for assessing external deformity and surgical correction, possibly providing a non-irradiating diagnostic and monitoring tool to augment clinical imaging.