Can Ultrasound imaging be a suitable alternative to MRI for building personalized musculoskeletal models?

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Background

Anatomically personalized musculoskeletal models (MSKMs) are mathematical representations of the human musculoskeletal system (including bones, joints, and muscles). They are combined to motion analysis data recorded from an individual to provide accurate understanding of articular biomechanics during a movement task.

Currently, magnetic resonance imaging (MRI) - based MSKMs are considered the gold standard in the field. However, MRI scans are time-consuming, cumbersome to the patient and costly. Alternatively, B-mode ultrasound (US) [1] can be used for non-invasive capture of skeletal anatomy information.

As part of a broader project aiming at assessing the feasibility of using US to build MSKMs, thereby reducing the dependency on MRI (Fig. 1), this placement project aimed at preparing and processing motion analysis data and US images in order to build MSKMs of the lower limbs.

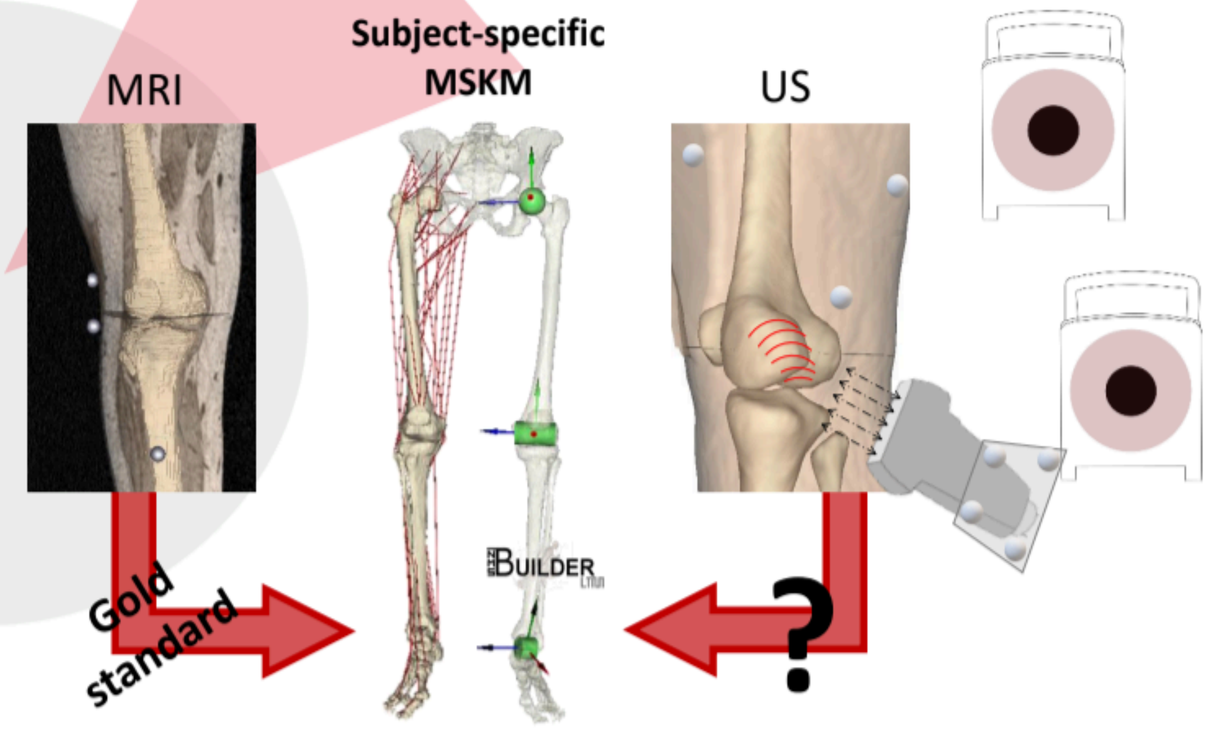

***Figure 1**: Design of the project aiming at replacing MRI with US.*

Methods

Subjects and data:

- 10 young adults (27±4 y.o.);
- 'Sweeps' performed over hip, knee and ankle in the supine and standing configurations .

Data Processing:

- Use ITK-Snap for the segmentation of US images (Fig. 2);
- Extraction of 3D surface from the segmented images (Fig. 2);
- Vicon Nexus 2 used to build VSK models and .c3d files from the motion analysis data (Fig. 3);
- MATLAB used for post-processing of gait data.

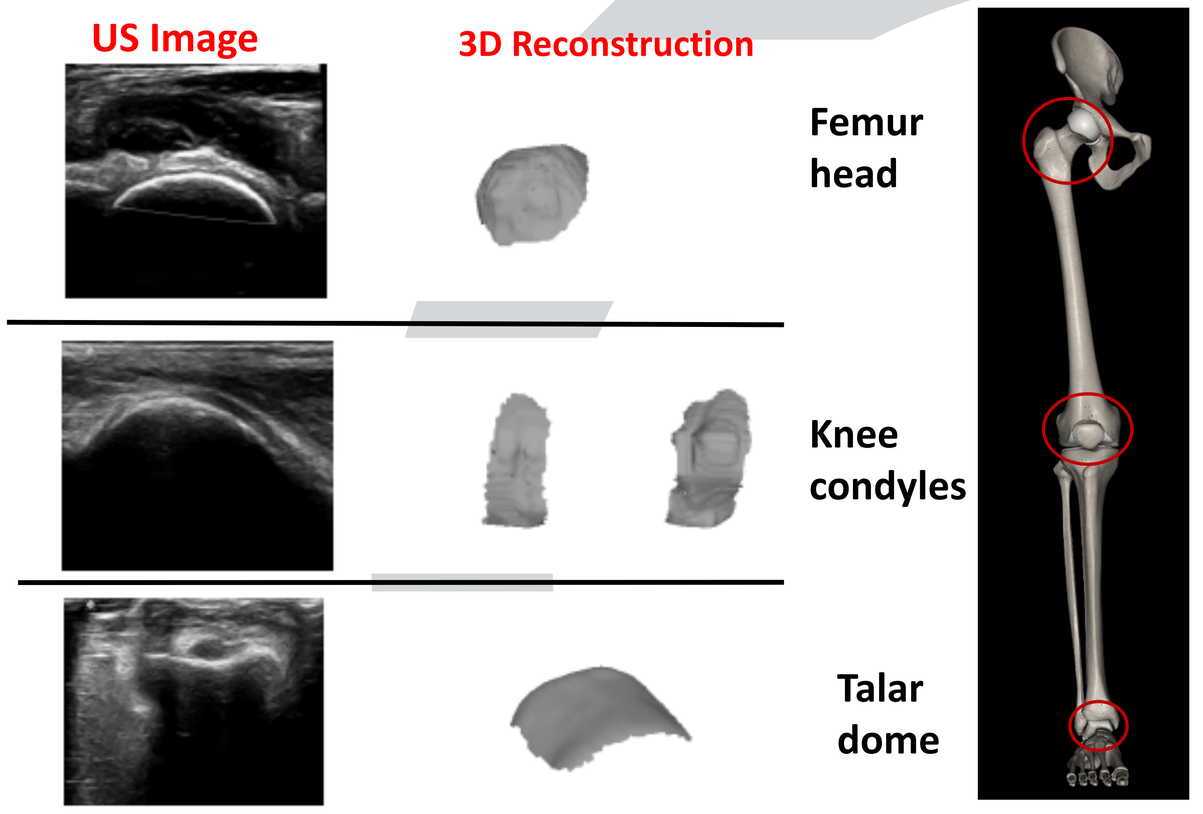

***Figure 2:** Identification of joint surface on US images and 3D reconstruction*

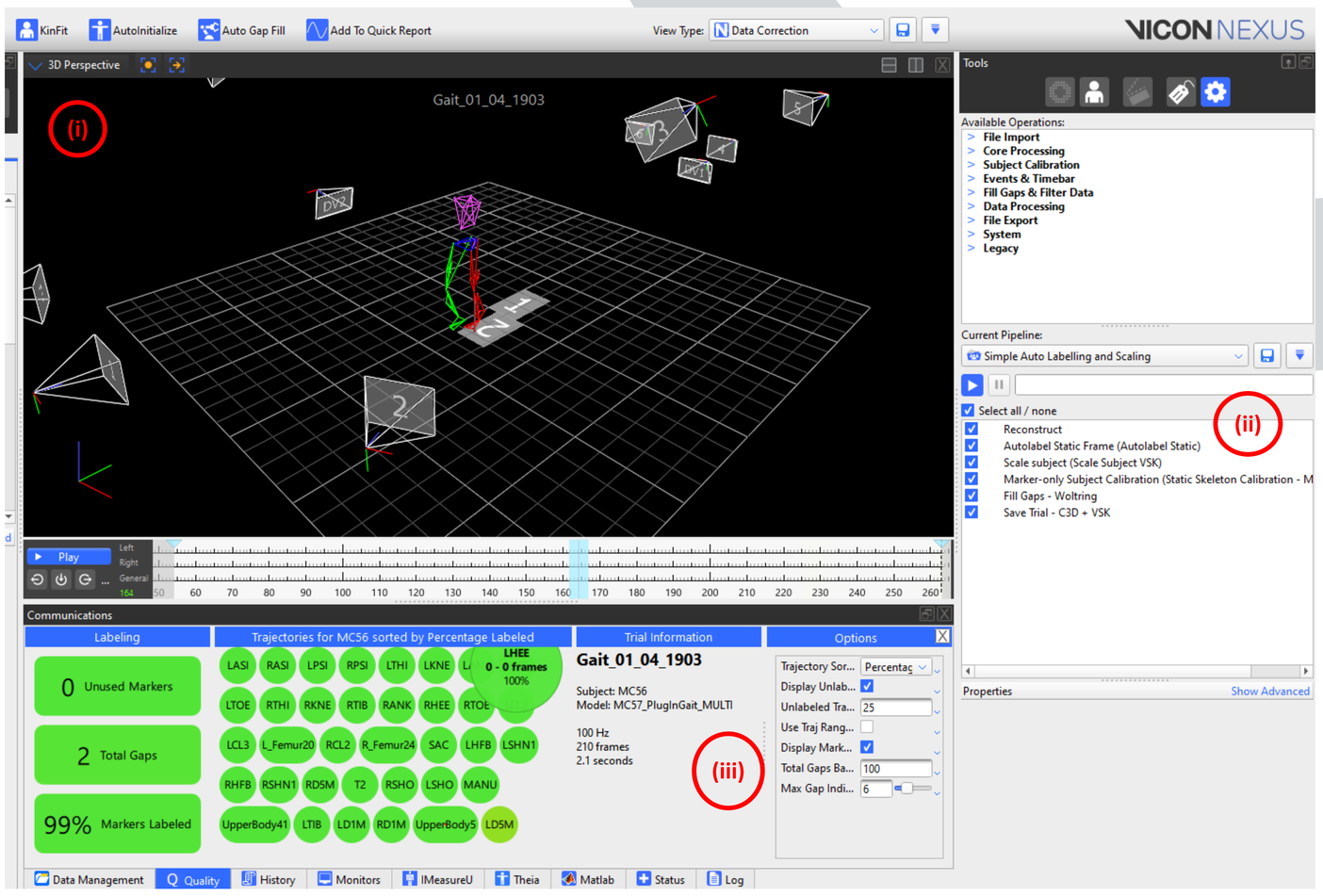

***Figure 3:** Vicon Nexus 2 interface: (i) the view pane is used to visualize the captured data from one or more cameras, (ii) displays the current pipeline used for processing, (iii) displays the quality of the processed motion capture experiment.*

Results

- 68% of the US data were segmented to produce surface extractions.
- 93% of the motion analysis data were processed into .c3d files. About 23% of this data was batch processed.

Discussion

The US imaging performed in standing configuration generally produced better 3D surface reconstructions for the condyle and anterior and superior iliac spine scans.

Batch processing could be used for motion analysis data when involving simple movements such as knee flexion and squats. However, most of the motion capture data required manual processing due to artefacts.

The processed data will be used in future work to assess the feasibility of using US to build MSKMs.

References

[1] *Greatrex et al.*, Applied Bionics and Biomechanics, vol. 2017, 1-8, 2017.

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MultiSim
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The University Of Sheffield.

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