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Compensation of experimentally induced soft tissue artefact with a combination of optoelectronic motion analysis system and a 2D ultrasound probe

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Abstract

Introduction
In human motion analyses with optoelectronic systems the 3D position of at least three markers attached to a particular body segment are used to estimate the pose of the underlying bone. During movement, the position of the markers relative to each other and to the underlying bone is not fixed because, for example, skin slides and muscles contract. These segment distortions introduce error into bone pose estimation called Soft Tissue Artefact (STA).

Our aim was to define the degree of STA compensation possible using one 2D ultrasound (US) probe combined with an optoelectronic motion analysis system (CAT&MAUS).

Methods
We used a butchered lamb leg in this study. The surface of a part of the femur was reconstructed as a static reference using the principles of 3D freehand US [1]. Then, while the leg was moved to induce STA, the femur edge in this region was imaged with the US probe. This bone edge was automatically segmented in each frame and, by combining the skin marker trajectories with registration between the bone edge and the reference surface, the femur position could be reconstructed (Figure 1). The importance of the US registration relative to the skin marker trajectories was varied by a weighting factor (1, 10, 100, 1000, 10000, 100000). The bone poses calculated with the various weighting factors were compared to the bone pose revealed by a bone pin (R2, RMSE & Bland Altman). We also assessed the bone poses reconstructed using the skin marker trajectories alone.

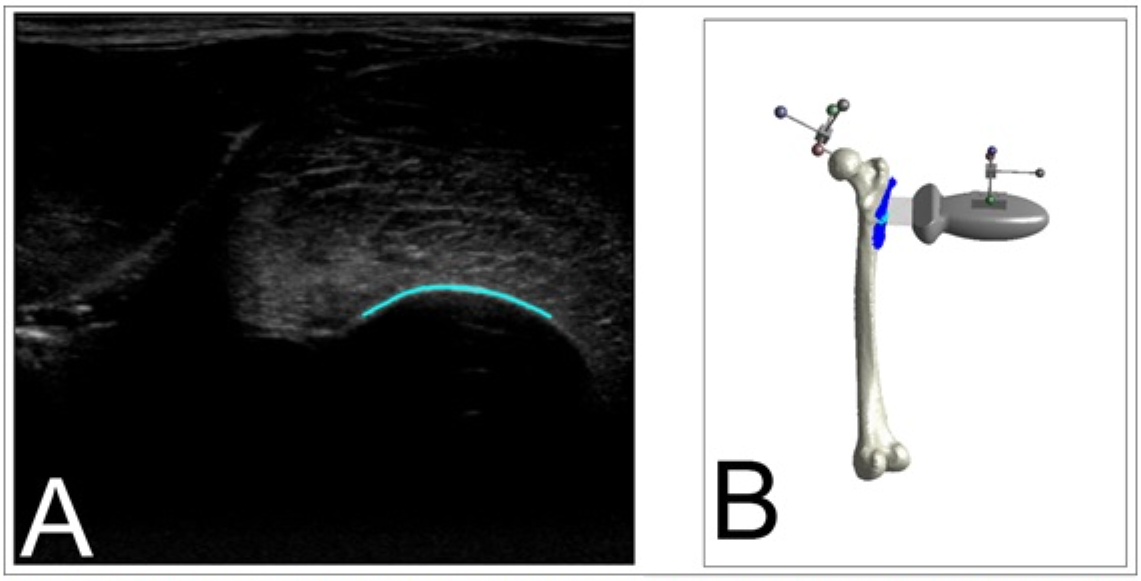

Figure 1. The procedure was reliant on an automatic bone segmentation algorithm (A) and a tracked US transducer (B)

Results
We found that including the US data or weighting in favour of it with factors of 10 and 100 reliably reduced STA by an average of at least 30%. All the metrics (R^2, RMSE, *md* & CI) revealed comparatively greater fidelity to the bone pin kinematics for 5 out of the 6 degrees of freedom (DOF) and, for displacements along the Z axis, only R^2 (0.16 vs. 0.09) and CI (3.50 vs. 4.84) were poorer. At higher weighting factors, greater degrees of STA compensation were possible but reliability was poor.

Discussion
We have demonstrated the potential for reducing STA in optoelectronic motion analysis by including data from a clinical US system. Inclusion of a 2nd transducer would address current issues with accuracy but slow processing time. Ultimately US hardware and software could be optimised for the purpose of extremely accurate tracking of bony motion.

Acknowledgements
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