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VALIDATION OF 3D MODELS OF THE OUTER AND INNER SURFACES OF AN OVINE FEMUR

K. Rathnayaka[*], T. Sahama[*], M. Schuetz[*#], B Schmutz[*]
[*]Institute of health and biomedical innovation, Queensland University of technology, Brisbane
[#]Princess Alexandra Hospital, Brisbane

The validation of Computed Tomography (CT) based 3D models takes an integral part in studies involving 3D models of bones. This is of particular importance when such models are used for Finite Element studies. The validation of 3D models typically involves the generation of a reference model representing the bones outer surface. Several different devices have been utilised for digitising a bone's outer surface such as mechanical 3D digitising arms, mechanical 3D contact scanners, electro-magnetic tracking devices and 3D laser scanners. However, none of these devices is capable of digitising a bone's internal surfaces, such as the medullary canal of a long bone.

Therefore, this study investigated the use of a 3D contact scanner, in conjunction with a microCT scanner, for generating a reference standard for validating the internal and external surfaces of a CT based 3D model of an ovine femur.

One fresh ovine limb was scanned using a clinical CT scanner (Phillips, Brilliance 64) with a pixel size of 0.4 mm^2 and slice spacing of 0.5 mm. Then the limb was dissected to obtain the soft tissue free bone while care was taken to protect the bone's surface.

A desktop mechanical 3D contact scanner (Roland DG Corporation, MDX 20, Japan) was used to digitise the surface of the denuded bone. The scanner was used with the resolution of $0.3 \times 0.3 \times 0.025$ mm. The digitised surfaces were reconstructed into a 3D model using reverse engineering techniques in Rapidform (Inus Technology, Korea).

After digitisation, the distal and proximal parts of the bone were removed such that the shaft could be scanned with a microCT (μCT40, Scanco Medical, Switzerland) scanner. The shaft, with the bone marrow removed, was immersed in water and scanned with a voxel size of 0.03 mm^3. The bone contours were extracted from the image data utilising the Canny edge filter in Matlab (The Mathswork).. The extracted bone contours were reconstructed into 3D models using Amira 5.1 (Visage Imaging, Germany).

The 3D models of the bone's outer surface reconstructed from CT and microCT data were compared against the 3D model generated using the contact scanner. The 3D model of the inner canal reconstructed from the microCT data was compared against the 3D models reconstructed from the clinical CT scanner data. The disparity between the surface geometries of two models was calculated in Rapidform and recorded as average distance with standard deviation.

The comparison of the 3D model of the whole bone generated from the clinical CT data with the reference model generated a mean error of 0.19±0.16 mm while the shaft was more accurate(0.08±0.06 mm) than the proximal (0.26±0.18 mm) and distal (0.22±0.16 mm) parts. The comparison between the outer 3D model generated from the microCT data and the contact scanner model generated a mean error of 0.10±0.03 mm indicating that the microCT generated models are sufficiently accurate for validation of 3D models generated from other methods. The comparison of the inner models generated from microCT data with that of clinical CT data generated an error of 0.09±0.07 mm

Utilising a mechanical contact scanner in conjunction with a microCT scanner enabled to validate the outer surface of a CT based 3D model of an ovine femur as well as the surface of the model's medullary canal.