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METHODS FOR GENERATING PERSONALISED INFANT FEMUR MODELS COMBINING PAIRED CT AND MRI SCANS

André Castro[1], Zainab Altai[2], Amaka Offiah[2], Susan Shelmerdine[3], Owen Arthurs[3], Xinshan Li[2], Damien Lacroix[2]

[1]**Instituto Superior Técnico/University of Sheffield, Portugal**
andrepgcastro@gmail.com

[2]**The University of Sheffield, United Kingdom**
zakaltai1@sheffield.ac.uk, a.offiah@sheffield.ac.uk, xinshan.li@sheffield.ac.uk, d.lacroix@sheffield.ac.uk

[3]**Great Ormond Street Hospital for Children, United Kingdom**
Susan.Shelmerdine@gosh.nhs.uk, Owen.Arthurs@gosh.nhs.uk

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Summary: Most fractures seen in child abuse occur in children younger than 3 years old, with 80% occurring before 18 months. Reports have shown that at least 20% of cases of child abuse, under the age of 3 years old, are misdiagnosed as due to other causes, implying a need to improve diagnostic methods. The growing skeleton contains non-ossified cartilaginous regions at the epiphyses, which may play an important role in infant bone biomechanical behaviour, specifically in fracture mechanisms. The goal of this work was to investigate the contribution of these non-mineralised regions to the mechanical response of the whole infant bone, considering the hard-soft tissue transition and boundary conditions that may lead to fracture of long bones. Previous finite element (FE) studies based post-mortem computer tomography (CT) scans of infant bones were limited in terms of soft tissue characterisation. Therefore this current study introduces the use of magnetic resonance imaging (MRI) and corresponding CT scans, to allow for the anatomical and constitutive characterisation of both mineralised and non-mineralised tissues subject-specific FE models of the infant femur. In summary, this work used anonymised paired CT and MR images of post mortem infant femurs at two different stages of development (4 and 7 months). Images were reconstructed into FE models and simulated using a new functional workflow involving Amira® (independent CT and MRI segmentation, followed by spatial alignment of the images), ScanIP® (merging of layers and FE meshing), Bonemat® (subject-specific material properties assignment based on CT attenuation) and Abaqus® (porohyperelastic time-dependent simulation). The simulation outcomes suggest that the biomechanical behaviour of the femoral diaphysis is not visibly altered when compared with previous bone-only FE studies, particularly under torsional loads. However, the more accurate boundary conditions made possible by the presence of the non-ossified femoral head allowed for a deeper insight into the developmental stages of the infant femur and its risk of injury when subjected to potentially harming external loads. This work also has the potential to contribute for the future study of long bone metaphyseal fractures.