PREDICTING BONE DEFORMITIES IN CEREBRAL PALSY

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INTRODUCTION
Cerebral Palsy (CP) is a non-progressive neuromuscular motor disorder that affects the motor control of skeletal muscles. Children with CP walk with an altered gait due to muscle contractures and increased tone of the muscles. The inefficient way of walking alters bone growth resulting in bone deformities. In order to improve functionality, many children must undergo extensive multi-level surgery. With many different bone and muscle deformities and levels of functionality, it is often difficult to determine which surgical procedure is appropriate. The objective of this research is to develop a finite element model of bone growth in cerebral palsy in order to predict bone deformities. The first step in this direction is to characterise the morphological bone deformities and gait patterns.

FIGURE 1
(a) Crouched gait position in a child with spastic cerebral palsy [www.qbu.ac.uk]. (b) Gait analysis of child with CP. [Figures courtesy of Julie Stebbins]

MATERIAL AND METHODS
The morphology of nine CP children and ten healthy children was obtained by analysing the 3D MRIs. Location of anatomical landmarks along the femur were detected using medical imaging software (Analyze 6.0, B.I.R., MN). Each point was then defined with respect to bone-embedded Cartesian coordinates (x,y,z). In order to compare results between different subjects, the coordinates were normalised. Femoral anteversion, neck-shaft angle, and the femoral bicondylar angle were measured from MRI scans (Fig 2, 3).

FIGURE 2
(a) Selected anatomical landmarks. FHC, femoral head centre, GTRO, great trochanter, LEP, lateral epicondyle and MEP, medial epicondyle [6]. (b) The bone/embedded coordinate systems used [2]. (c) MRI measurement of femoral anteverision using transverse slice through the proximal and distal femur and calculating the angle (bottom) between the line of the femoral neck (top) and the posterior epicondyle (middle)

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FIGURE 3
(a) Method used to calculate the center of the diaphysis and the line of the shaft of the femur. (b) MRI frontal plane projection of the neck-shaft angle. (c) MRI frontal plane projection of the bicondylar angle determined by the angle of the femur shaft and the line perpendicular to the infracondylar plane

ANTICIPATED RESULTS AND FUTURE WORK
All the morphology and gait data has been collected. The next step is to correlate functionality and morphology using statistical methods such as principle component analysis (PCA) to determine which groups of gait parameters correlate with the morphologic parameters. The final step will be to create a 3D finite element model for CP growth in order to predict bone deformities. According to mechanobiological rules, the computer model will simulate bone growth based on the current geometry and loading conditions seen in children with cerebral palsy. Understanding how loading influences subsequent growth of the bone could help surgeons in pre-surgical planning. Such a model could be a valuable tool in pre-surgical planning, helping to determine the effects of certain procedures on bone growth.

REFERENCES