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MODELLING FETAL HEAD MOTION AND ITS MECHANICAL INTERACTION WITH THE PELVIC FLOOR DURING CHILDBIRTH

Hypothesis / aims of study

The mechanism of birth is complex and depends on many factors, including the anatomy and material properties of the pelvic structures and the fetal head. In order to investigate these factors and their effects during the second stage of labour, a computer modelling framework has been created to simulate vaginal delivery. The model represents the process of a fetal head descending through the pelvic floor muscles. The force required for delivery, and the maximum stretch ratio, were plotted to demonstrate the effects of childbirth on the individual-specific pelvic floor muscles.

Study design, materials and methods

Pelvic floor models were created from magnetic resonance images (MRI), released to us from a previous study [1]. MRIs of healthy nulliparous women were acquired using a Siemens Magnetom Avanto 1.5T scanner. Thirteen components (bony pelvis, muscles and organs) of the pelvic floor were digitised and fitted using in-house software CMISS. A fetal head mesh was generated from a skull replica produced by ESP Ltd [2], with a biparietal diameter of 90mm and a suboccipitofrontal diameter of 100mm. The head was positioned occiput anterior, and displaced through the pelvic floor muscles in a series of steps, by prescribing the vertical descent of one point within the head. The head was otherwise free to translate and rotate, and the path of the head was determined by its geometry and interactions with the pelvic floor muscles, which were governed by the physical laws of finite deformation mechanics, subject to contact constraints and solved using the finite element method. The descent was defined as the distance between the lowest point of the head and the line joining the ischial spines.

Results

Figure 1 shows the motion of the fetal head as it descended through the personalised pelvic floor of one case study. The force required for delivery (normalised to the maximum force) and the maximum principal stretch ratio are plotted in Figure 2. The maximum stretch ratio was located at the right levator ani attachment to the pubis.

Interpretation of results

The location of the maximum stretch ratio is consistent with the prevalence of birth-related injuries at the levator ani attachments to pubis. This framework provides a quantitative tool for investigating the factors that affect the childbirth process, including pelvic floor muscle fibre anisotropy, muscle activation, and fetal head moulding.

Concluding message

We have developed and demonstrated a computer modelling framework to quantitatively analyse pelvic floor mechanics during the second stage of labour on an individual-specific basis. Further research is needed to test other factors so that their roles during labour can be better understood. In future, this model may be used to assist clinicians in the decision making process regarding childbirth.

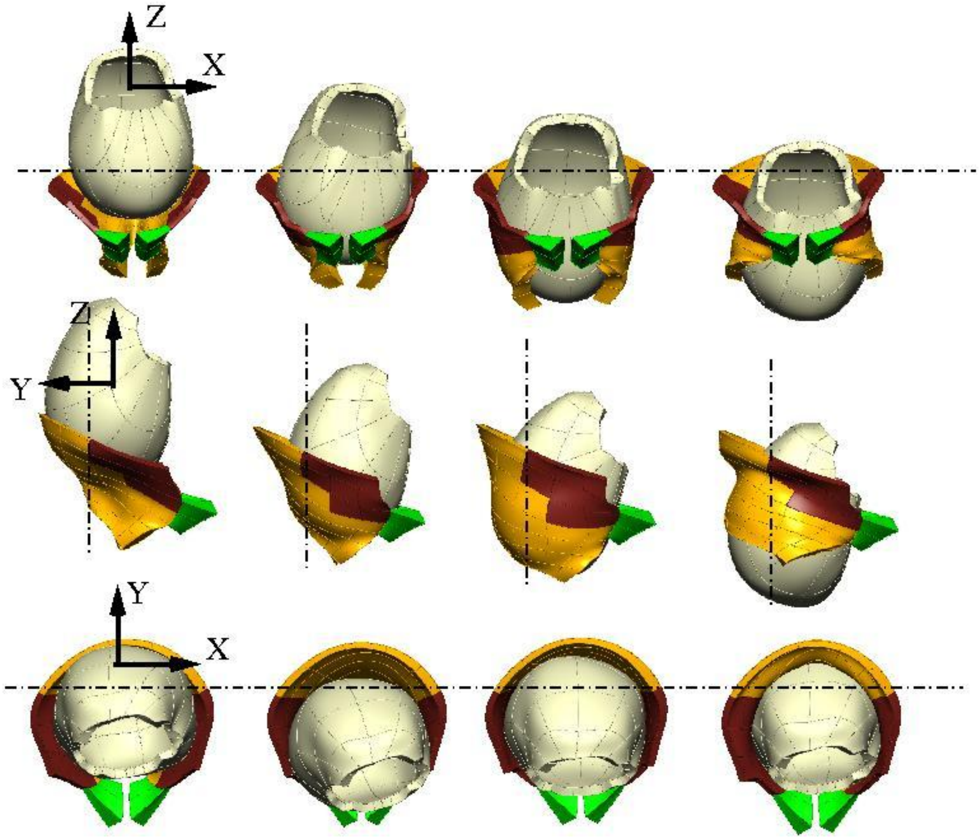

Figure 1 Descent of a fetal head through the pelvic floor muscles of one case study. Views are anterior (top row), right lateral (middle row) and superior (bottom row). The dashed lines mark the z (top) and y (middle, bottom) locations of the ischial spines. Yellow: levator ani; brown: obturator internus; green: pubis; silver: fetal head.

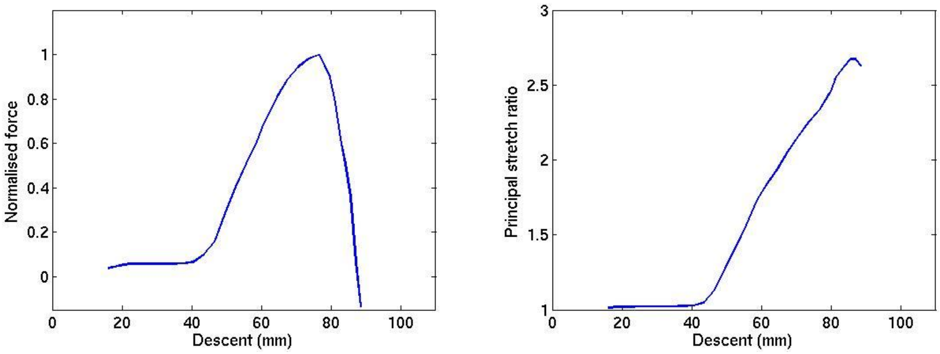

Figure 2 Normalised force and principal stretch ratio versus descent of the case study in Figure 1.

References

1. Obstet Gynecol (2008) 111(3); 631-638
2. J Biomechanics (2001) 34; 1125-1133

Specify source of funding or grant	**The University of Auckland, Auckland, New Zealand**
Is this a clinical trial?	**No**
What were the subjects in the study?	**HUMAN**
Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**University of Auckland Human Participants Ethics Committee**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**