Advancing treatment of craniosynostosis using validated in silico models

Mehran Moazen[1]

[1] *Department of Mechanical Engineering, University College London, WC1E 7JE, UK*

Description: The physical-mechanical interactions that shape our skulls during growth are poorly understood. This lack of fundamental knowledge limits our ability to advance treatment of a wide range of craniofacial conditions mostly affecting children. This is a significant engineering challenge due to the complexity of this system. For example, craniosynostosis (CR) is a condition cause by early fusion of cranial joints, affecting 1 in 2000 births, where its prevalence has increased by 2-3x in recent years while its optimum management is still subject of controversy.

In my team since 2013, we have been working on developing a validated computational framework to predict skull growth with the vision to virtually test various treatment options for the management of various forms of CR. This work has been in collaboration with Headlines craniofacial Support (a charity run by those affected by craniosynostosis) and several clinical teams, children hospitals, across the world including: Oxford, Paris, Olsztyn, Gothenburg and Seattle.

We initially developed and validated our approach in normal and genetically modified mouse (model of CR - [Fig 1A,B – 1-3],). Then we scaled up our approach to human skull [4]. We first developed a validated FE model of normal calvarial growth in human [Fig 1C - 4], having characterised morphological changes during the human craniofacial growth in n=241, aged 0-4 years [5]. We then applied our approach to 2 patient-specific models of CR [6,7] predicting calvarial growth following the surgery. We recently used our computational framework to compare 9 different treatment options for management of sagittal CR, i.e. the most prevalent form of CR affecting the joint in the midline of the skull [Fig 1D - 8]. Our results highlight that different surgical techniques can constrain the growth of the brain in different ways that can potentially have an impact on the neurodevelopment of these children.

Further work is ongoing to apply our approach to other forms of CR.

Figure 1: [A] validating modelling approach in mouse; [B] validating pattern of bone formation at the sutures; [C] predicting human skull growth; [D] comparing 9 treatment options for sagittal craniosynostosis.

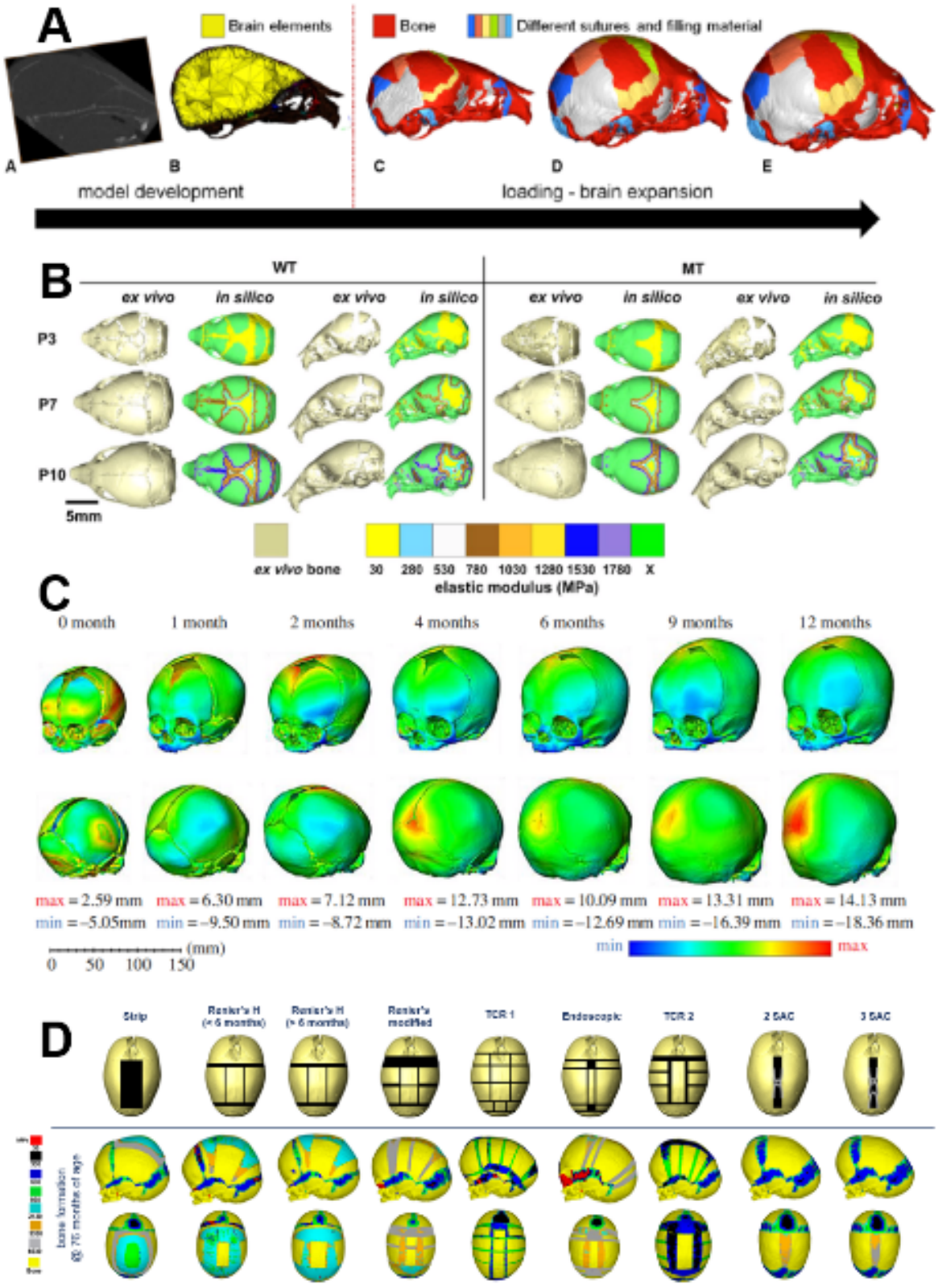

Figure 2: Mehran Moazen, principal investigator.

Weblinks: http://moazenlab.com/; https://www.headlines.org.uk/; https://www.ouh.nhs.uk/craniofacial/; https://hopital-necker.aphp.fr/

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