THE IMPORTANCE OF ACCURATE MUSCLE MODELLING FOR BIOMECHANICAL ANALYSES: A VALIDATION AND SENSITIVITY STUDY

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Introduction

Computer-based simulation techniques such as multi-body dynamics analysis are becoming increasingly popular in the field of skull mechanics. However, to be confident of the results, models need to be validated against experimental data, and the effects of uncertainties or inaccuracies in the chosen model attributes should be assessed with sensitivity analyses. Unfortunately, there have been few skull modelling studies of this kind to date [e.g. Sellers & Crompton, 2004; de Zee *et al*, 2007; Curtis *et al*, 2010].

Here we present the first subject-specific multi-body model of a reptile skull that has been successfully validated against *in vivo* measurements from the same specimen. In addition, we studied the importance of different input variables in several sensitivity analyses.

Methods

Maximum bite forces were recorded for an adult lizard (*Tupinambis merianae*). After the *in vivo* experiments the specimen was euthanized, dissected and scanned with micro-computed-tomography. These data were used to build a detailed multi-body model (Fig. 1). Bites at different positions were modelled and the predicted bite forces were compared with the *in vivo* recordings.

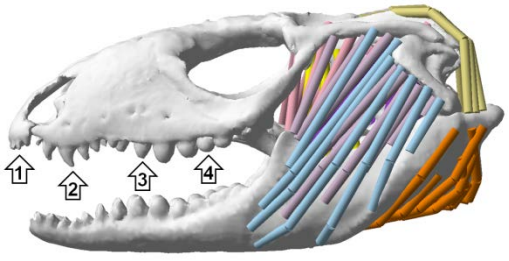

Figure 1: Multi-body computer model and positions of the modelled bites.

Results

Our subject-specific model predicts bite forces that are very close to the *in vivo* measurements (Fig. 2). However, the model is very sensitive to changes in some muscle attributes such as fibre length, intrinsic muscle strength, and force orientation, with bite force predictions varying considerably when these three variables are altered.

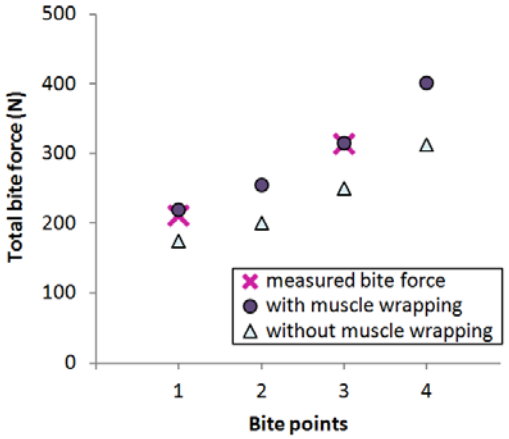

Figure 2: Effect of modelling muscle strands as straight lines vs. wrapped around bones. Note that in vivo bite forces are underestimated by the model without wrapping.

Discussion

Our results highlight the importance of conducting comprehensive sensitivity analyses so that the effects of uncertainties and errors in the choice of input variables can be estimated.

We conclude that accurate muscle measurements are crucial to building realistic multi-body models and that subject-specific data should be used whenever possible.

References

Curtis *et al*, J Biomech, 43:2804-2809, 2010.

Sellers & Crompton, Ann Anat, 186:89-95, 2004.

de Zee *et al*, J Biomech, 40:1192-1201, 2007.