Mass, center of mass, and definition of an anatomical coordinate system for the pig head and brain

Nikoo Soltan[1], Gunter P. Siegmund[2,3], Peter A. Cripton[1,4], Claire F. Jones[5]

[1]Department of Mechanical Engineering, University of British Columbia; [2]MEA Forensic Engineers & Scientists; [3]School of Kinesiology, University of British Columbia; [4]School of Biomedical Engineering, University of British Columbia; [5]School of Electrical and Mechanical Engineering, University of Adelaide

MOTIVATION

Defining the pig head and brain center of mass in a relevant anatomical coordinate system can aid the comparison of kinematics data between porcine models, and translation to other biomechanical surrogates and human subjects.

INTRODUCTION

- Porcine models of head/neck injury are a valuable translational resource[1-3] and can involve measuring kinematics following a scaled mechanical perturbation[4,5].
- However, the inertial properties of the pig head and brain have not been characterized, which limits scaling of loading conditions and consistent reporting/comparison of kinematics.

OBJECTIVES

For the commonly studied domestic pig:

1. Determine the head and brain mass, and center of mass (CoM) relative to palpable landmarks.
2. Define a translationally relevant anatomical coordinate system (ACS).

METHODS

- SAHMRI Animal Ethics Committee approval: SAM22-031
- 11 female Large White × Landrace pigs (18-48 kg) were imaged using computed tomography (CT).
- CTs were density-calibrated with a phantom and the head and brain were segmented via thresholding (Fig.1A).
- 3D models were cut at the occipital condyles and ears (Fig. 1B).

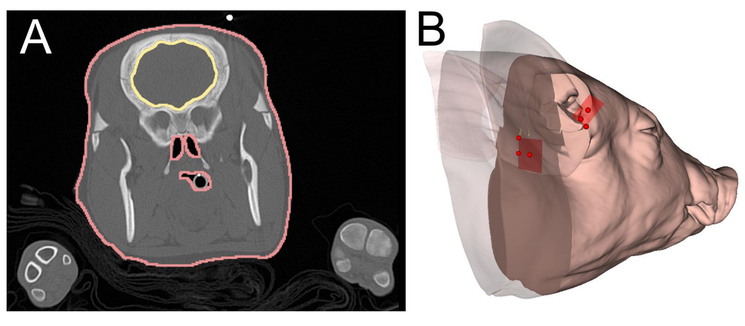

Fig. 1: *(A) Axial CT slice with outline of segmented brain (yellow) and head (pink). (B) Neck and ear cutting planes.*

- Mass and CoM of the head and brain were calculated using the volume and density of each voxel.

METHODS (cont.)

- An ACS was defined using 4 palpable landmarks (Fig. 2) with origin between RZ and LZ.
- The head and brain CoMs were transformed and reported in the ACS.

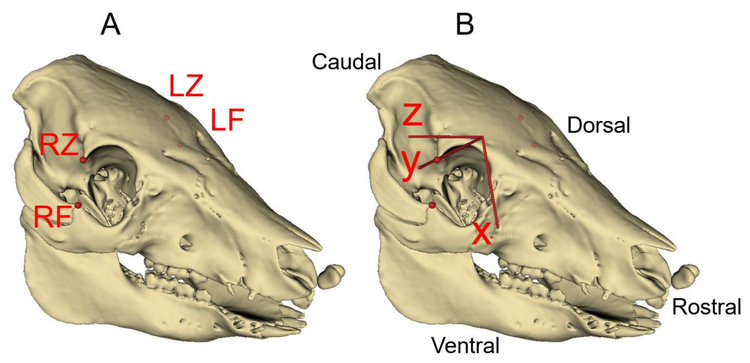

Fig. 2: *(A) Landmarks for ACS definition: right/left frontal process of zygomatic bone (RF, LF), and right/left zygomatic process of the frontal bone (RZ, LZ). (B) Positive axes of defined ACS.*

RESULTS

Table 1: *Mean head & brain mass and % BM.*

	Mass [g]	% Body Mass
Brain	103 ± 9	0.33 ± 0.08
Head	2533 ± 646	7.80 ± 0.79

Table 2: *Mean head & brain CoM coordinates in the ACS.*

	x [mm]	y [mm]	z [mm]
Brain	-1.7 ± 1.3	-0.3 ± 0.5	17.0 ± 1.7
Head	46.3 ± 5.4	-0.9 ± 2.8	8.0 ± 5.6

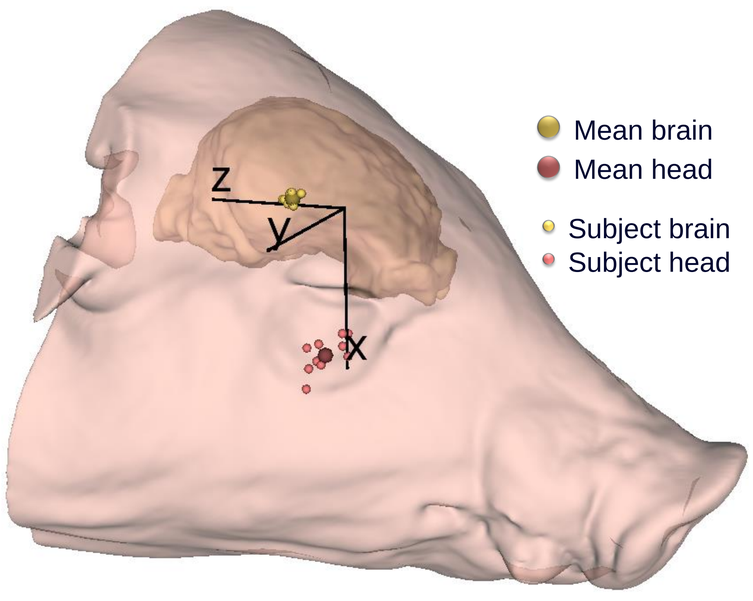

Fig. 3: *Head and brain center of mass (n = 11) in the coordinate system of a representative animal.*

RESULTS (cont.)

- Mean brain and head masses constituted 0.33 and 7.80% of body mass, respectively (Table 1).
- The mean brain and head CoMs were primarily caudal and ventral to the ACS origin, respectively (Table 2, Fig. 3).

DISCUSSION

- Palpable landmarks can be used to non-invasively establish subject-specific ACSs for the pig head and brain.
- Proposed ACS axes are analogous to human head coordinate system[6] (Fig. 4) with a pig-equivalent Frankfort plane.

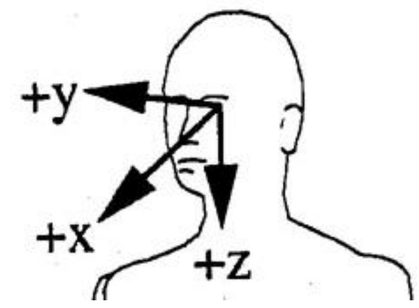

Fig. 4: *Human head coordinate system. Adapted from SAE J211.*

- Pig head-to-body mass ratios were similar to humans while brain-to-body mass ratios were considerably smaller than for humans[7,8].
- Head and brain CoMs were not coincident; reporting kinematics at their respective CoMs may be prudent.
- Reported mean head and brain CoMs can be used as generic estimates when subject-specific CoM calculations from 3D imaging is not feasible.

REFERENCES

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