

### 3D MUSCLE MOMENT ARMS USING MUSCULOSKELETAL MODELING

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#### INTRODUCTION

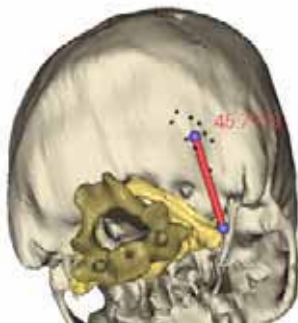
Upper cervical muscle biomechanics is poorly reported in the literature. However, these muscles seem to play an important role in head stabilization during cervical spine movement. The objectives of this study were to analyze the *in vitro* 3D moment arms of the suboccipital muscles during upper cervical spine movement and to implement these biomechanical muscle data in a musculoskeletal model.

#### METHODS

Kinematics data were sampled from digitizing technical markers (aluminum balls: diameter, 4mm) placed on the upper cervical segments (skull, C1 and C2) of 7 fresh specimens. Suboccipital muscles (rectus capitis posterior major (RCPM), rectus capitis posterior minor (RCPm), obliquus capitis superior (OCS), obliquus capitis inferior (OCI)) were kept intact to assure accurate digitizing of their insertions (Mmark) and fiber orientation in a maximal flexion position. Five successive positions for axial rotation (AR) and flexion-extension (FE) were processed. Axial rotation was achieved from maximal right rotation to maximal left rotation. All kinematics and muscle data were obtained using a 3-D digitizer (Faro® arm, model 08 Bronze, USA). Moreover, medical imaging of each specimen supplied morphometric data for 3D reconstruction (Amira®, Germany). According to a validated registration method [2], registration of kinematics and muscle data with morphometric data was processed using the DataManager software (<http://www.tecno.ior.it>). Muscle orientation was defined by the line of action, a straight line between attachment centroids (figures 1 and 2).

Then, for both movements, muscle lengths were computed for the five positions. Muscle moment arm was computed using a tendon excursion method previously described [4].

**Figure 1:** Surface muscle markers (●) after digitizing of the

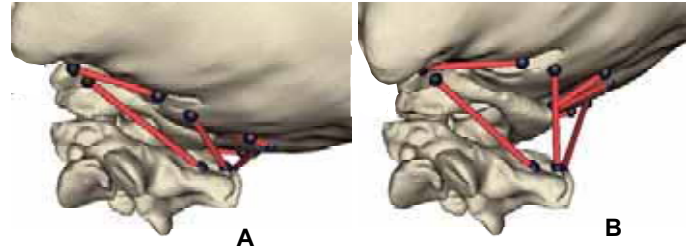


right occipital insertion of the OCS. Centroid of attachment site (●), muscle action line (—) and length (mm).

#### RESULTS AND DISCUSSION

Average moment arms (table 1) showed comparable value between right and left muscles for both movements. Absolute moment arms were similar for RCPM, OCS and OCI in AR and for RCPM, RCPM and OCS in FE. Moment

arm magnitude was close to zero for RCPm in AR and for OCI in FE. In general, moment arms were larger for AR except for RCPm. For AR, our results confirmed the antagonist role of OCS compared to RCPM and OCI.



**Figure 2:** Musculoskeletal model of one specimen in extension (A) and maximal flexion (B) of the C0-C2 complex. Muscles action line (—) and insertion (●).

	AR		FE	
	left muscle	right muscle	left muscle	right muscle
<b>RCPm</b>	1.9 (12.4)	-0.7	19.3 (7.1)	22.1 (5.3)
<b>RCPM</b>	-23.3 (5.0)	22.3 (5.8)	14.9 (3.6)	18.8 (5.0)
<b>OCS</b>	24.5 (6.5)	-22.8 (11.1)	17.2 (3.4)	17.5 (5.1)
<b>OCI</b>	-24.6 (2.1)	24.8 (3.0)	-2.2 (8)	-2.2 (6.6)

**Table 1:** Average suboccipital muscle moment arms (mm) and SD during AR and FE. Negative values represent antagonist action regarding the primary movement.

Our data were sampled using an accurate device that is commonly used in the literature. Kinematics data were computed using validated method for registration of different data sets. If some morphometric and biomechanical data are found in the literature, only few are available about suboccipital muscle length variations and moment arms. Our results are partially in agreement with previous studies [3]. Vasavada et al [3] have observed similar data in AR concerning the investigated muscles but differences are observed for flexion extension. These differences are most probably due to different methodological approaches. In this study kinematic and muscle data were obtained from the same specimens. This integration provides an interesting source for the analysis of musculoskeletal mechanic using an integrated computer graphic environment.

#### REFERENCE

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