

# Fluoroscopic investigation of cervical joint motion in healthy subjects

by  
**Xu Wang**

Pain in the neck region is one of the most common medical conditions. Neck pain is a potential cause of altered neck proprioception and altered motor control. The cervical spine is a multi-joint unit, and the cervical spine has been studied extensively to assess the range of motion and repeated motions with associated repositioning ability for persons without and with neck problems. However, the repositioning ability and motion pattern of individual cervical joints have only been described minimally until now. Individual cervical joints' upright posture repositioning ability (Study I), dynamic motion repeatability (Study II) and anti-directional motion (Study III) were examined in healthy subjects who were asked to flex and extend the cervical spine from an upright posture to an end-range position. Most cervical spine movements are initiated from the upright cervical posture or postures closely related to this posture. Therefore, this posture is the baseline for the studies. The distribution of reposition errors showed larger errors in the upper cervical regions. The studies confirmed with some limitations the clinical and scientific assumption that cervical joint motion was repeatable. Individual cervical joint repositioning and movement are essential to understand normal variations of the healthy cervical spine biomechanics. In the present work, the repeatability of single joint flexion and extension movements, including fluctuation of anti-directional joint motion (previously described as reverse motion in clinical studies, converse motion in biomechanical studies) were examined. To investigate the individual cervical joints' repositioning ability, the subjects were asked to return to the upright cervical posture as precisely as they could after a cervical flexion or extension movement. A novel fluoroscopic video technology and Matlab based program analyzed the individual joint repositioning errors from C0/C1 to C6/C7. The repositioning errors were presented as real errors and absolute errors in degrees. Individual joint motion during flexion and extension was calculated in degrees. For detailed joint motion pattern analysis, the flexion or extension movement was evenly divided into ten epochs with respect to the C0/C7 ROM from upright posture to end-range position. Repeated flexion and extension movements were performed to examine the joint motion repeatability with long (1 week) and short (20 s) time intervals. Anti- and pro-directional motions were measured to reflect the variations during repeated joint flexion and extension. The cervical spine returns to the upright cervical posture after flexion and extension, as it counterbalances the multiple joint motions within the cervical spine. The cervical joints returned after flexion and extension movements with positive or negative joint repositioning errors. Despite the variations in the upright cervical posture after cervical flexion and extension movements, the variations through cervical flexion and extension movements were repeated with an error of approximately 2.5 degrees. Cervical joints move repeatedly through flexion and extension with an average variation of 0.00° to 0.05° in real values, and an average variation of absolute values ranging from 2.02° to 2.33°. The movements include anti-directional motion, which contributes to the fluctuations of the flexion or extension of joint motions. The average anti-directional motion of the healthy cervical spine was scattered throughout flexion or extension movements. Moreover, the upper cervical joints showed larger anti-directional motion compared to the lower cervical joints. The current thesis confirms that the anti-directional motion exists in free and unrestricted cervical flexion and extension movements with an approximately average of 40 %. The results quantify the variations of cervical joint motion during flexion and extension movements, which may help to understand interventions directed towards improved joint motions. The variation of repositioning differences after flexion and extension suggests that this variation should be considered, when head and neck repositioning errors are applied in rehabilitation and in science.

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**Ph.D. lecture**

by  
**Xu Wang**

**Monday 1 October 2018**



**DEPARTMENT OF HEALTH SCIENCE AND TECHNOLOGY**  
AALBORG UNIVERSITY

This thesis is based on Xu Wang's research work at:



**SMI**  
**Department of Health Science and Technology**  
**Aalborg University**  
**Denmark**

## **Program for Ph.D. lecture on**

**Monday 1 October 2018**

**by**

**Xu Wang**

To fulfill the requirements for the Ph.D. degree, Xu Wang has submitted the thesis: Fluoroscopic investigation of cervical joint motion in healthy subjects, to the Faculty Council of Medicine at Aalborg University.

The Faculty Council has appointed the following adjudication committee to evaluate the thesis and the associated lecture:

**Professor Jan Hartvigsen  
University of Southern Denmark  
Denmark**

**Professor Alan Breen  
Bournemouth University  
UK**

**Chairman:  
Associate Professor Mark de Zee  
Aalborg University  
Denmark**

**Moderator:  
Professor Thomas Graven-Nielsen  
Aalborg University  
Denmark**

The Ph.D. lecture is public and will take place on:

**Monday 1 October 2018 at 13:00  
Aalborg University – Room A4-106  
Fredrik Bajers Vej 7  
9220 Aalborg East**

Fluoroscopic investigation of cervical joint motion in healthy subjects

Chairman: Associate Professor Mark de Zee

Moderator: Professor Thomas Graven-Nielsen

13.00 Opening by the Moderator

13.05 Ph.D. lecture by Xu Wang

13.50 Break

14.00 Questions and comments from the Committee  
Questions and comments from the audience at the  
Moderator's discretion

16.00 (No later than)  
Conclusion of the session by the Moderator

After the session a reception will be arranged