MORPHOLOGY, ARCHITECTURE AND BIOMECHANICS OF HUMAN CERVICAL MULTIFIDUS MUSCLES

Jess S. Anderson[1], Andrew W. Hsu[1], and Anita N. Vasavada[1,2]

[1]Department of Veterinary and Comparative Anatomy, Pharmacology and Physiology
[2]Program in Bioengineering, Washington State University, Pullman, WA USA
E-mail: vasavada@wsu.edu Web: www.bioengineering.wsu.edu\alias\?AnitaVasavada

INTRODUCTION

Multifidus is a deep spinal muscle which may play a critical role in spinal stability, proprioception, injury and pain. The morphology of lumbar multifidus has been reported (Macintosh *et al.*, 1986), but little is known about cervical multifidus. The objectives of this study were (1) to describe the fascicular attachment pattern of cervical multifidus; (2) to quantify the muscle's architecture parameters and (3) to model its moment-generating capacity.

METHODS

We studied cervical multifidus in nine cadaveric specimens (6F, 3M). Fascicles of multifidus with common cranial and caudal attachments were isolated and are referred to here as *fascicular subgroups.* After harvesting and digestion of connective tissue, the mass and musculotendon, fascicle and sarcomere lengths were measured. Fascicle length was normalized by optimal sarcomere length (2.8 μ) to calculate optimal fascicle length. Physiological cross sectional area (PCSA) was calculated by dividing mass by density and optimal fascicle length. The data were incorporated into a biomechanical model of the neck (Vasavada *et al.*, 1998) developed in Software for Interactive Musculoskeletal Modeling (Musculographics, Santa Rosa, CA). Each fascicular subgroup was modeled as a distinct muscle, and moment arms, force- and moment-generating capacity were calculated for extension, axial rotation and lateral bending.

RESULTS AND DISCUSSION

Cervical multifidus can be divided into two layers (Figure 1). The superficial layer consists of three bands of fascicles originating from the facet capsules of C4/C5 through C6/C7, which all insert on the spinous process of C2. A deeper layer of fascicles originates more posteromedially on the facet capsules and inserts on superior laminae. Fascicles originating from C4/C5 insert on C2, those from C5/C6 on C3, and those from C6/C7 on C4. The two layers of multifidus are also seen in the thoracic and lumbar spine; however, fascicles arise from transverse processes in the thoracic spine (unpublished observations) and mamillary processes in the lumbar spine (Macintosh et al, 1986) instead of facet capsules.

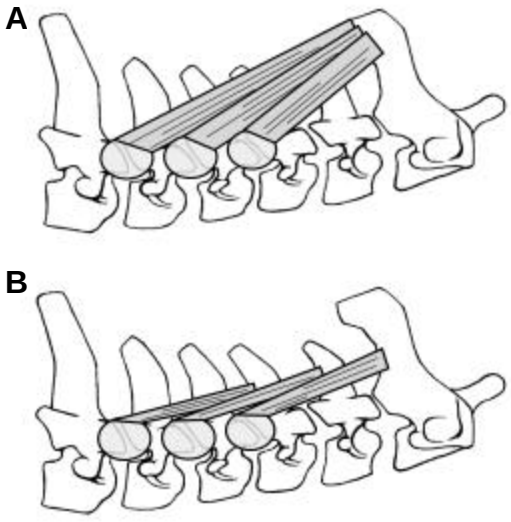

Figure 1. Schematic of multifidus attachment patterns in the cervical region (C2-C7). (A) Superficial layer. (B) Deep layer.

The mass of individual fascicular subgroups ranges from 0.1 to 2.7 g, and the total mass of multifidus averages 5.8 g (± 2.2 g), with the superficial layer comprising 61% (± 11.5%) of the total. On average, fascicle length is approximately half the total musculotendon length. For subgroups that cross the same number of segments, musculotendon lengths are shorter in the deep layer. Average sarcomere length is 2.5 μ, which is shorter than optimal length. If it is assumed that all cadavers went into rigor in a neutral spine posture, this implies that sarcomeres would be at optimal length in a slightly flexed posture.

Table 1: Architecture parameters of cervical multifidus.

	Mass (g)	PCSA (cm^2)	MT length (cm)	Optimal fascicle length (cm)
Superficial				
C4/C5-C2	0.9 (0.6)	0.4 (0.2)	3.7 (0.4)	1.9
C5/C6-C2	1.5 (0.8)	0.6 (0.3)	5.0 (1.0)	2.6
C6/C7-C2	1.4 (0.7)	0.5 (0.2)	5.6 (1.5)	2.9
Deep				
C4/C5-C2	0.4 (0.2)	0.2 (0.1)	3.4 (0.8)	1.9
C5/C6-C3	0.8 (0.5)	0.4 (0.2)	3.1 (1.1)	2.0
C6/C7-C4	1.1 (0.4)	0.5 (0.1)	3.4 (0.5)	2.0
Total	5.8 (2.2)	2.3 (0.6)		

In the neutral position, multifidus has equal moment-generating capacity for extension and lateral bending. The total moment-generating capacity of multifidus is less than 1 Nm in any plane of motion. Extension moment-generating capacity decreases beyond 40º extension due to decreases in both moment arm and force. Extension moment-generating capacity increases with flexed postures due to increases in force. Axial rotation moment-generating capacity is greater in ipsilateral rotated postures (due to increases in both moment arm and force) and lower in contralateral rotated postures (due to decreases in moment arm). Lateral bending moment-generating capacity increases in ipsilateral bent postures primarily because of increases in moment arm, and in contralateral bent postures because of increases in force.

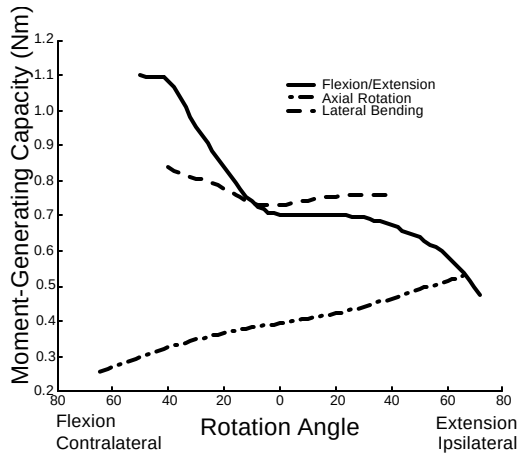

Figure 2: Maximum moment-generating capcity of cervical multifidus (sum of all fascicular subgroups).

SUMMARY

We have described the fascicular attachment patterns, quantified architecture parameters, and calculated biomechanical properties of cervical multifidus. Further, we confirmed that multifidus has direct attachment onto the cervical facet capsule, corroborating its hypothesized role in neck pain and injury (e.g., Winkelstein *et al.*, 2000). Although multifidus is capable of generating only small forces and moments, its ability to control motions at specific intervertebral joints may make it an important contributor to the control of head and neck posture.

REFERENCES

Macintosh *et al.* (1986). *Clin Biomech*, **1**:196-204.

Vasavada *et al.* (1998). *Spine*, **23**: 412-421.

Winkelstein *et al.* (2000). *Spine* **25**: 1238-1246.

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