Functional Anatomy of Human Scalene Musculature: Rotation of the Cervical Spine

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Abstract

Objectives: Actions of the scalene muscles include flexion and lateral flexion of the cervical spine and elevation of the first and second ribs. The cervical rotational qualities of the scalene muscles remain unclear. Textbooks and recent studies report contradictory findings with respect to the cervical rotational properties of the scalene muscles. The present study was designed to take a mechanical approach to determining whether the scalene muscles produce rotation of the cervical spine.

Methods: The scalene muscles were isolated, removed, and replaced by a durable suture material. The suture material was attached at the origin and then passed through a hole on the corresponding rib near the central point of the insertion. The suture material was pulled down through the corresponding costal insertion hole to simulate contraction of each muscle.

Results: The simulated anterior, middle, and posterior scalene muscles, working independently and jointly, produced ipsilateral rotation of the cervical spine. The upper cervical spine rotated in the ipsilateral direction in response to the simulated muscle contraction. Findings were similar for the lower cervical spine with the exception of 2 specimens, which rotated contralaterally in response to the simulation.

Conclusion: Experimental models of the scalene muscles are capable of producing ipsilateral rotation of the cervical spine. The findings of this study support the accepted main actions of the scalene muscles. The clinical applications for understanding the cervical rotational properties of the scalene muscles include the diagnosis, management, and treatment of cervical pain conditions as well as thoracic outlet syndrome. (J Manipulative Physiol Ther 2010;33:594-602)

Key Indexing Terms: *Neck Muscles; Musculoskeletal Manipulations; Biomechanics; Cervical Vertebrae*

The scalene musculature of the lateral aspect of the neck classically exists as 3 muscles: the anterior, middle, and posterior scalene (Fig 1). Scalene muscles vary with respect to their origin and insertions on the cervical vertebrae and upper ribs.[1] The scalene muscles are also often complicated by the presence of fused fascicles between muscles and additional muscles, such as the scalenus minimus muscle.[1]

The anterior scalene (AS) classically arises from the anterior tubercles of transverse processes of the third through sixth cervical vertebrae and inserts on the scalene tubercle of the first rib (Fig 1). Variations of the attachment points for the AS include originating from the second cervical vertebra, absence of attachment to the sixth cervical vertebra, and insertion onto the second or even third rib.[2] The middle scalene (MS) muscle classically arises from the posterior tubercles of transverse processes of the second through seventh cervical vertebrae and inserts onto the first rib (Fig 1). Variations of the attachment points for the MS include originating from the transverse processes of the atlas and inserting onto the second rib.[2] The posterior scalene (PS) classically arises from the posterior tubercles of transverse processes of the fourth, fifth, and sixth cervical vertebrae and insert onto the second rib (Fig 1). The PS may also arise from the third and seventh cervical vertebra and often fuses with the MS and first external intercostal muscle to insert on the second or third rib.[2]

The actions of the scalene muscles are generally accepted to include flexion of the cervical spine when the scalene muscles contract bilaterally and lateral flexion of the cervical spine when the muscles act unilaterally.[3-6] When the cervical spine is stabilized, the scalene muscles also act to elevate the first and second ribs during forced inspiration.[3-6] Whether the scalene muscles are individually or collectively capable of rotating the cervical spine in either the contralateral or ipsilateral direction remains unclear. Two commonly used clinical anatomy textbooks do not mention rotation of the cervical spine for the action

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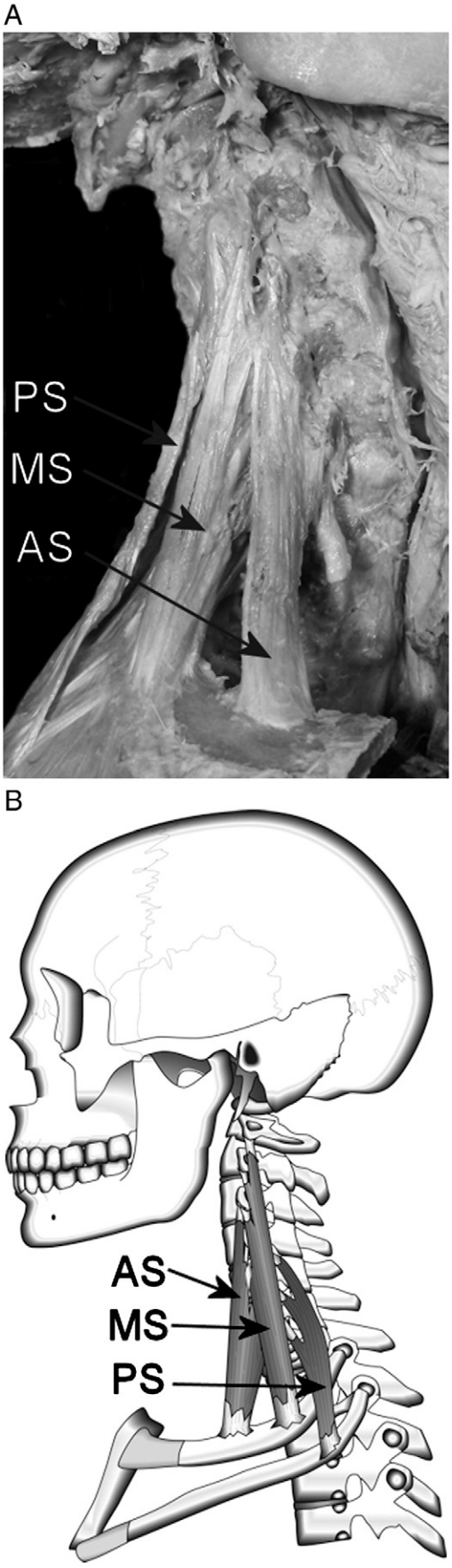

of any of the 3 scalene muscles.[4,5] An anatomical textbook devoted to the muscular system mentions the controversial nature of the scalene's role in cervical rotation and then concludes, based on muscle fiber directionality, that all 3 scalenes produce contralateral rotation of the cervical spine.[5] An anatomical textbook devoted to the spine lists contralateral rotation of the cervical spine under the main actions of the AS and MS muscles but not the PS muscle.[3] The classic 1918, 20th edition of *Anatomy of the Human Body* by Gray[7] assigns no cervical rotational functional at all to the scalene muscles, whereas the 29th American edition of *Gray's Anatomy* edited by Goss[8] states no cervical rotational function for the AS but states that the MS and PS muscles both rotate the neck slightly, with no mention of direction.

Recent studies have reported contradictory findings with respect to the rotational qualities of the scalene muscles as they act on the cervical spine.[9,10] Buford et al[9] produced ipsilateral rotation of the cervical spine in the macaque monkey through electrical stimulation of the scalene musculature. Furthermore, Buford et al[9] were able to produce a muscular stretch in both the macaque and human with rotation of the cervical spine in the ipsilateral direction. Falla et al[10] were unable to detect a significant signal from surface electrodes placed over the AS muscle when the cervical spine was rotated using isometric rotation against a moderate resistance. When compared with the significant signal produced by the sternocleidomastoid muscle, the signal produced by the AS was negligible. Furthermore, where the sternocleidomastoid muscles showed a significant difference between right and left sternocleidomastoid muscles and right and left rotation, Falla et al[10] were unable to identify a significant difference between ipsilateral and contralateral rotation of the cervical spine for the AS muscle.

The present study was designed to take a very straightforward, mechanical approach to determining whether the scalene muscles produce rotation of the cervical spine from a neutral position.

Methods

The lateral neck regions of 7 preserved human cadavers (6 female, 1 male) and 2 fresh/frozen female cadavers were dissected to reveal the AS, MS, and PS muscles. The preserved cadavers were perfused through the common carotid artery with a 5% phenol/2% formaldehyde embalming fluid. The fresh/frozen cadavers were several weeks postmortem and allowed to thaw for 3 days before

Fig 1. *Lateral aspect of the cervical region demonstrating the origin and insertion of the AS, MS, and PS muscles. A, Photograph. B, Illustration.*