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Preliminary evaluation of dorsal muscle activity during resisted cervical extension in patients with longstanding pain and disability following anterior cervical decompression and fusion surgery

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Abstract

Objectives To compare mechanical activity (deformation and deformation rate) of the dorsal neck muscles between individuals with longstanding symptoms after anterior cervical decompression and fusion (ACDF) surgery and healthy controls.

Design Preliminary cross-sectional study.

Setting Neurosurgery clinic.

Participants Ten individuals {mean age 60 [standard deviation (SD) 7.1]} who had undergone ACDF surgery 10 to 13 years previously and 10 healthy age- and sex-matched controls.

Main outcomes Mechanical activity of the different layers of dorsal neck muscles, measured at the C4 segment using ultrasonography (speckle tracking analysis) during a standardised, resisted cervical extension task.

Results A significant group × muscle interaction was found for muscle deformation ($P < 0.03$) but not for deformation rate ($P > 0.79$). The ACDF group showed significantly less deformation of the semispinalis capitis muscle during the extension task compared with the control group [mean 3.12 (SD 2.06) and 6.64 (SD 4.17), respectively; mean difference 3.34 (95% confidence interval −0.54 to 7.21)].

Conclusions As the semispinalis capitis muscle is a powerful neck extensor, the finding of altered activation following ACDF surgery lends support to the inclusion of exercise to train neck muscle performance in the management of these patients.

Keywords: Extensor muscles; Neck surgery; Disc disease; Ultrasonography; Exercise

Introduction

Persistent mechanical neck pain and disability is often reported by individuals who have previously undergone anterior cervical decompression and fusion (ACDF) surgery for cervical disc disease [1–6], despite an overall surgical success rate of approximately 80% [7,8]. Altered muscle function is a recognised feature of painful neck disorders [9,10], and may be a factor in the persistent or recurrent nature of mechanical neck pain as cervical muscles play a significant role in the physical support of the cervical vertebral column [11]. In turn, the presence of pain has been shown to have an

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immediate detrimental impact on the function of cervical muscles [12,13], indicative of a pain–muscle dysfunction cycle in patients with mechanical neck pain. Individuals with longstanding persistent neck pain and disability following ACDF surgery may also exhibit a compromised cervical muscle system. However, to date, the motor function of this patient group has received little research attention.

Initial studies investigating the voluntary contractile performance of the cervical muscles in patients following ACDF surgery reported normal dorsal neck muscle strength of 47% to 79% [1,2], and normal cervical muscle endurance of 11% to 20% [1,4,6] in patients compared with healthy controls. Although these studies reported reduced capacity to generate and sustain torque and endurance following ACDF surgery, they did not determine which muscles had deficient contractile performance. For example, the dorsal neck muscle group is comprised of five layers of muscle, each with some capacity to exert extensor moments to the cervical spine. A previous study in patients with non-surgical-related neck pain reported altered behaviour within these dorsal neck muscle layers when performing resisted extension tasks [14]. Clarification of the specific motor impairments underlying the observed deficits in contractile performance of cervical muscles following ACDF surgery would inform the design of rehabilitative exercises for management of these patients.

This preliminary study aimed to compare the mechanical activity (deformation and deformation rate) of the multilayered dorsal neck muscles between individuals who had undergone ACDF surgery (ACDF group) and individuals who had not undergone ACDF surgery (control group) during a resisted extension task. Mechanical muscle activity was recorded by ultrasound (speckle tracking). It was hypothesised that differences in mechanical activity of the dorsal neck muscles would be evident between the two groups, based on the significant impairments in contractile performance observed previously in this patient group compared with healthy individuals [1,2,4,6]. It was anticipated that the findings of this study would provide feasibility data to underpin a larger study to investigate the mechanisms underlying motor deficits in this patient group, who often suffer longstanding pain and disability.

Methods

Participants

Participants were recruited by convenience sampling (i.e. individuals residing in close proximity to the city where the study was performed). Participants in the ACDF group were identified and recruited from a cohort of individuals who had participated previously in a randomised controlled study. Ten individuals {seven women and three men, mean age 60 [standard deviation (SD) 7.1] years} reporting residual pain {≥10 mm on a visual analogue scale (VAS) [15]} and disability {≥20% on the Neck Disability Index (NDI) [16]} 10 to 13 years after ACDF surgery for cervical disc disease participated in the study. These patients had an average VAS score of 36 (SD 24.9) mm and an average NDI score of 31% (SD 8.9). The control group comprised 10 healthy individuals, matched with the ACDF group for age and sex [mean age 60 (SD 6.5) years]. Individuals were excluded from the control group if they reported a history of neck or shoulder pain or injury, had a VAS score ≥10 mm when asked to rate their general level of neck discomfort [mean 0.08 (SD 0.29) mm] [17], reported previous trauma to the neck or head, reported significant pain in the thorax or lower back, or reported any neurological or inflammatory conditions.

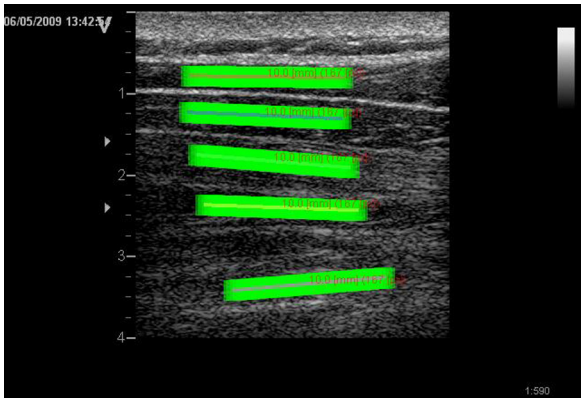

Fig. 1. Longitudinal ultrasound image of dorsal neck muscles with regions of interest from superficial to deep: trapezius, splenius, semispinalis capitis, semispinalis cervicis and multifidus.

Ultrasound measurements

Ultrasound recordings of dorsal cervical muscle activity were made using a 14.0-MHz linear transducer (38 mm footprint) and an Ultrasound Vivid 9 dimension (GE Healthcare, Horten, Norway) unit with a high frame rate (78 frames/second) operated in B-mode and a two-dimensional ultrasound imaging system. Ultrasound images (ultrasound 'video movie' of the dorsal neck muscles) of dorsal cervical muscle activity were recorded throughout the experimental resisted cervical dynamic extension task, and were subsequently analysed as image sequences ('video movies') by postprocess speckle tracking analysis.

The upper trapezius, splenius, semispinalis capitis, semispinalis cervicis and cervical multifidus muscles were recorded (Fig. 1). All recordings were made at the level of the C4 vertebrae, identified by palpation of the C4 spinous process. In order to locate the transducer accurately, it was initially positioned in a transverse orientation at the marked C4 level, permitting identification of targeted muscle layers and bony landmarks. The transducer was aligned longitudinally with the orientation of the dorsal muscles by rotating it 90° to ensure an optimal image plane for the postprocess speckle tracking analysis [18]. The transducer was located and maintained in position by one researcher during all testing procedures.