Muscle Activation Patterns During Shoulder Elevation Following Acromioclavicular Joint Disruption, Surgical Versus Non-Operative Treatment

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INTRODUCTION: Injuries to the acromioclavicular joint (ACJ) are among the most common shoulder injuries among the young athletic population, often compromising the function of the entire shoulder complex by disrupting scapuloclavicular mechanics. Due to the clavicle's role as a functional strut, connecting the thorax to the shoulder complex through ACJ, any disruption can alter the joint's screw axis and impair coordinated motion across multiple planes. These changes can often manifest as scapular dyskinesis, which can negatively impact long-term shoulder health. For individuals with a type III ACJ injury, as classified by the Rockwood scale, treatment options include surgical reconstruction or non-operative conservative management. Regardless of the chosen treatment approach, effective rehabilitation must target the underlying causes of abnormal scapular motion—one of which is neuromuscular in nature and can be assessed through muscle activation patterns. To our knowledge, no detailed analysis has examined shoulder muscle activation following ACJ disruption and subsequent surgical or conservative treatment. Therefore, the purpose of this study was to use surface electromyography (EMG) to investigate shoulder muscle activation amplitudes in the ipsilateral limb of both groups, compared to their contralateral (uninjured) side. We hypothesized that both surgically and non-operatively managed individuals would demonstrate alterations in muscle activation patterns between limbs.

METHODS: Twenty participants (17 men, 3 women; mean age 43 ± 11 years; mean body mass 84 ± 17 kg) with an acute unilateral acromioclavicular joint (ACJ) disruption (Rockwood classification III–IV) sustained within the past 1 to 3 years were retrospectively consented to participate in this study (IRB code: HSC-MS-20-0585). Eleven participants had undergone surgical reconstruction, while nine elected non-operative treatment. Electromyography (EMG) was recorded from seven shoulder girdle muscles (upper/middle/lower trapezius, anterior/medial/posterior deltoid, pectoralis major) on both the ipsilateral and contralateral sides as participants performed shoulder abduction, scaption, and flexion. Retro-reflective markers were affixed to anatomical landmarks to identify each stage of the movement cycle, and a metronome set to 70 beats per minute ensured consistent movement rhythm. EMG signals were processed into linear envelopes and normalized to the maximum activation recorded across all movements. These signals were then time-normalized to enable comparison across each movement cycle. A generalized linear mixed model was used to examine the effects of treatment (surgical vs. non-operative), limb (ipsilateral vs. contralateral), and movement (abduction, scaption, flexion) on the average of each normalized activation, during the upward and downward phase of each movement. For the scope of this abstract, we present only the results for the trapezius muscles due to their predominant involvement in scapular motion.

RESULTS: Figure 1 shows the normalized activations of the trapezius muscles throughout the entire movement cycle (both upward and downward phases) during abduction, scaption, and flexion, comparing the ipsilateral and contralateral limbs in both the non-operative and surgical groups. Additionally, Table 1 presents the average normalized activations of the trapezius muscles for the upward phase of each movement.

	Non-operative						**Surgical**					
	Upper Trapezius		Middle Trapezius		Lower Trapezius		Upper Trapezius		Middle Trapezius		Lower Trapezius	
	Ipsi	Cont	Ipsi	Cont	Ipsi	Cont	Ipsi	Cont	Ipsi	Cont	Ipsi	Cont
Abd	0.36±0.1*	0.44±0.1	0.4±0.1	0.41±0.1	0.4±0.05*	0.36±0.1	0.43±0.1	0.43±0.1	0.46±0.1*	0.32±0.1	0.38±0.1*	0.31±0.1
Scap	0.33±0.1*	0.39±0.1	0.37±0.1	0.33±0.1	0.4±0.04*	0.32±0.1	0.41±0.1	0.39±0.1	0.26±0.1*	0.32±0.1	0.34±0.1	0.3±0.1
Flex	0.37±0.1	0.34±0.1	0.25±0.1	0.21±0.1	0.29±0.04*	0.25±0.1	0.35±0.1	0.39±0.1	0.27±0.1	0.26±0.05	0.3±0.1	0.28±0.1

*Table 1: Average normalized activations (mean ± std) for the trapezius during the upward phase of movements (Abd, Scap, Flex). * denotes p<0.05*

In the non-operative group, the ipsilateral upper trapezius showed significantly lower activation during the upward phase of abduction and scaption compared to the contralateral limb ($p<0.05$). In contrast, the ipsilateral lower trapezius demonstrated higher activation across all three movements—abduction, scaption, and flexion ($p<0.05$). The medial deltoid and pectoralis major (results not shown) also showed increased activation on the ipsilateral side during scaption ($p<0.05$). In the surgical group, no significant differences were observed between ipsilateral and contralateral limbs for the upper or lower trapezius, except for higher ipsilateral lower trapezius activation during abduction ($p<0.05$). The ipsilateral middle trapezius exhibited greater activation during abduction and scaption ($p<0.05$), while the ipsilateral medial deltoid (results not shown) demonstrated reduced activation across all three movements compared to the contralateral side ($p<0.05$).

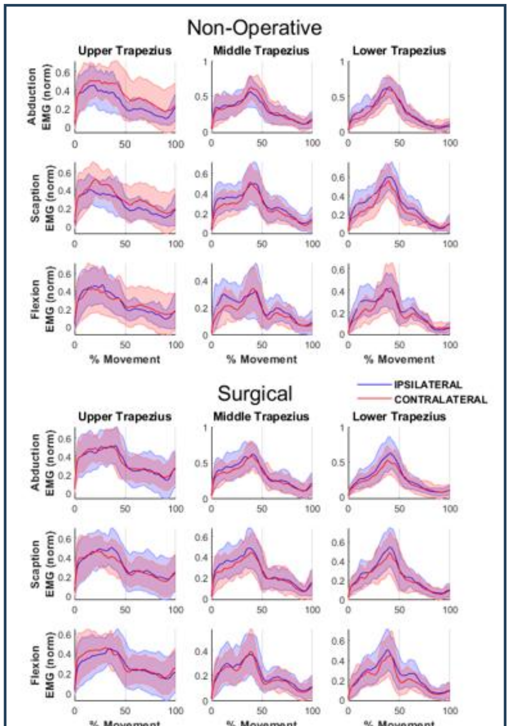

Fig 1: Normalized activations for the trapezius muscles throughout the full movement cycle for Abd, Scap & Flex

DISCUSSION: Distinct interlimb differences in muscle activation were identified in both the surgical and non-operative groups, with the non-operative group showing more pronounced asymmetries. Notably, the non-operative group exhibited reduced recruitment of the upper trapezius and increased recruitment of the lower trapezius in the ipsilateral limb. The upper trapezius, lower trapezius, and serratus anterior are key muscles for scapular stability and mobility, working in coordination to maintain the dynamic force couple required for controlled scapular motion.[1] Previous studies have reported that excessive activation of the upper trapezius, combined with reduced activation of the lower trapezius, can result in diminished upward rotation, increased protraction, and anterior tilt of the scapula.[2] These altered scapular kinematics have further been shown to reduce the subacromial space, potentially leading to pathological contact with the supraspinatus tendon[3], compromising its long-term health. It is possible that the trapezius activation patterns observed in our study may represent a compensatory strategy, given that a disrupted ACJ may no longer provide its strut-like function necessary for maintaining optimal scapulohumeral rhythm.

SIGNIFICANCE/CLINICAL RELEVANCE: The use of surface EMG offers a practical and clinically applicable method for evaluating shoulder muscle function following ACJ disruption, supporting its utility in guiding individualized rehabilitation protocols.

REFERENCES: [1] Kibler et al. (2013) *Br J Sports Med.* 47(14):877-885; [2] Kara et al. (2021) *J Athl Tr.* 56(12):1327-1333; [3] Ludewig et al. (2000) *Phys Ther.* 80(3):27-291.