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CASE SERIES

# THE UTILIZATION OF MULLIGAN CONCEPT THORACIC SUSTAINED NATURAL APOPHYSEAL GLIDES ON PATIENTS CLASSIFIED WITH SECONDARY IMPINGEMENT SYNDROME: A MULTI-SITE CASE SERIES

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## ABSTRACT

***Background and Purpose:*** Secondary impingement syndrome (SIS) is a common complaint in the sporting population particularly among athletes engaging in overhead activities. While symptoms may be present at the shoulder with patients complaining of SIS, spinal alignment or dysfunction can influence scapular positioning and overall shoulder girdle function. As an adjunct therapy to traditional interventions for SIS, thoracic high-velocity low-amplitude (HVLA) thrusts have been utilized and correlated with patient reported decreases in pain. Mulligan Concept (MC) thoracic sustained natural apophyseal glides (SNAGs) are an emerging treatment intervention utilized to treat patients with shoulder pain and dysfunction as the evidence supporting an interdependent relationship between the thoracic spine and the shoulder is growing. The purpose of this case series was to investigate the effects of one MC thoracic SNAG treatment session on subjects classified with SIS, while utilizing a classification-based treatment protocol.

***Case Descriptions:*** Seven subjects classified with SIS were treated utilizing a MC thoracic SNAG. The Numeric Rating Scale (NRS) was administered at initial evaluation, immediately following intervention, and at the 48-h follow-up to identify patient-reported pain during range of motion, manual strength testing, and special tests of the shoulder. Investigators collected the Shoulder Pain and Disability Index (SPADI) at initial evaluation and the 48-h follow-up to identify patient-reported dysfunction.

***Outcomes:*** Following one MC thoracic SNAG treatment (3 sets of 10 repetitions), minimal clinically important differences (MCIDs) were reported utilizing the NRS. A decrease in pain during active shoulder abduction (ABD) was detected immediately post-treatment, and the NRS change scores for resisted external rotation (RER) and active ABD were statistically different and clinically important at the 48-h follow-up.

***Discussion:*** Based on the results of this case series, thoracic SNAGs may influence short-term pain levels and shoulder mobility in the included subjects with SIS and support the concept of regional interdependence (RI) between the thoracic spine and glenohumeral joint. Continued exploration into the proposed benefits of the MC thoracic SNAG treatment as an adjunct therapy when treating patients complaining of SIS is warranted.

***Key Words:*** Impingement syndrome, regional interdependence, intervention

***Level of Evidence:*** 4 (Case Series)

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## BACKGROUND AND PURPOSE

Secondary impingement syndrome at the glenohumeral joint, accounts for up to 44%-65% of all shoulder related medical visits.[1-6] Secondary impingement, defined as impingement secondary to instability in the shoulder, occurs mostly in athletes, under 35 years of age, and completing overhead activity.[7] Commonly, the physical presentation of patients classified with SIS includes a slouched posture or kyphosis,[2] which is indicated by an increase of thoracic spine flexion, resulting in decreased elevation of the glenohumeral joint.[8,9] A kyphotic posture may predispose athletes who participate in overhead sports such as swimming, tennis, baseball, football, volleyball, or javelin prone to developing symptoms of SIS due to the added demands of sporting activities at the shoulder.[8,10-13] Patients with SIS may also develop compensatory motor patterns in the glenohumeral joint and thoracic spine in order to protect painful tissue.[8] Dysfunction of the thoracic spine may influence shoulder complex function, therefore treatment focused away from the local glenohumeral joint on the thoracic spine could result in changes in shoulder pain and function.[14,27]

In response, clinicians and researchers alike have begun to utilize the regional interdependence (RI) model to treat patients classified with SIS as the available evidence is limited regarding which traditional treatment method (i.e., rest, non-steroidal anti-inflammatory drugs [NSAIDs], corticosteroid injections, therapeutic exercise, passive modalities, and manipulation) is recommended.[9,13] Regional interdependence is defined as, "seemingly unrelated dysfunction in a separate region of the body that may contribute to the patient's chief complaint".[14, p. 90] Utilizing the RI model and treating the thoracic spine utilizing interventions such as high-velocity low-amplitude (HVLA) thrusts and sustained natural apophyseal glides (SNAGs) in clinical practice creates an expanded approach for treating SIS beyond the traditional local techniques.[1]

Application of HVLA thrusts occurs as a Grade-5 manipulation at the end-range of joint motion performed on a bony prominence and distinguished from other forms of manual therapy by an audible "pop".[18-22] Comparatively, Mulligan Concept (MC) sustained natural apophyseal glides (SNAGs) is a spinal mobilization technique which combines elements of active physiological movement with an accessory glide directed along the facet joint plane that facilitates pain-free movement throughout osteokinematic range of motion.[16] To date, only HVLA thrusts have been investigated as a treatment for SIS.

Boyles et al[2] assessed the short-term effects of HVLA thrusts demonstrating positive short-term effects with statistically significant results at 48-hour follow-up for shoulder pain and disability index (SPADI) and NPRS values for Neer Impingement Test, Hawkins Test, resisted empty can, resisted internal rotation, resisted external rotation, and active abduction utilizing HVLA thrusts in the management of SIS. Patients (N = 56) were recruited and evaluated based on modified inclusion criteria from Bang and Deyle.[1] Subjects between 18 and 50 years of age, reported a 2 or greater pain rating on a 10-point Numeric Pain Rating Scale (NPRS) with either a positive orthopedic special test in Category 1 *and* reported a 2 or greater on NPRS in either Category 2 *or* any resisted test in Category 3 (Table 2).

Unlike posterior to anterior manipulative procedures such as HVLA thrusts, the advantage of a thoracic SNAG is the facilitation of the correct physiological motion while in weight-bearing.[24] The benefit of the thoracic SNAG treatment to the clinician is the ability to directly affect the painfully restricted movement, even in the acute stage, by using a movement that would normally increase the patient's symptoms but are now pain-free.[16,24] The MC primary guidelines and concept stress the treatment should be **p**ain free, **i**mmediate and **lo**ng-**l**asting, referenced as the PILL concept.[17] A clinician may incorporate a sub-therapeutic SNAG into their initial assessment and if the response matches the PILL concept, the SNAG is clinically indicated at the therapeutic level. Traditionally, researchers and clinicians alike have focused primarily on the painful arm movement rather than the RI theory that mobility of the thoracic spine may affect glenohumeral joint movement. Accordingly, the purpose of this case series was to investigate the effects of one Mulligan Concept thoracic SNAG treatment session on subjects classified with SIS, while utilizing a classification-based treatment protocol.

## Description of Cases: Participant History and Systems Review

Two primary investigators who averaged 12 years of clinical experience, and had both completed three Mulligan Concept Upper Extremity courses that included practical training in the use of cervical and thoracic SNAGs were involved in this case series. Both investigators ensured standardization of all examination, outcome assessments, and treatment techniques performed through video recordings and communication. Investigators established a standard body position at the start of each shoulder motion measurement, and measured glenohumeral joint ROM utilizing the Clinometer application available on a smart phone, via both the android and iOS platforms. The same MC thoracic SNAG treatment protocol was utilized for all patients, although application of the protocol regarding force and direction were specific to each subject. In an attempt to isolate the possible effects of the MC thoracic SNAG, no other intervention (e.g., stretching, modalities, or home program) were applied, nor were modifications of activity imposed.

Seven consecutive patients (6 males, 1 female) representing three "in-season" sports (water polo, baseball, basketball) and one "off-season" sport (volleyball) (Table 1) ranging in age from 15-22 years (mean = 19$\pm$2.83) who presented to the clinic with complaints of SIS were included in this multi-center case series. All subjects denied an acute musculoskeletal injury to the shoulder within the previous 30 days or receiving prior treatment for the current presentation of shoulder pain. Each participant provided informed consent to use their patient case and data, and participant confidentiality was protected according to the United States' Health Insurance Portability and Accountability Act (HIPPA).

**Table 1.** *Patient Demographics*

| | |
|---|---|
| **Gender** | |
| Male | n=6 |
| Female | n=1 |
| **Sport** | |
| Water Polo | n = 3 |
| Baseball | n=2 |
| Basketball | n=1 |
| Volleyball | n=1 |
| **Age** | |
| Range | 15-22 years |
| Mean | 19 years |
| SD± | 2.83 years |

## Clinical Impression #1

Secondary Impingement Syndrome (SIS) is commonly addressed using treatments focused on reducing soft tissue (e.g., tendon, bursae) inflammation and increasing neuromuscular dynamics (e.g., strengthening, proprioception). As the subjects had not reported any previous treatment for the current presentation of shoulder pain and denied any acute musculoskeletal injury within the last 30 days, the cause of the subjects' chief complaint was hypothesized to be a result of repetitive overhead activity. Further evaluation needed to be performed to determine whether the subjects could be classified with SIS versus a scapulothoracic restriction based on traditional evaluation techniques.

## Examination

Investigators began the examination of each subject by administering the Numeric Rating Scale (NRS), Shoulder Pain and Disability Index (SPADI) outcome measures, as well as collecting patient-reported history relating to duration, mode of onset, distribution of symptoms, nature of symptoms, aggravating/relieving factors, and any prior glenohumeral joint treatments. Physical examination included glenohumeral joint ROM, cervical ROM, Spurling's test, Cervical Distraction test, and special tests for the shoulder. The subject self-reported pain utilizing the NRS was reported during the completion of the following orthopedic special tests: Neer impingement test, Hawkins impingement test, active shoulder abduction, and resisted muscle tests for external rotation (RER), internal rotation (RIR), and empty can (REC). For the purpose of this study, due to secondary impingement syndrome not fitting the traditional definition of impingement syndrome, investigators defined SIS in subjects reporting a combination of weakness during resisted muscle testing, decreased activity of the rotator cuff muscles, crepitus, stiffness within the glenohumeral joint which may result in loss of activity and sleep

disturbances, or pain associated with arm elevation above the height of the shoulder while being internally rotated.[1,7,8,12,13]

Inclusion in the study occurred if participants met the classification-based inclusion criteria established by Boyles et al[2] (Table 2). Participants were excluded from the study if they met any of the exclusion criteria listed in Table 3. After consent was obtained, each patient was assessed to determine the vertebral level for treatment by the clinician superficially palpating for spinous process tenderness at T1-T7 vertebral levels, followed by the patient performing active trunk extension with hands over head to elicit pain over the thoracic spinous processes while the clinician superficially palpated to determine the level of vertebral hypomobility (Figure 1). The mobility of the vertebrae was judged to be normal, hypomobile or hypermobile. Interpreting the mobility was based on the clinician's perception and experience of rating mobility of a spinal segment.[25] The matched level of spinous process tenderness and hypomobile segment was deemed the initial treatment level (Table 4). The clinician completed a single sub-therapeutic dose of the thoracic SNAG, at the established treatment level (the determined hypermobile segment). After identifying the painful or restricted level the clinician placed one arm around the patient's chest above the established treatment level, while placing the ulnar border of the mobilizing (treatment) hand over the thoracic spinous process of the determined level and performed a single thoracic SNAG using a cephalad glide applied parallel to the facet joint plane (i.e. toward the patient's eyes) (Figure 1).[17] The patient actively performed one repetition of trunk extension returning to the starting point while the clinician continued to apply the glide. The subject then reported whether an immediate pain-free

**Table 2.** *Inclusion Criteria (Boyles et al., 2009)*[†]

| | |
|---|---|
| **Category 1** | |
| ≥ 2 NRS | Neer's Impingement Sign |
| | Hawkins Impingement Sign |
| **Category 2** | |
| ≥ 2 NRS | Active Shoulder Abduction |
| **Category 3** | |
| ≥ 2 NRS | Resisted Internal Rotation |
| | Resisted External Rotation |
| | Empty Can |

† = Required to have NRS of ≥2 on either test in Category 1 and an NRS of ≥2 with one test in Category 2 or 3

**Table 3.** *Exclusion Criteria*

| |
|---|
| Primary complaint of neck or thoracic pain |
| Demonstrated neurological deficit |
| Positive Spurling's test |
| Received shoulder mobilization or thoracic manipulation for current shoulder pain within the last 30 days |
| Received cortisone injection into the shoulder joint within the last 30 days |

**Figure 1.** *Trunk Extension*

**Table 4.** *Thoracic SNAG Treatment Level*

| | |
|---|---|
| Patient #1 | T7 |
| Patient #2 | T7 |
| Patient #3 | T7 |
| Patient #4 | T6 |
| Patient #5 | T5 |
| Patient #6 | T6 |

response was achieved. A subject report of an immediate pain-free response indicated the treatment level was determined. In the event the patient did not report a pain-free effect to the single sub-therapeutic application, the clinician adjusted (e.g., re-directed angle and/or intensity) the thoracic SNAG and performed a second application. Inability to elicit a pain-free response at the originally assessed level caused the clinician to move to the next vertebral level directly adjacent to the originally assessed segment and provide another single sub-therapeutic thoracic SNAG. A maximum of three consecutive vertebral levels was assessed, and the treatment level was determined as the level in which the sub-therapeutic dosage of the thoracic SNAG the patient reported the pain-free effect.

### Clinical Impression #2

Based on the ROM measurements, results of special tests, and patient-reported history, the investigators developed the working clinical diagnosis of SIS as a result of thoracic restriction. As the subjects' complaints were consistent with the examination results and traditional treatments had yet to be administered, investigators focused treatment on the thoracic region in an attempt to use a RI treatment approach. It was theorized that utilizing MC thoracic SNAGs could assist in resolving any underlying positional fault of the thoracic spine that may have been contributing to their decreased mobility at the glenohumeral joint resulting in a clinical presentation of SIS.

## OUTCOME MEASURES

To evaluate the effect of treatment for SIS, patient-reported outcome measures were utilized to assess perceived levels of pain (NRS) and functional disability (SPADI) as well as impairment based outcomes (i.e., active shoulder ROM) to measure shoulder function. Investigators utilized minimal clinically important differences (MCIDs) and minimal detectable change (MDC) to interpret patient-reported outcomes measures including the benefits derived from treatment, the impact upon the patient, and the implications for clinical management of the condition. Outcome measurements were collected at the initial evaluation, immediately post-treatment, and 48-hours post-treatment. A description of each outcome measure is listed in Table 5.

## INTERVENTION

Treatment began at the vertebral level determined during the patient evaluation and sub-therapeutic thoracic SNAG assessment (Table 4). The investigator provided verbal instructions for the patient to move into trunk extension and provide over-pressure at the end-range of motion while the investigator maintained the transverse glide for a set of 10 repetitions (Figure 1). After the patient clearly understood treatment parameters and the importance of a pain-free treatment, each patient was treated therapeutically. Upon completion of the first set of 10 repetitions, the patient rested for one minute. The clinician then re-applied the thoracic

**Table 5.** *Description of Outcome Measures*

| Outcome Measure | Description |
|---|---|
| **Numeric Rating Scale (NRS)** | A unidimensional, verbally reported, 11-point scale to measure pain intensity in adults and is anchored on the left (score of 0) with the phrase "no pain" and on the right (score of 10) with the phrase "worst imaginable pain". Numeric rating scales have been shown to yield reliable and valid data and shown to be the most responsive (effect size 0.86) Normative data values of the NRS have not been reported in the current literature. Intraclass correlation coefficient (ICC) for test re-test is 0.68 for the NRS in a broad population of patients with various musculoskeletal conditions. The NRS is used to capture the subjects' perceived level of pain as a result of their secondary impingement syndrome. |
| **Shoulder Pain and Disability Index (SPADI)** | The SPADI is a 100-point, 13-item self-administered questionnaire which is divided into two subscales: a five-item pain subscale and an eight-item disability subscale. Each subscale is summed and transformed to a score out of 100. A mean is taken of the two subscales to give a total score out of 100, higher score indicating greater impairment or disability. Normative data values of the SPADI for SIS have not been reported in the current literature. Test-retest reliability of the SPADI total combined subscale scores ranged from 0.64 to 0.66. The SPADI is used to measure the impact of shoulder pathology on pain and disability. |

SNAG at the previously identified level for a total treatment of 3 sets of 10 repetitions with one-minute rest between sets. Total treatment time was less than five minutes.

Immediately following the thoracic SNAG treatment, patients were re-evaluated for pain levels using the orthopedic special tests, resisted muscle tests, and ROM to examine the effects of one treatment of thoracic SNAGs. After completing treatment, all patients resumed normal sport activity. Patients returned to the clinic 48-hours after initial treatment for follow-up with the same provider. Outcomes collection of pain levels (NRS) for orthopedic special tests, function (SPADI), and ROM measurements to assess short term effects on pain and function were conducted. No treatment/examination was conducted at the follow-up and the patient was considered to have completed the study at this time. One patient (N=1) was excluded from the study after failing to return for the 48-hour post-treatment follow-up due to illness unrelated to treatment.

## DATA ANALYSIS

All data was analyzed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). One-way repeated measures analysis of variance (RM-ANOVA) tests were conducted to evaluate the effect of MC SNAGs on the NRS, and shoulder ROM across time. Mean differences from the initial visit scores and 95% confidence intervals (CIs) were calculated for the NRS, and shoulder ROM for post-treatment and at 48-hour follow-up. Significant changes were further analyzed with Bonferroni post hoc testing. Prior to data analysis, normality of distribution was assessed and the alpha level was set at $p < .05$. Effect size differences were computed with partial eta squared ($\eta_p^2$). A small effect size is $\eta_p^2 = 0.02$; medium effect size is $\eta_p^2 = 0.13$; large effect size is $\eta_p^2 = 0.26$.[28]

## OUTCOMES

### Numeric Rating Scale (NRS)

Application of Mulligan Concept thoracic SNAGs did not result in statistically significant improvements in pain (NRS) over time for Hawkins impingement test [Wilks' Lambda = .453, F (2, 4) = 2.415, $p < .05$, $\eta_p^2 = .547$, power = .257] or Neer impingement test [Wilks' Lambda = .724 F (2, 4) = .763, p. < .05, $\eta_p^2$ .276, power = .112]. (Table 6). The mean changes in NRS scores for Hawkins from initial visit to post-treatment (M = 0.00, 95% CI [3.65 - 3.65], p = .05), and from initial visit to 48-hour follow-up visit (M = .667, 95% CI [.511 - 1.84], p = .05) were not significant. Overall effect size ($\eta_p^2$) for pain was 0.55.

However, statistically significant improvements in pain (NRS) during resisted shoulder ROM did occur with resisted external rotation (RER) over time [Wilks' Lambda = .180, F (2, 4) = 9.08, $p < .05$, $\eta_p^2 = .820$, power = .715]. The mean changes in NRS for

**Table 6.** *Statistical and Clinical Outcomes for Pain (NPRS) from Baseline to Post-Treatment and 48-hour Follow-up*

| | Initial Evaluation | Post-Treatment | 48-hour Follow-up | Initial to 48-hour Follow-up Total Mean Change | MCID | Initial to 48-hour Follow-up Total Mean Change *p*-value | Partial Eta Squared |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **NRS** | | | | | | | |
| Neer | 4.2 | 3.2 | 3.8 | .40 | 2 | .524 | 0.28 |
| Hawkins | 1.7 | 1.7 | 1.0 | .70 | 2 | .205 | 0.55 |
| EC, resisted | 2.3 | 2.0 | 1.2 | 1.1 | 2 | .468 | 0.32 |
| IR, resisted | 1.8 | .67 | 1.0 | .80 | 2 | .060 | 0.75 |
| ER, resisted | 5.7 | 4.1 | 2.2 | 3.5** | 2 | .028* | 0.82 |
| Active ABD | 3.7 | 2.8 | 1.5 | 2.2** | 2 | .215 | 0.54 |

NRS = Numeric Rating Scale; MCID = Minimal Clinically Important Difference; EC = empty can; IR = internal rotation; ER = external rotation; ABD = abduction; * = Statistically significant *p* = .05 ** = achieved MCID

RER from initial to post-treatment (M = 1.58, 95% CI [.621 – 2.54], p = .05), and from initial visit to 48-hour follow-up visit (M = 3.50, 95% CI [.550 – 6.45], p = .05 were significantly different. Although resisted internal rotation (RIR) over time [Wilks' Lambda = .246, F (2, 4) = 6.13, p < .05, $\eta_p^2$ = .754, power = .549] did demonstrate a large effect size, there was not a statistically significant difference.

### Shoulder Pain and Disability Index (SPADI)

A paired samples (dependent) *t*-test was used to compare the mean baseline SPADI score to the 48-hour follow-up SPADI score after a single Mulligan Concept thoracic SNAG. The mean initial visit SPADI was 23.06 (+/-6.62) and the 48-hour follow-up visit was 16.28 (+/-10.19). A statistically significant decrease from the initial visit SPADI was achieved ($t(5) = 3.25$, $p = 0.05$) however this value was not clinically significant (Table 7).

### Range of Motion (ROM)

Mulligan Concept thoracic SNAGs failed to produce statistically significant changes in overall shoulder ROM for all measured motions over time. However, shoulder external rotation (ER) [Wilk's Lambda = .512, F (2, 4) = 1.90, p < .05, $\eta_p^2$ = .488, power = .212], and flexion (FLEX) [Wilk's Lambda = .482, F (2, 4) = 2.14, p < .05, $\eta_p^2$ = .518, power = .233] did demonstrate moderate effect sizes (Table 8).

## DISCUSSION

In this multi-site case series, two practitioners of MC utilized thoracic SNAGs to attempt to decrease pain and improve disability at the glenohumeral joint in subjects initially classified with SIS. The Investigators developed this case series based on a report by Boyles et al,[2] however due to low power in our study, identifying statistically significant differences was not possible. Based on the results of this case series, the use of thoracic SNAGs in patients classified with SIS may have an impact on short-term pain and disability. However, the changes observed did not reach the level of clinically meaningful difference. One possible reason why clinically significant change was not realized was that subjects reported pain and

**Table 7.** *Statistical and Clinical Outcomes for Disability (SPADI) from Baseline to 48-hour Follow-up*

| | Initial Evaluation | 48-hour Follow-up | Total Mean Change | MCID | t | *df* | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **SPADI** | 23.06 | 16.28 | 6.78 | 10 | 3.25 | 5 | 0.23* |

SPADI = Shoulder Pain and Disability Index; MCID = Minimal Clinically Important Difference; *Statistically significant different, *p* = .05

**Table 8.** *Statistical and Clinical Outcomes for Shoulder Range of Motion (ROM) from Baseline to Post-Treatment and 48-hour Follow-up*

| | Initial Evaluation | Post-Treatment | 48-hour Follow-up | Total Mean Change | MDC | Initial to 48-hour Follow-up Total Mean Change *p*-value | Partial Eta Squared |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **ROM** | | | | | | | |
| Shoulder FLEX | 146.1° | 144.4° | 152.0° | 5.93° | 8° | .232 | 0.51 |
| Shoulder EXT | 62.5° | 62.4° | 63.8° | 1.23° | 11° | .889 | 0.57 |
| Shoulder ABD | 150.2° | 130.7° | 153.3° | 3.15° | 4° | .589 | 0.23 |
| Shoulder IR | 48.8° | 58.2°* | 56.0° | 7.15° | 8° | .479 | 0.31 |
| Shoulder ER | 104.5° | 108.4° | 95.0° | -9.47° | 9° | .262 | 0.48 |

ROM = Range of Motion; MDC = Minimal Detectable Change; IR = internal rotation; ER = external rotation; ABD = abduction; FLEX = flexion; EXT = extension; * = achieved MDC

dysfunction within 30 days of onset of symptoms, whereas Boyles et al[2] subjects had been experiencing shoulder pain for longer periods of time. This may explain the relatively low initial NRS and SPADI scores which could have resulted in a floor effect.

Additional factors why clinically significant change was not realized include the decision to treat the patient at a single thoracic level which differs from Boyles et al[2] who treated three different levels of the spine with HVLA, and the decision to treat subjects with a manual therapy intervention that does not fall under the category of manipulation. It is possible the single location was not the optimal treatment level and may illustrate the need to treat subjects with SIS using a multi-level intervention versus a single-level treatment approach. Likewise, a treatment intervention utilizing thoracic SNAGs in conjunction with a glenohumeral MWM may produce greater results for patients who do not respond favorably to the thoracic SNAGs alone. The evaluation of thoracic SNAGs in isolation from local interventions such as manual therapy directed at the glenohumeral joint may explain the lack of clinically significant differences that occurred during this case series. Pain associated with SIS may be a result of a local response to injury which may necessitate a local treatment intervention as suggested by Lewis[4] and Teys[29] who reported that for patients with shoulder pain, posteriorly directed pressure applied to the region of the humeral head led to an immediate increase in shoulder elevation range of motion and associated decrease in pain when compared with a sham and a control technique.

Boyles et al[2] did not report ROM values, therefore no comparison between this study and the results found by Boyles et al[2] could be achieved (Table 8), however several explanations for an immediate change of ROM are proposed. First, the application of thoracic SNAGs may improve thoracic mobility indirectly leading to improved shoulder range of motion. Otoshi et al[30] suggest that a reduction in thoracic kyphosis can lead to an improvement in shoulder ROM, and manual therapy that includes thoracic spine interventions may provide decreases in self-reported pain measures and disability in patients with SIS. Second, an increase in shoulder ROM may be a result of decreased neuromuscular inhibition. Cleland et al[31] demonstrated an increase in lower trapezius muscle strength immediately following thoracic manipulation. Lastly, a hypothesized hypoalgesic effect may contribute to the reduction of shoulder pain leading to an increase in shoulder range of motion.

Other research conducted regarding ROM and the shoulder include various research studies conducted to determine the effect of several stretching protocols aiming to improve glenohumeral internal rotation deficit (GIRD), a possible precursor to SIS. For example, one investigation utilizing a sleeper stretch demonstrated an average12.4° increase in subjects over a four-week static stretching program.[32] Similarly, use of sleeper stretches produced an increase of 3.1° in IR after one treatment session.[33] In a collegiate baseball population, a four-week stretching-plus-mobilization protocol demonstrated an increase of 19° in IR in subjects.[34] Linter et al[35] reported IR increases however, those increases were only achieved after a three-year IR stretching program. Shoulder ROM improvements associated with stretching protocols are found with static stretching, but the findings also suggest the improvements required repetitive application of the stretching protocols targeted to specific musculoskeletal tissues over extended time frames.

## LIMITATIONS AND FUTURE RESEARCH

Limitations of this study include a lack of a control group or randomization of patients, and that only short-term follow-up was conducted. A limitation inherent to all case series research is a small sample size and relatively specific patient population. Despite these limitations, the results of this case series demonstrate the potential to reduce pain and disability in patients classified with SIS. Continued investigation utilizing a cohort study format is needed to determine if the observed total mean changes for shoulder IR, ER, and FLEX ROM in this study from a single MC thoracic SNAG treatment challenge the efficacy of static stretching protocols. Also, cohort studies comparing immediate results of Mulligan Concept thoracic SNAGs versus thoracic manipulation and Mulligan Concept thoracic SNAGs combined with a glenohumeral MWM would be beneficial in determining the effectiveness of the thoracic SNAG technique. Additional research is also necessary to determine the effectiveness of a single

treatment versus the cumulative effects of multiple thoracic SNAG treatments on multiple spinal segments when warranted.

## CONCLUSION

The present case series is the first to investigate the use of thoracic SNAGs for the treatment of SIS. Based on the increases seen in shoulder internal and external rotation and shoulder flexion (ROM), as well as decreases in pain (NRS) with resisted external rotation (RER), the thoracic spine treatment intervention demonstrated in this case series, appears to benefit patients classified with SIS which supports the RI model. Although additional studies with larger sample sizes are needed to establish the clinical value of utilizing a single treatment session thoracic SNAG to treat patients complaining of SIS, this case series provides an initial framework for a clinical model utilizing manual therapy through regional interventions for patients with SIS.

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