EFFICACY OF REFLEXIVE NEUROMUSCULAR STABILIZATION DURING TREATMENT OF SCAPULAR DYSKINESIA IN AN OVERHEAD ATHLETE: A CASE REPORT

Joshua D. Cramer, DAT, LAT, ATC, CSCS, CES¹

Alan Nasypany, Ed.D, LAT, ATC²

ABSTRACT

Background and Purpose: Shoulder injuries are common amongst overhead athletes. Dysfunctional motor patterns (scapular dyskinesis) may be the cause or result. Improperly treated, they can sideline athletes or reduce quality of life. Current treatment protocols are lengthy and may result in recurrence. Individualization of treatment is key. Functional tests, like the Selective Functional Movement Assessment (SFMA), help discern and properly identify dysfunction, paving the way for interventions like reflexive neuromuscular stabilization (RNS). RNS focuses on restoring proper motor control and may positively influence healing. The purpose of this case report is to describe an evaluation and treatment strategy for scapular dysfunction in an overhead athlete.

Case Description: The subject was a 16-year-old, multi-sport athlete in the high school setting. He presented with upper back pain during his sophomore baseball season. Clinical findings upon examination included but were not limited to irregular scapular positioning as compared bilaterally, dysfunctional scapular movement patterns, soft tissue muscular irritability and loss of glenohumeral (GH) ROM in internal and external rotation, flexion and abduction. Intervention consisted of a combination of positional release therapy and reflexive neuromuscular stabilization aided by some traditional therapeutic modalities.

Outcomes: The combination of conservative treatments and RNS provided relief of the subject's symptoms in a shorter time frame, three treatments over the course of six days, than just utilizing traditional protocols. The utilization of the paired treatments resulted in diminished pain, restored ROM and improvement in perceived fluidity (speed and stability) of motion as observed by the clinician. A minimal clinically important difference (MCID) was reported on the disablement of the physically active scale (DPAs) on all follow-up treatments as well as on the numeric pain rating scale (NPRS) after the first and second treatments. The minimal detectable change (MDC) requirement was met on the patient specific functional scale (PSFS) prior to the second and third treatment. The activities measured with the PSFS were: GH flexion, GH abduction and throwing a baseball.

Discussion: In this case report, the use of the SFMA along with a traditional orthopedic examination allowed for proper identification and location of the dysfunctional motor patterns. The coupling of a traditional modality like the moist heat pack, with PRT and RNS proved to be a beneficial treatment combination for this subject as it provided a clinically meaningful resolution of his condition. Even though current literature suggests that treatment for scapular dysfunction is comprised of three phases over the course of ten weeks, clinicians should focus on the individualization of the treatment, possibly utilizing novel interventions like PRT and RNS.

Level of Evidence: 4 Case Report

Keywords: Movement patterns, motor control, shoulder complex

CORRESPONDING AUTHOR

Joshua Cramer
NovaCare Rehabilitation
Head Athletic Trainer – Germantown
Academy
Phone: (267)405-7499
Fax: (267)405-7499
E-mail: Joshua.Cramer@
GermantownAcademy.org

¹ NovaCare Rehabilitation/Germantown Academy, Fort Washington, PA, USA

² University of Idaho, Moscow, ID, USA

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INTRODUCTION

Pain and injuries to the shoulder complex are common amongst overhead athletes.¹⁻³ The sequencing of the throwing motion engages multiple muscles and joints due to the various motions that occur through numerous planes.⁴ The shoulder complex is comprised of series of bones (clavicle, humerus, scapula, sternum and rib cage) and three joints; sternoclavicular, acromioclavicular, glenohumeral, and a single scapulothoracic articulation. A great deal of mobility at the glenohumeral joint is derived from the shape of the glenohumeral (GH) joint and the mobility of the scapula in relation to the thorax.⁵ This relation creates the three-dimensional (3D) pattern known as scapulohumeral rhythm (SHR).^{6,7} Observable regions of the scapula that help define position are the medial border and inferior angle prominences relative to the thoracic cage.⁸ Individuals with healthy, fully functional shoulder complexes will have bilateral positional symmetry. This can be determined through a visual assessment. Proper anatomical positioning is essential to efficiently optimize SHR. Alterations of scapular positioning and motion are known as scapular dyskinesis.⁹ The abnormal movement patterns exhibited in this condition are: early scapular elevation (shrugging) during GH abduction and/or a rapid downward rotation during GH adduction, abnormal static scapular positioning and/or dynamic scapular motion characterized by the medial border and inferior angle prominences.⁸

These alterations may be the result of a number of causes: fatigue, neurologic dysfunction (eg, accessory, long thoracic or dorsal scapular nerve palsies) or muscular inhibition created by intra-articular GH or subacromial pathologies (eg, subacromial impingement, rotator cuff pathology, internal impingement, labral pathology, GH instability, GH arthritis, and adhesive capsulitis).¹⁰⁻¹⁹ Scapular dyskinesis has been shown to be present in as few as 67% and as many as 100% of athletes with shoulder injuries in various studies and may present in asymptomatic individuals as well.^{20,21}

Traditional rehabilitation protocols focus on stretching and strengthening, however, in recent years muscle activation and motor control have become the staple. Commonly utilized protocols are three-phased

(acute, recovery, maintenance) and may not be individualized based upon the results of clinical examination.²² These traditional protocols tend to last upwards of three months depending on severity and, based on clinical experience, if not conducted on an individual basis (and closely supervised) may culminate in reinforcing negative motor patterns. In 2014, Cools et al. created a clinical reasoning algorithm, which identified two causes of the dysfunction, flexibility and muscle performance. The algorithm ultimately leads the clinician to suggested therapeutic strategies.²² It may appear as though the guidelines, principles and protocols are straightforward however, the actual rehabilitation progression is commonly elaborate and prolonged (i.e., the diagnosis and classification may be more advanced than the treatment).²³

Incorporating a functional movement assessment into the evaluation process enables proper location and identification of sources of dysfunction. The selective functional movement assessment identifies three types of dysfunction: joint mobility dysfunction (JMD), tissue extensibility dysfunction (TED) and stability or motor control dysfunction (SMCD).²⁴ Joint mobility dysfunction is defined as a reduction of mobility of a spinal articular segment or peripheral joint.²⁴ Tissue extensibility dysfunction recognizes multiple soft tissues which could contribute to dysfunction (muscle, tendon, fascia, capsule, ligament, etc), and SMCD is an updated description of movement pattern or stability problems.²⁴ The term SMCD is an updated term which correctly describes “movement pattern stability problems”. In order to accurately distinguish a stability issue, one must reflect on a number of things: the CNS, PNS, motor programming, movement organization, timing, coordination, proprioception, joint and postural alignment, structural instability and muscular inhibition as well as what the original term centered around, strength of stabilizers.²⁴

Once the dysfunction is properly located and identified, it is important to select the proper treatment. Reflexive Neuromuscular Stabilization (RNS) is an updated concept derived from Reactive Neuromuscular Training (RNT) and is an umbrella term describing a variety of rehabilitation techniques designed to restore dynamic stability and motor control to an injured joint.²⁵ This is achieved through utilizing

movement pattern exercises which facilitate the central nervous system's (CNS) ability to interpret and integrate peripheral signals.^{26,27} Joint movement and position sense promote the peripheral signals in and around the articular structures of the joint.²⁶ When pertaining to the shoulder, mechanoreceptor feedback and central programming from the articular structures relay this information to the motor cortex helping the body perceive joint movement and position.^{26,28} All this is accomplished by placing a light external stimulus which augments the dysfunctional movement, thus forcing the patient to actively correct the faulty pattern.^{27,29} RNS is typically used in conjunction with traditional rehabilitation protocols to promote the return of functional movement and is accompanied by quicker return to play (RTP) timelines than traditional protocols.^{27,29} Currently, there is no definitive guideline as to when RNS should be implemented within a rehabilitation protocol, however, clinical reasoning and experience dictate addressing RNS towards the end of a rehabilitation session when the muscles are most fatigued allowing for resetting healthy motor patterns.²⁶ In an RNS treatment session, the clinician identifies the faulty movement (e.g., shrugging during shoulder flexion) and provides a stimulus that is designed to trigger the dysfunctional movement. The purpose of this triggering is to create proprioceptive awareness with the intent of allowing the patient to react and as a by-product initiating the "desired" movement in the pattern (i.e., movement in the opposite direction). The activity is best performed with the eyes closed and prior to the initiation of movement. Between each repetition the patient is encouraged to completely relax while the clinician stimulates the reflexive reaction and then the patient performs the movement. The advantage to RNS is that it mimics what naturally occurs in the body during movement. The body makes few conscious movement decisions when it is functioning optimally. The closer the process gets to reflex reaction, the better for normal performance. The purpose of this case report is to describe an evaluation and treatment strategy for scapular dysfunction in an overhead athlete.

CASE DESCRIPTION

The subject, an otherwise healthy 16-year-old multi-sport (football and baseball) high school athlete,

presented with upper back pain (UBP) during his sophomore baseball season. The symptoms were chronic and the patient had been symptomatic for approximately three and a half weeks with no prior history of back pain or injury. The patient did not recall any single traumatic incident resulting in the onset of symptoms. The discomfort began to slowly extend up through his neck and into his right shoulder complex. The patient had appeared in games as both a pitcher and centerfielder but was transitioning solely to centerfield. During practices the patient noted a significant decrease in throwing velocity (88 mph down to 67 mph), as measured with a radar gun, and distance; most noticeably when attempting to throw from mid-centerfield to home plate. Prior to injury the patient was capable of such a throw with ease, but as symptoms progressively worsened he had difficulty with his throws reaching past second base.

Decreases in upper body strength were identified by the strength and conditioning coach while focusing on various back exercises (lat pull down, seated high and low rows, hang clean and power clean). These exercises elicited both significant weakness and pain throughout his upper back. After two weeks pushing through workouts in the gym and on the field, pain levels around the upper back increased, ultimately sidelining him from sport specific activity and leading him to the clinic for evaluation and treatment.

CLINICAL IMPRESSION #1

The lack of an acute traumatic incident led the clinician to believe the nature of the injury was chronic and did not appear emergent. When the nature of the injury is chronic, dysfunctional movement patterns may play a key role in the cause. A functional movement assessment becomes a key part of the evaluation process to single out any dysfunctional movement patterns. One popular movement assessment available is the Selective Functional Movement Assessment (SFMA), which is a regional/global orthopedic functional examination. The use of the SFMA allows for location and identification of the type of dysfunction and should be implemented as part of a traditional orthopedic examination.²⁴ This form of a treatment-based classification (TBC) may allow for individualization when implementing the intervention.

EXAMINATION

Upon initial examination the patient presented with pain and point tenderness around the right (dominant) glenohumeral (GH) joint and scapula with decreases in ROM. Range of motion was measured using a goniometer with the patient in a seated position. Placing the patient in a seated position removed any hip involvement and allowed the clinician to take measurements as well as observe bilateral scapular movement and positioning occurring solely within the shoulder complex.²⁷ Internal and external rotation measurements were taken in 90°/90°. The patient had full PROM however, flexion and abduction produced 3/10 on the NPRS. All measurements are presented in Table 1. All motions produced increases in pain while the fluidity (speed + stability) throughout flexion and abduction were deficient when compared bilaterally as noted through clinician observation. A tender point evaluation was conducted marking any painful points during palpation around the scapula and GH joint. Upper limb neural tension tests were all negative and no common symptoms of neurologic pathology were present, (ie. burning, numbness, tingling).

Special tests for the rotator cuff (RC) and labrum produced the following results: Gum-Turn test³⁰ and Belly Press test³¹ were negative, while the Lift-Off test³² produced minimal pain thus ruling out RC

pathology. The Dynamic Labral Shear test,³³ Kim Test,³⁴ and Grind test³⁵ elicited negative results ruling out labral lesions. As there was no identifiable mechanism and each test produced negative results, the clinician proceeded with the Selective Functional Movement Assessment (SFMA) to evaluate movement patterns.

The SFMA top tier tests (used to quickly evaluate regions) demonstrated dysfunctional non-painful (DN) movements for cervical flexion (CF), cervical extension (CE), right cervical rotation (CR), and left upper extremity (UE) patterns one and two. Dysfunctional painful (DP) UE patterns one and two were present on the right. The only functional painful (FP) movement was cervical rotation to the left, all other movements, multi-segmental flexion, extension and rotation, single leg stance and overhead deep squat all produced functional non-painful (FN) movements. During the UE patterns irregular scapular positioning and movements were detected. Using the results of the SFMA top tier, the clinician followed up with the SFMA algorithmic breakouts to further discern the type of dysfunction. Working through all the breakouts, starting with the DN and working through the DP, it was determined the main dysfunction causing the subject's symptoms was an SMCD in the UE patterns of the right side.

Table 1. *Objective measurements.*

	Initial Exam	Pre Tx 1	Pre Tx 2	Pre Tx 3	Post Tx 3/Discharge
ROM:					
IR	60°	61°	73°	79°	87°
ER	67°	69°	74°	82°	93°
Abduction	110°	135°	162°	181°	184°
Flexion	85°	119	153	177°	194°
MMT w/o pain:					
Post. Delt.	3/5				5/5
Upp. Trap.	3/5				5/5
Rhom/Lev Scap	3/5				5/5
IR (side)	5/5				5/5
ER (side)	5/5				5/5
MMT w/pain:					Pain-free:
Ant. Delt.	3/5				5/5
Mid. Delt.	3/5				5/5
Serr. Ant.	4/5				5/5
IR (90°/90°)	3/5				5/5
ER (90°/90°)	3/5				5/5

Lastly, a tender point evaluation was conducted with the subject lying prone and the clinician marking (with a pen) any points of tenderness from the neck down to the mid-back. Tender points were located around the distal neck along the levator scapulae and into the upper trapezius, along the medial border of the scapula as well as throughout serratus anterior.

CLINICAL IMPRESSION #2

At this juncture it was concluded the SMCD was likely the primary culprit behind the symptoms. Upper trapezius, levator scapulae, and serratus anterior appeared upregulated (facilitated) creating tension, irregular scapular positioning, and aberrant movement patterns ultimately leading to pain. This led the clinician in a direction to better individualize the treatment. The combination of traditional techniques and RNS seemed ideal for pain management and resetting motor patterns. The use of a moist hot pack would help relax and down-regulate the superficial soft tissue structures therefore decreasing pain and allowing for the RNS to properly restore functional motor patterns and restore fluidity of movement and ROM bilaterally. The fostering of new motor patterns would likely decrease the chances of recurrence.

INTERVENTIONS

Treatment Procedure

The initial goal of treatment was to decrease pain and relax the surrounding soft tissues structures. For this, the combination of a moist heat pack was used to relax the superficial tissue while Positional Release Therapy (PRT) was utilized to address any tender points discovered during the tender point examination. Positional release therapy is a technique stemming from strain-counterstrain and is used by placing the body (tissues and appendages) in a position of relaxation and comfort to remedy somatic dysfunction.³⁶ Between the moist hot pack and PRT tension decreased and tender points were eliminated. The next step was to restore functional scapular movement patterns. Reflexive Neuromuscular Stabilization provided stimulus to the muscles to restore (groove) the desired motor patterns. Starting with retraction, the clinician used his fingers to place a stimulus along the lateral border of the scapula as the subject elevated ("shrugged") his shoulder.

This movement was conducted a few times with finger placement moving back and forth along the lateral border. Next, stimulus was applied across the spine of the scapula as the patient abducted his arm. This was to correct upward rotation. The last phase of the RNS treatment utilized the "Reach, Roll and Lift" and "Pillow Press" techniques.³⁷

The "Reach, Roll and Lift" was accomplished with the patient in a folded over kneeling "prayer" position. (Figure 1) The starting position involves the subject kneeling down and sitting back on his heels. The "Reach" has the patient slide his hand as far out as possible remaining in complete contact with the surface at all times. This engages serratus anterior.³⁷ Once the patient was symmetrical bilaterally he advanced to the "Roll". The "Roll" engages the external rotators and stabilizes the humerus in external rotation. Last is the "Lift". While maintaining full reach and ER the patient was instructed to lift his arm off the table facilitating the lower trapezius.

The Pillow Press places the patient in the supine position with the involved side raised above the head, palm facing upwards and propped up on a max of three pillows. (Figure 2) The uninvolved side is placed palm down alongside the body. With the goal of producing an isometric contraction, the patient was asked, with both hands, to press down on the pillows and the table simultaneously. This may be repeated removing one pillow at a time. The contraction facilitates lower trapezius firing on the involved side and the upper trapezius firing on the uninvolved side with retraction while depressing the scapula just as with the "Lift".³⁷

To reinforce proper motor control and facilitate proper function, the FMS "Functional Taping & Assessment Clinical Manual, recommends taping.³⁷ Leukotape® was utilized for facilitation taping of the upper and lower trapezius. To accomplish this, three strips of cover-roll® were first placed from the acromion process down the lateral border to the inferior angle, the acromion process across the spine of the scapula to the C6-C7 junction, and lastly, the third strip was applied across the thoracic spine over the paraspinal musculature connecting the other two strips to make a triangle. The second phase of the taping was applying the Leukotape® over the

Figure 1. The Reach-roll-lift exercise for scapular stability, focuses on lower trapezius. A. “Reach” component; B. “Roll” component; C. “Lift” component

Cover-roll® keeping the muscles in a shortened, relaxed position as not to impose force. (Figure 3)

Once the tape was applied the patient was reassessed. Range of motion remained normal and pain-free. The patient was instructed to keep the tape on until his next visit when new tape was applied. Facilitation taping was used throughout the remainder of the season before every game and bullpen session.

Patient-Reported Outcomes

Four outcomes measures were selected for data collection. They were selected for the purposes of gathering patient perceived measurements of disablement and quality of life from a global (whole-body) as well as local (shoulder complex) standpoint. Outcome measures utilized during the treatment process were the Disablement for the Physically Active scale (DPAs), Numeric Pain Rating Scale (NPRS), the

Shoulder Pain and Disability Index (SPADI), and the Patient Specific Functional Scale (PSFS). (Table 2)

The DPAs is a generic and multidimensional patient reported outcome instrument which is used to measure the perceived limitations a patient with a musculoskeletal injury may experience.³⁸ The DPAs was taken prior to each treatment and at discharge. Initial DPAs score was 52 out of a possible 80. The minimal clinically important different (MCID) of 9 was met for each follow-up score.^{38,39} At the time of discharge, the score had decreased to 16 which is the minimum, or best score possible.

The NPRS is a unidimensional numeric counterpart to the visual analog scale (VAS) and is used to measure pain intensity.^{40,42,43} The first NPRS score was taken at the time of initial evaluation and was rated as an 8/10 for current pain (refer to figure 1.1). Pre- and

Figure 2. Pillow press with 2 pillows. The subject simultaneously presses down on the pillows with the palm facing up while the other hand presses down on the table with the palm facing down.

Figure 3. Supportive taping used for the subject
A. Pull first strip of Cover-Roll® from acromion to inferior angle. Second strip from acromion to C6-7 junction and third strip intersecting the first two strips.
B. Follow the same path with Leukotape®.

post-initial treatment his current NPRS scores were 7 and 2 respectively for a decrease of 5 meeting the MCID requirement.⁴⁰⁻⁴² The following treatment also met the requirements of the MCID with pre-and

post-treatment scores of 3 and 1. By the end of the third treatment all pain had been eliminated.

The SPADI is used to measure pain and disability accompanying shoulder pathology. It is a self-administered guide consisting of two subcategories, pain and disability, broken into 13 items, and lower scores indicate better outcomes.⁹ All three SPADI scores were taken prior to each treatment with an initial total score of 21.25%. The initial score dropped to 10.77% prior to the second treatment and 2.30% prior to the third treatment. These SPADI scores just missed the criteria for the minimal detectable change (MDC) of 13 points.^{46,47}

Lastly, the PSFS, which is an instrument intended to evaluate functional change, mainly in patients presenting with musculoskeletal disorders, was utilized.⁴⁸ Activities tested were: GH flexion, GH abduction and throwing. As for total scores, each score was taken pre-treatment. The initial score was 3.67 and increased to 5.67 meeting the MDC of 2.⁴⁹ The following treatment also met the MDC for a total score of 8 and the final score was 9.33. For a complete listing of all scores please refer to Table 1. Of note, ranges of motion tested during initial evaluation increased as follows: ER increased from 67° to 93°, IR increased from 60° to 87°, abduction and flexion both produced full arcs of motion with bilateral fluidity. At final examination, all motions and all MMT's were pain-free and MMT's were graded at 5/5 for all musculature. A follow-up SFMA top tier was conducted and demonstrated no dysfunctional painful movements. All movements were now functional non-painful with the exception of upper extremity patterns one and two on the left side. Both resulted in dysfunctional non-painful movements. As the left shoulder was not the focus of the treatment, this was not identified as return criteria. The subject would eventually follow-up to clear out those dysfunctional patterns at a later time. Lastly, some sport-specific throwing tests were conducted. The two tests were throwing a fastball from the wind-up position and throwing from mid-centerfield to home plate. Prior to injury the subject's fastball was clocked at approximately 88 mph by radar gun. During this post-treatment test he clocked in at 87 mph. As for throwing distance, he was once again able to complete the throw from mid-centerfield to home plate.

Table 2. *Patient-reported outcomes.*

	IE	Pre Tx 1	Post Tx 1	Pre Tx 2	Post Tx 2	Pre Tx 3	Post Tx 3/Discharge
DPA's		52		40*		26*	16*
NPRS (Current)	8/10	7/10	2/10*	3/10	1/10	1/10	0/10
SPADI (Total Score)		21.25%		10.77%		2.30%	
PSFS		GH flexion = 3 GH ABD = 5 Throwing = 3 Avg = 3.67		GH flexion = 6* GH ABD = 7 Throwing = 4 Avg = 5.67*		GH flexion = 8 GH ABD = 9 Throwing = 7* Avg = 8*	GH flexion = 10 GH ABD = 10 Throwing = 8 Avg = 9.33
<p>DPA's=Disability in the Physically Active Scale; NPRS=Numeric Pain Rating Scale; SPADI=Shoulder Pain and Disability Index; PSFS=Patient Specific Functional Scale ER; IR; ABD; Flex = measured using AROM</p> <p>*MCID met DPA's = 9 NPRS = 2 SPADI = 8 or 13.1 (Shoulder Pain)</p> <p>**MDC met SPADI = 18.1 (Musculoskel. UE Problems) SPADI = 21.5 (Shoulder Problems) PSFS = 2 (avg score), 3 (single activity)</p>							

DISCUSSION

Clinical results associated with treatment of this subject were positive indicating the selection and versatility of the evaluation and treatment was ideal for this individual. Results of the patient reported outcomes demonstrated improvements in pain and disability in this case. The manner in which the subject presented was reason enough for the clinician to not only conduct a typical orthopedic evaluation but also a functional movement screening. As there was no specific lesion or injury, the utilization of the SFMA was key in identifying type and detecting the location of a dysfunctional motor pattern. The identification of dysfunction enabled the clinician to construct an individualized treatment plan, focused on stability and motor control.

The versatility and variety of treatments each served a purpose. The use of the moist hot pack not only relaxed the superficial tissue but also relaxed the subject during the rest of the treatment which played an important role as sometimes patients are not always willful believers in their treatment (due to pain presentation or inability to relax), and then may face barriers to healing or altering movement strategies. The PRT was a quick and effective technique for identifying and treating tender points along the scapula and upper back. Once all tender points were eliminated, the clinician was successful in using RNS to relearn the proper motor patterns.

This combination of PRT and RNS appears to be a proactive effective combination for treating soft tissue structures presenting with dysfunctional motor patterns.

There are many ways to evaluate and treat the shoulder complex but a treatment-based classification system should be considered especially when a specific mechanism is unknown. Using a system to classify the dysfunction will allow the clinician to go beyond traditional rehabilitation protocols and incorporate treatment techniques focusing on dysfunction and not only specific local injuries.

Any case report is accompanied by limitations. In the instance of a single case report with a focus on one subject there is going to be less clinical generalizability as compared to a case series or a study with a larger sample size. Through one subject there is no proven validity or reliability of the treatment. The nature of the subject's complaint also plays a major role. Since there was no discernable injury and the issue at hand was a dysfunction, it is harder to compare cases in future research. The subject was also given instructions to rest in between treatments but there was no monitoring of the individual during these times. Lastly, since multiple treatment interventions were used, it is hard to distinguish the amount of contribution of each to the eventual outcome.

CONCLUSIONS

The subject of this case report improved quickly as he returned to sport within a week. Given the clinically meaningful reduction in pain and improvements in reported function, this case report demonstrates how RNS combined with traditional therapeutic modalities positively affected the rehabilitation and return to sport of an adolescent overhead athlete. Future higher-level research is needed to fully explore the effectiveness of RNS when treating dysfunctional motor patterns.

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