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Case Study: The Effects of Cervical Bony Abnormalities on Recurrent Brachial Plexus Stingers in a Collegiate Division I Football Player

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Abstract

Background: Brachial plexus (BP) injuries, also known as stingers, are prevalent in contact sports and usually result in neuropraxia lasting for a few seconds to minutes. A 21-year-old Division I sprint football player of Asian descent with a bony abnormality at the C5-C6 level sustained a brachial plexus injury when tackling an opponent on September 1, 2012, resulting in neurological symptoms lasting for one week. He complained of paresthesia radiating from his left shoulder to his fingertips, as well as slight pain at the C5-C6 level with left lateral flexion and rotation. An extensive previous history of cervical spine trauma resulted in thorough examination of the athlete's case. A week later, an additional brachial plexus injury was sustained, and the athlete was referred to an orthopedic surgeon for further diagnostic imaging and evaluation. Examination showed a negative Spurling's test, normal x-rays, and an abnormal presence at the C5-C6 vertebral level on MRI. The athlete was cleared to return to play (RTP) when signs/symptoms (s/s) ceased, and after diagnostic imaging was conducted and the anatomical anomaly was deemed benign. Differential Diagnosis: Brachial plexus stinger, chronic brachial plexus syndrome, posterior longitudinal ligament (PLL) calcification or uncinate process bone spurring predisposing to stingers. Treatment: After range of motion (ROM) and manual muscle tests (MMTs) were restored and the anatomical abnormality was deemed benign, the athlete returned to competition with the use of a cowboy collar. Initial treatment was ice, rest, non-steroidal anti-inflammatory drugs (NSAIDs) and thermotherapy to modulate pain. The athlete was placed on a rehabilitation plan and instructed to perform cervical ROM and strength exercises and followed a 9 minute shoulder exercise protocol. He also performed functional exercises and received instruction on proper tackling and blocking techniques before RTP. Uniqueness: Although brachial plexus injuries are common in football, neurological s/s generally subside within a short period of time. The athlete in this case study had evidence of either a PLL calcification, common in the Asian population, or a uncinate process spurring; both of which lead to spinal stenosis and thus an increased risk of sustaining a brachial plexus injury. This case is unique, because measurements of the spinal canal were within normal limits, yet s/s persisted. Conclusions: Previous history of numerous brachial plexus injuries and a traumatic cervical spine injury were believed to be attributed to a structural abnormality at the C5-C6 vertebral level. The origin of the abnormality is unknown, and the abnormality was determined to pose no major threat to the athlete. Although RTP was controversial, this athlete was allowed to be treated symptomatically, and cleared for full RTP.

Keywords: Stingers, Calcification, Stenosis

1. Introduction

Cervical spine injuries occur frequently in contact sports, namely football, wrestling, and men's lacrosse.[1] The cervical spine consists of 7 vertebrae, 8 corresponding nerve roots, a vast network of blood vessels, and numerous stabilizing muscles and ligaments. Of particular importance are the anterior and posterior longitudinal ligaments,

which provide support to the spinal column. The anterior longitudinal ligament (ALL), stretches from the sacrum to the C2 vertebra, preventing excessive spinal extension. The posterior longitudinal ligament (PLL) also stretches from the sacrum to C2, and prevents excessive spinal flexion.[2] These ligaments are imperative in providing protection to the spinal cord and restraining excessive motion on the spine, thus preventing trauma to the spinal cord. All spinal injuries should be taken very seriously and any damage to the spinal cord regarded as a medical emergency.

Injuries to the brachial plexus are extremely common in collision sports, and can be referred to as "burners" or "stingers".[1] Brachial plexus neuropraxias, or "stingers", are temporary peripheral nerve injuries that affect the muscles and nerves of the upper extremity due to abnormalities in nerve conduction. They can occur at any nerve root along the cervical spine, yet are most common at C5-C6.[3] According to Chao et. al, "An estimated 49-65% of collegiate football players experience a stinger at least once in their career, with a recurrence rate of 87%."[1(p.69)] In the field of athletics, football players are shown to exhibit the largest number of stingers, with defensive backs sustaining the most.[4] The most common mechanisms of injury include compression of the nerve root by neck extension and ipsilateral lateral flexion, traction of the brachial plexus through shoulder depression and contralateral lateral flexion, or direct trauma to the superior medial scapula on Erb's point. Signs and symptoms associated with "stingers" include unilateral burning radiating from neck to hand, weakness of the deltoid, coracobrachialis, biceps brachii, pronator teres, infraspinatus, and supraspinatus muscles, appearance of a dropped shoulder, immediate pain/discomfort, myotome and dermatome abnormalities, and possible loss of ROM and function. Upon examination, it is likely that an athlete will exhibit a positive Sperling's Test or Tinel's sign, signifying damage to the brachial plexus.[4] It is also common to see an athlete shaking out the arm or hand, in attempts to restore normal neurovascular functioning and rid of the tingling feeling.

Due to the intricacy and abundance of the neural structures found in the brachial plexus, neurovascular compromise is expected. Neuropraxia typically resolves within seconds to a few minutes, yet more severe or chronic cases can last up to two weeks. Recurrent injuries to the brachial plexus result in a lower tolerance to trauma, thus making athletes who have sustained a stinger more susceptible to incur another. The term chronic brachial plexus syndrome is associated with those individuals who continue to receive such injuries, and whose symptoms persist for longer than a week. Neurological symptoms lasting longer than two weeks should be examined for spinal cord trauma, abnormal anatomical structures, or the presence of spinal stenosis. Abnormal anatomical structures can include vertebral disc bulges, ligament abnormalities, calcifications, or congenital defects. X-rays, magnetic resonance images (MRIs) or computed tomography (CT) scans are vital tests used to rule out the presence of these.[3] Cervical stenosis is characterized by a narrowing of the spinal canal, with a diameter of less than 13 mm, compared to the normal lengths of 14-23 mm. Athletes that are found to have stenosis are typically affected by injury to the brachial plexus. "More than 47% of university football players with known stinger injuries had concomitant cervical stenosis". [3(p.699)] Athletes that possess any or all of these characteristics are more likely to sustain brachial plexus injuries and have more extensive and severe symptoms.

2. Case History

A 21-year-old male Cornell sprint football defensive back of Asian descent sustained a brachial plexus injury to the C5-C6 vertebrae on September 1, 2012. During a regular season practice, the athlete's neck was forced into hyperextension and left lateral flexion when tackling an opponent. The mechanism of injury (MOI) can be characterized as a flexion-extension mechanism, which occurs when the cervical nerve root is compressed, in this case, at the C5-C6 level.[3] Upon impact, the athlete fell to the ground and landed face first. He remained lying there for a few minutes while athletic trainers (ATs) arrived on the scene and checked for cervical trauma. The athlete exhibited full consciousness and showed no life-threatening signs of spinal cord trauma. As a result, he walked off of the field and received a full evaluation. The athlete's chief complaint at the time was paresthesia and radiating pain in his left trapezius, deltoid, arm, and fingers. He also complained of neck pain when extending and rotating his head to the left. Further sideline evaluation demonstrated a pain level of 6/10, unilateral pain lateral to the C5-C6 joint line on the left side of the spine, decreased ROM in left lateral flexion and left rotation, and a 4/5 MMT for shoulder abduction and elbow flexion. There was no evidence of swelling, deformity, ecchymosis, warmth, or redness. The athlete showed no change in gait, yet continued to hang his left arm lower than his right and attempted to "shake out" the numbness and tingling running down his left arm. ROM was full and without pain for neck flexion, right lateral flexion and right rotation, yet he experienced a decreased ROM and substantial pain with neck

extension, left lateral flexion, and left rotation. The athlete was diagnosed with a brachial plexus injury at the C5-C6 level, also known as a "stinger." A positive Spurling's Test indicated possible nerve root impingement.

Cryotherapy was applied to the affected area, and the athlete was withheld from the remainder of the practice. By the end of practice, the athlete was still experiencing paresthesia and was instructed to report to the athletic training room (ATR) the following day. The athlete experienced no further s/s of a stinger until he received another stinger a week later when tackling an opponent. Both the MOI and the location of paresthesia were the same as in the previous incident. The s/s associated with this incident continued for approximately two days. The athlete was restricted from participation until s/s diminished, and was placed on a rehabilitation plan for the neck and shoulder. Neck exercises included active ROM in flexion, extension, rotation, and lateral flexion. The athlete followed the 9 min shoulder protocol that was provided by the Cornell Sports Medicine team. This protocol incorporated the following exercises: shoulder shrugs, lateral raises, front raises, forward roll shrugs, empty can raises, backward roll shrugs, lateral rotations to 90 degrees, cross chest raises, internal/external rotation, horizontal standing flys, side pull-ups, bent-over rows, side pull-up presses, standing overhead lateral raises, tricep presses, and bicep curls. The use of therapeutic modalities included thermotherapy in the form of a heat pack before practice for 15 minutes and cryotherapy via application of an ice pack for 15 minutes after practice. The use of NSAIDs was enforced as needed. Once the s/s resided and the athlete returned to baseline MMT strength and ROM levels without any pain, he was referred to one of the team physicians, Dr. E.K., for further evaluation.

Previous history revealed that the athlete had sustained numerous spinal injuries within the past four years. Among these were numerous stingers experienced throughout high school, a non-sport related injury, and two stingers sustained during the fall 2012 football season. On August 21, 2010, the athlete was involved in a non-sport related biking accident in which he was immediately admitted to the Cayuga Medical Center in Ithaca, NY. Dr. S.K. performed a CT on the athlete's skull, resulting in a diagnosis of numerous bifrontal contusions, a right temporal contusion, and a left temporal bone fracture. The CT scan of the neck was negative, yet a flexion/extension x-ray of the cervical spine showed a possible acute fracture. Further observation concluded in a 1.3 mm retrolisthesis and subsequent subluxation of the C2 and C3 vertebra. Intravertebral height and foraminal structure proved to be normal. All upper/lower extremity (UE/LE) MMTs were normal 5/5 strengths. He was released from the hospital 5 days later with instructions to wear a Miami-J collar, perform rehabilitation in a Long Island facility close to his hometown, and follow up with an ear, nose, and throat (ENT) surgeon and neurosurgeon.

On October 28, 2010, the athlete met with the neurosurgeon, Dr. G.Z. from Cayuga Medical Center in Ithaca, NY. Flexion/extension x-rays of the cervical spine were performed and came back negative for abnormal movement. In comparison to initial x-rays performed on the date of the injury, there were no visible misalignments or instability present in the C1-C7 view. However, there was a slight deficit in neck flexion/extension ROM and a mild uncinate process spurring evident at the C5-C6 vertebral level. The uncinate process is located on the lateral borders of the superior surface of C3-T1 vertebral plates. This hook-shaped structure prevents posterior translation and excessive flexion of the vertebral bodies.[5] If significant, the spurring associated with this anatomical structure can give rise to spinal stenosis. Dr. E.K. informed the athlete that there was no cervical trauma, and advised him to speak to the athletic staff at Cornell University about returning to play football in the fall.

Figure 1. Presence of uncinate process or PLL calcification at C5-C6 level as seen on MRI of cervical spine

The athlete was cleared by the ENT, Dr. R.S., on July 31, 2012. Prior to the start of the fall 2012 football season, the athlete was seen by Dr. B.J. to obtain clearance for participation. Reexamination of flexion/extension x-rays from 10/28/10 displayed a slight deficit in spinal flexion with resultant muscle spasm. As a result, plain x-rays were ordered and examined. There was no evidence of any cervical misalignments, edema, or instability. The doctor cleared the athlete to play sprint football, claiming that he had no greater risk of participation than any other athlete of similar size and physical ability. As a result, the athlete completed the pre-participation examination for Cornell University athletics and filled out the associated sports clearance form. On this form, the athlete noted the details of his previous biking accident as well as experiencing an episode of a "stinger" on August 22, 2012. However, he failed to expand on the episode or admit to having any numbness, tingling, or weakness in his arms or legs after being hit or falling. The team physician, Dr. A.W., completed the athlete's PPE and cleared the athlete to play without reservation.

Reexamination of the athlete by the AT resulted in full ROM and strength of the shoulder and neck, negative Empty Can and Drop Arm tests, and absence of any neurological s/s. Although the evaluation showed no signs of injury, the doctor was uncomfortable with the fact that the athlete had recently sustained two significant stingers. This, combined with the previous history of cervical trauma and neuropraxia, resulted in the scheduling of an MRI. An orthopedic surgeon, Dr. J.M., reviewed the MRI results and discovered a small abnormality within the spinal canal. This caused him to restrict the athlete from athletic activity until he consulted a second opinion from a radiologist. After much deliberation and research, the surgeon explained that the MRI showed what looked like a calcification on posterior longitudinal ligament at the C5-C6 level. He wasn't sure whether this abnormality was benign, a result of the high quality of the MRI which normally wouldn't show such a defect, or an actual calcification. The final diagnosis was a calcification of the PLL, which could have been attributed to blood that had accumulated and calcified from the biking accident two years prior, or was simply a congenital defect. Contrary to what was expected, normal measurements of the spinal canal were obtained by the physician, who then cleared the athlete to return to full participation in football. The diagnosis of the PLL abnormality was a CSF flow artifact, which apparently the radiologist and physician believed had no connection with the stingers the athlete was experiencing.

Individuals of Asian descent, particularly Japanese males, are more susceptible to a congenital calcification of the PLL. In fact, 4.3% of the Japanese population is found to have this abnormality. The calcification is progressive; it is established at birth and increases in size and strength. According to Stapleton et al., "Proteins that process extracellular inorganic phosphate, collagen fibrils, and transcription factors involved in osteoblast and chondrocyte development and differentiation have all been implicated in the pathophysiology of PLL."[8(abstract)] Sato believes that mesenchymal fibroblasts within the PLL arrange in an abnormal array, eventually converting into osteoblasts.[9] With this being said, the resultant calcification creates a bump that protrudes into the spinal canal, thus decreasing its space. "The ossified PLL appeared as an ossified plaque, extending longitudinally and posteriorly, contiguous with the ligamentous enthesis to the vertebra and to the deep layer of the PLL."[9(p.176)] Repetitive flexion and extension motions can irritate the PLL, causing a further increase in size. Forced hyperextension or hyperflexion, as seen in the MOI for stingers, may push the calcification into the spinal cord. Since the canal is already compromised, any trauma to the cervical spine would then cause neurological symptoms.

After obtaining the opinions and diagnoses of five different physicians, only two addressed the presence of a bony abnormality on the athlete's cervical spine. It was very interesting to see that both Dr. G.Z. and Dr. J.M. recognized an abnormality on the C5-C6 vertebral level, yet had different opinions as to its origin and significance. Both diagnoses result in spinal stenosis, which increases the risk of receiving stingers and gives reason to debate whether or not to allow the athlete to continue to play football. What is interesting is the fact that there was no evidence of spinal stenosis, yet the diagnosis that he was given assumed so. The fact that the athlete has had numerous stingers over the past few years also contributes to this risk. However, despite these dangers, the team physician cleared the athlete to participate in full-contact and advised him to wear a cowboy collar when playing, discontinuing participation if any neurological symptoms recurred. After clearance, the athlete exhibited no further symptoms and received no additional brachial plexus injuries.

3. Review of the Literature

Brachial plexus injuries are common in contact sports, especially in football and rugby. Such "stingers" most commonly result from one of four mechanisms of injury; hyperextension or hyperflexion of the cervical spine, and traction or direct trauma of the brachial plexus. When hyperextended, there is usually a subsequent lateral flexion and axial load of the neck, thus compressing the affected cervical nerve root. This is further exacerbated by the pincer mechanism, which leads to spinal cord compression by the vertebra directly above and below the affected nerve root. Flexion of the neck to 30 degrees causes the spinal column to become straight, and predisposes it to serious injury. Hyperflexion of the neck places additional stress on the vertebral structures, resulting in buckling, instability, and fracture of vertebrae. This is most often seen with spearing, a football technique in which a player strikes the opponent directly with his head, causing the cervical spine to become compressed between the head and trunk.[1] Traction of the brachial plexus is achieved when pressure is applied to the ipsilateral arm with simultaneous lateral bending of the neck to the opposite side. Lastly, direct trauma to the brachial plexus will generate neuropraxia along the affected nerve root. This commonly occurs to the lower left sternal border, Erb's point, where the plexus is most superficial.[3]

Although damage to the brachial plexus is often deemed more severe and complicated than most musculoskeletal injuries, evaluation and diagnosis are quite similar. Initial evaluation of the cervical spine should immediately rule out any serious cervical injury that may result in paralysis or further damage. Any evidence of a loss of consciousness, neck pain, or significant neurological deficits should denote stabilization of the spine and proper transportation to the hospital. If no such symptoms arise, the athlete should be removed off of the field for a more in-depth evaluation. This should include palpation of all vertebral structures in the cervical spine, assessment of all dermatomes and myotomes, MMTs of the proximal arm muscles, and ROM of the neck. Pain characteristics such as the quality, quantity, intensity, location, radiation, and duration of pain should be noted and used for further reference. Special tests such as the Brachial Plexus Traction test, Cervical Distraction, Spurling's test, and Tinel's Sign will assess nerve root impingement and neurological dysfunction.

Neuropraxia and weakness should diminish within minutes of the injury, yet some symptoms may last up to 24 hours. In rare cases, symptoms can last up to two weeks, and require further testing to identify the culprit causing the neurological deficits. A combination of X-rays, CTs, flexion-extension radiographs, MRIs, and EMGs are ordered for athletes that display prolonged symptoms.[3] Examination of the sagittal diameter of the cervical spinal canal through the Torg ratio is implemented to rule out presence of spinal stenosis. This measurement tracks the, "Distance from the midpoint of the posterior surface of the vertebral body to the nearest point of the corresponding spinolaminar line on the lateral cervical spine radiographs." [6(p.183)] Results show that there was a positive correlation and greater incidence of stingers in athletes diagnosed with spinal stenosis, particularly at the C4-C6 level.[6] However, according to Page et al., the Torg ratio is not an accurate determinant of spinal stenosis and resultant brachial plexus incidence. In their study, only 37% of football athletes that suffered stingers had a ratio of 0.8 or lower. Therefore, sensitivity of the ratio in predicting the likelihood of sustaining a stinger was 71%, and specificity was 68%.[7] Most studies require a minimum combined sensitivity and specificity rate of 170%, thus deeming this an ineffective means of predicting the prevalence of stingers. There are plenty of stingers sustained by athletes that have normal spinal canals, as well as asymptomatic athletes with spinal stenosis. It should be noted that the athlete in the case study sustained recurrent stingers, yet had no evidence of spinal stenosis.

The Cornell football player showed no characteristics of any of these diagnoses. Although his symptoms resolved days after his initial injury, he managed to acquire two additional stingers within a two week time period. This is relatively unheard of, and with no explanation for its occurrence, the medical staff had to take a different approach.

After consulting the literature, a differential diagnosis was made. It was believed that an anatomical abnormality was causing a narrowing of the spinal canal, quite similar to that of spinal stenosis. Although the canal diameter was not affected enough to be considered stenotic, it was proposed to have a significant impact on the C5- C6 vertebral level. The presence of a calcified PLL, which is perceived as somewhat of a statistical anomaly, proved to have some validity as the cause to his neuropraxia.

Due to the rare nature of this abnormality, there is not a wide breadth of knowledge or experience in working with an athlete that has a calcified PLL. This may be the reason why it was never detected by previous medical professionals. Treatment is unspecified for the PLL calcification; therefore, individuals follow the protocol distinguished for brachial plexus injuries. For acute stingers, ice, heat, and NSAIDS are utilized to reduce pain and inflammation. Cervical traction to relieve tension and the use of a cervical collar are recommended to prevent hyperextension of the neck. Deep tissue massage and cervical joint mobilizations may also provide neurological relief. If pain continues, cortisone can be injected in the affected nerve root. Although surgery is scarcely used to treat stingers, a discectomy or spinal fusion may be performed in severe cases.[10]

In addition, there is no true RTP or rehabilitation protocol to be followed, making it difficult to effectively prepare the athlete for competition. Rehabilitation programs for brachial plexus injuries are individualized and aim to prevent further damage to the cervical spine. Progressive goals include restoration of full and pain-free ROM of the neck, strengthening of the neck, scapular, and back muscles, pain control, restoration of normal neurological function, utilization of proper posture, and instruction on proper tackling technique. Isometric exercises will be introduced first, followed by concentric resistive exercises of increasing intensity. Stretching will be implemented after full and pain-free ROM is obtained in order to decrease the risk of irritating the brachial plexus.[3] It is important to rehabilitate bilaterally to ensure symmetrical strength and flexibility.

The creation of a proper RTP protocol involves collaboration between the athlete, coach, parents, and team physician. In order to RTP, the athlete must be asymptomatic and demonstrate full ROM and strength at or above his individual baseline level. Once established, a slow and controlled progression must be utilized to prevent re-injury. As such, any recurring symptoms will result in immediate cessation of exercise. The following day, exercise will be resumed at one level lower than when symptomatic. Once full return to play is permitted, the athlete should be monitored for proper technique and to ensure that paresthesia doesn't resume. Enforcing trunk stabilization and a chest out posture in which pressure is taken off of the brachial plexus may reduce the likelihood of sustaining further stingers.[1] The use of a cervical orthosis has shown some success in limiting the amount of lateral deviation and extension of the cervical spine, which can be attributed to a decrease in stingers. However, strengthening of the neck, shoulder, back, and core muscles will produce more stability than any protective equipment provides.[10] Most importantly, the athlete must feel both comfortable with his injury and confident in his ability to overcome it and play without hesitation.

Although most athletes are allowed to continue participating in their respected sports, athletes with spinal stenosis, chronic brachial plexus injuries, abnormal radiographic imaging, and congenital defects affecting the spine are often restricted from contact sports. These spinal abnormalities predispose the athlete to an increased risk of injury, and can lead to serious damage to the spinal cord itself. Individuals that encounter multiple stingers or surgical procedures have a decreased chance of being cleared to play. Absolute contraindications to participation are cervical cord neuropraxia, spinal instability, vertebral fractures, ligamentous injury, and congenital abnormalities of the cervical spine.[3] Any abnormal findings on radiographic imaging or the spinal cord itself require further scrutiny for proper plan of care. This is due to the fact that the spinal cord is an integral part of the human body and must be protected to prevent serious debilitating injuries. Accurate diagnosis of the injury, compliance to rehabilitation, elicitation of appropriate treatment, and proper return to play protocols should result in positive outcomes for the athlete. Whether it is returning to full participation in contact sports, choosing a new sport, or refraining from all physical activity, the decision lies in the best interest for the health and overall well-being of the injured athlete. At any rate, return to participation should not expose the athlete to any increased danger or risk of re-injury.

4. Discussion/Defense of Case's Management

Upon receiving his first episode of a stinger, the Cornell athlete expressed the common signs that come with the injury; paresthesia, upper extremity weakness, neck soreness, and a slight decreased ROM of the neck. As a result, he was removed from practice until his symptoms ceased. About 10 days after the athlete sustained his first stinger at the collegiate level, a sports medicine physician ordered imaging of the cervical spine to rule out any lurking pathologies. On the MRI, he noticed that something wasn't quite right about his cervical spine. Upon further

inspection, he discovered an abnormal presence along the C5-C6 vertebral level. The athlete's past history of brachial plexus stingers throughout high school and college worried the physician, who tried to correlate its repetitive nature with the cervical abnormality. However, it was very odd that none of the other doctors had noticed or questioned the reason why the athlete was experiencing so many neurological issues. It is common knowledge that the spine is imperative to the functioning of the human body, and something that must be taken very seriously. With this in mind the lack of concern that many of the other physicians had regarding his injury is astonishing. It seemed as if there was no hesitation in allowing the athlete to return to physical activity, especially to a contact sport such as football. In addition to this, there wasn't even a requirement that the athlete engage in any sort of rehabilitation plan to strengthen his neck and surrounding musculature. In any athlete that suffers an injury to a part of the body, there should be some sort of rehabilitation protocol in place to help strengthen it to baseline value. This is especially true in something as serious as a neurological impairment.

Once the MRI results revealed a cervical abnormality, the physician consulted the literature to help diagnose and understand it. Through his research, he concluded that the athlete had a PLL calcification on the C5-C6 level, and that his Asian lineage may have caused this to form. Due to the rarity of this abnormality, reference to outside support for explanation was consulted. Evidence showed that PLL calcifications often cause spinal stenosis, thus narrowing the spinal canal and placing pressure on the spinal cord. This would then predispose the athlete to a higher risk of sustaining brachial plexus injuries. What was confusing was the fact that the athlete was said to have no evidence of spinal stenosis, yet still received the long-lasting neurological symptoms that come with a narrow canal. This raised questions regarding the validity of both the diagnosis and the measurement of the spinal canal. The number of stingers the athlete experienced and the ease at which he received them was also perplexing. It seemed as if a light blow to the brachial plexus region would automatically send paresthesia up and down his arm. This proved to be very worrisome, and raised speculations as to if the medical staff was going to clear him to participate in football for the remainder of the season.

It was very shocking and nerve-racking when word was released that the athlete was in fact cleared to play. It was incomprehensible why an athlete who had a known congenital defect in his cervical spine, especially one that was noted for having an increased risk of neurological symptoms associated with it, was allowed to participate in the intense and high-contact sport of football. Not only this, but with the history of recurrent injury and long-lasting symptoms, it was quite baffling. The athlete also didn't have any knowledge of the injury, how long symptoms were supposed to last for, or the various treatment protocols available. The doctor informed him that he may have had a spinal abnormality, yet failed to inform him of what it was or how it would affect him. This instilled an unnecessary amount of fear and grievance over something that doctors claimed has no clinical relevance or risk. He was also unaware of the cervical abnormality, despite its discovery after his accident in 2010. The athlete should have been notified about this, especially due to its probable role in his brachial plexus injuries. It would also have provided him with some relief when his symptoms were not diminishing, and could have allowed him to inform the medical staff so that they might have been able to make a correlation between the two. With no access to this information, the athlete is lucky that one of the physicians was able to pick up on it and truly investigate the complexity of the injury.

It is hard to comment on the efficacy of the rehabilitation and treatment protocols that were used in this case study, because there weren't really any utilized. This is not to say that the athlete was merely sitting on the sidelines not doing anything, yet there were no specific protocols elicited to the athlete. There was also no timeline created for his probable return to play, or what to do if symptoms persisted or worsened. Therefore, onus was placed on the athletic training staff to handle the situation accordingly. The success of their actions is unknown, because the athlete sustained at least two more stingers within the remainder of the season, and nothing seemed to stop them from happening. Also, the symptoms varied in longevity, and nothing that truly affected their severity or duration was found. It was very frustrating and burdensome to try and create a protocol that would enable the athlete to participate safely and successfully, while simultaneously minimize the risk of sustaining further injury. It would have been beneficial for the physicians to recommend specific exercises for the athlete to complete, as well as a progression to follow. It is likely that a steady and individualized rehabilitation procedure also would have made the athlete feel more comfortable with his treatment, and therefore ease reluctances regarding returning to play.

Therapeutic modalities and exercise comprised the treatment utilized for this athlete. The use of thermotherapy prior to practice and cryotherapy afterward was favorable in this situation. The likelihood of a positive effect of electrical stimulation on the athlete is uncertain because the sensations of the treatment are comparable to that of his neuropraxia. To the best of known knowledge, there are no other modalities that could have assisted in or expedited the recovery process. In respects to therapeutic exercise, cervical traction and joint mobilizations could have been performed on the athlete. This may help relieve pressure off of the cervical spine, while also allowing the spine to realign into proper formation. If in fact one of the vertebras was misaligned, it could have been pressing against the spinal cord, thus producing the numbness and tingling. Despite these benefits, however, only the use of a cervical

"cowboy collar" was recommended. By the end of the first week back at practice, the athlete discontinued the use of the collar completely. It would be both beneficial and conservative to require that the collar be worn, because it does have some validity in reducing the likelihood of neck hyperextension. This, in turn, may be able to decrease the possibility of encountering another brachial plexus injury.

Due to the past history of neurological injury and the presence of a cervical abnormality, it is uncertain whether or not to clear the athlete to participate in sprint football. Although the abnormality may be benign, its proximity to the spinal cord and the fact that there are conflicting diagnoses is worrisome. It seemed pretty obvious that there is in fact a correlation between the abnormality and the frequency of stingers, and is not in the athlete's best interest to sustain another one. The fact that each subsequent stinger results in prolonged paresthesia and motor weakness further proves this point. The athlete would most likely find success and a decrease in brachial plexus injury risk by participating in sports that involve less contact and risk of spinal injury. After RTP, there was extreme unease, anxiety, and a sense of hesitancy and fear of re-injury noted in the athlete. With this being said, the doctor's orders to allow the athlete to be cleared for full contact participation in football remains a controversial topic.

This case study is important, because it stresses the dire need for ATs and other health professionals to "think outside of the box" and consider other possible perspectives on injuries. When symptoms fail to decrease, treatments fail, injuries continue to recur, and features that don't fit are present, new case patterns must be considered and actions taken to try and solve the problem. This holds true for all injuries, yet particular attention should be given to the spinal cord, an integral part of the human body that must be protected and evaluated with utmost care.

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