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Multi-level Cervical Spine Surgery in Athletes

Robert G. Watkins IV, David Chang* and Robert G. Watkins III

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Orthopaedic Spine Surgeon, Marina Spine Center-A Cedars Sinai Affiliate, Marina del Rey, CA 90292, USA

Corresponding author:

David Chang, M.D.
Orthopaedic Spine Surgeon
Marina Spine Center-A Cedars Sinai Affiliate
4640 Admiralty Way, Suite 600
Marina del Rey, CA 90292, USA
E-mail:davidchangmd@gmail.com

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ABSTRACT

Multi-level cervical pathology in athletes is a difficult decision-making process that lacks much guidance from the literature.Our objective is to provide a framework for systematic evaluation and decision-making on treatment and return to play in athletes.This paper utilized literature review, authors' experience, and case examples in order to present a classification of sports and factors essential to the risk evaluation.Ultimately, the physician needs to provide the athlete with a risk assessment of return to play with or without surgical intervention.

Keywords: Athletes,Cervical, Fusion, Multi-level, Sports, Spine.

INTRODUCTION

Return to play after a cervical injury assumes that there is a player that wants to return to their sport despite having suffered a severe injury. It also assumes that there is a team that is willing to hire the player or allow the player to compete despite the team having numerous other players who have no prior cervical injury. Additionally, there must be a physician with the experience to predict the risk of future spinal injury. This paper is a combination of literature review, author experience and case examples to provide a framework for making complex decisions in athletes. Consent was not obtained because this is a retrospective review that did not affect treatment.

Risk by sport

Sports can be categorized into several groups based on risk of injury: collision, contact, and repetitive.[1] Collision sports have the highest frequency and risk of head contact; examples, football, ice hockey, rugby, martial arts and wrestling. This is the highest risk for cervical spine problems. A sport, such as football that has a premium on yardage gained, has inherent risk of lowering the head and using the crown of the head to initiate blows, therefore, has an inherent risk for creating cervical fracture dislocations. This is due to straightening of the spine and axial load being borne directly down the anterior spinal column, much like pushing the ends of a soda straw and having it buckle in the middle.[2]

Additional rules in football that attempt to eliminate use of the head as an offensive weapon were initiated to protect the person being hit, while in reality they protect the hitter from neck injury. Cervical injury is different in different sports, as a hockey player can be driven head first into the boards and in rugby there can be an unusual collapse of the scrum. Additionally, any sport in which the player can be dropped directly on his/her head has a significant risk of neck injury.

Contact sports are considered a medium risk for cervical injury.[1] Sports not designed for high velocity head contact such as soccer, basketball, volleyball, baseball and water polo can still have a cervical injury, but at a lower frequency. There are also high velocity injuries in certain non-contact sports such as skiing, gymnastics and cheerleading. Repetitive sports that require a lot of cervical motion such as golf, baseball, and swimming can produce wear and tear injury to the cervical spine, but with a lower risk of a catastrophic head contact injury.

INJURY EVALUATION

The return to play decision starts with a history and physical examination to determine presence of a current radiculopathy or myelopathy. The source of the problem needs to be isolated *to what nerve, what level, and what pathology.* What is the history of the injury? Was there a transitory quadriparesis? How severe was the paralysis and how long did it last?Factors used in consideration of the risk/benefit assessment of condition and treatment are summarized in Table 1. As of yet, there is no quantitative grading system for these risk factors.

Considering the injury factors that affect risk assessment, we also evaluate the studies involved in each case. X-rays with flexion-extension films are used to determine ligamentous injuries that may not heal and can produce instabilities. Presence of kyphosis in head-contact athletes may be a contraindication to a

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Table 1: Preoperative factors that affect risk assessment.

· Sport and Position » Risk for: Head Contact, Violent Fall, Repetitive Trauma or Motion » Career and Age
· Severity of Injury (duration of symptoms)
· Symptoms » Severity and Chronicity
· Physical Exam » Radiculopathy versus Myelopathy » Strength of Postural(core) Muscles
· X-rays » Kyphosis, Rotation, Instability, Stiffness » Level of Pathology – C3-C4
· MRI » DDD – at index and adjacent levels » Stenosis – 8mm, Presence of CSF, Cord Deformation » Myelomalaciavs Persistent Central Canal
· CT » Spondylolysis, Facet Pathology

return to collision sports. Rotational abnormalities are also considered. Hypermobile or stiff segments are evaluated. If these segments are not functioning; for example, whether they are stiffened from degeneration or surgical fusion they can produce abnormal increased risk on adjacent segments.

In our experience, many NFL players with herniations and/or stenosis at C3-C4 have a loss of lordosis centered at this level. Under axial loading, the neck typically fails in flexion[3,4] and a kyphotic segment increases the risk of a flexion injury. A fusion of C3-C4 at the middle of a straight or kyphotic segment in a head-contact position may put significant stress on the C2-C3 segment. The risk of catastrophic spinal cord injury at C2-C3 and/or chronic pain from future occipital to C3 degeneration needs to be considered before returning a head-contact athlete to play after a C3-C4 fusion.

A preoperative MRI determines the health or injury to the spinal cord, level of disc herniation, disc degeneration and extent of stenosis. Assessing the stenosis on the MRI involves several factors, one of which is cord flattening and cord deformation. As the cord flattens, it is stretched out, potentially collapsing blood supply inherent in the spinal cord. Flattening of the cord is a significant risk factor in addition to central canal measurements. Stenosis of 8 mm or less in the central canal measurements on MRI or CT are important defining elements of stenosis. The assessment of spinal fluid around the cord versus no visible spinal fluid is also a consideration of the degree of stenosis. An area of myelomalacia is an indication of an injury to the spinal cord (Figure1).

Spinal cord signal changes include high-signal intensity on T2, indicative of edema and better prognosis, and low-signal intensity on T1, indicative of necrosis and worse prognosis. Evaluation of the MRI must distinguish between myelomalacia, syrinx or retained central canal in the spinal cord (a normal anatomic variant). [5]

The MRI and CT scan can also reveal evidence of bony spinal column injury. The lateral mass fracture and facet fractures can present with reasonably minimal pathology and symptomatology especially in the competitive setting. After a fracture, assessing the degree of foraminal stenosis and nerve root pathology are important determinations in diagnosis and prognosis. These fractures can heal without surgery and the resultant abnormality is considered in the determination whether to return to play. Factors used to consider surgical treatment are summarized in Table 2.

SURGERY

Fusions in the form of anterior cervical discectomy and fusion (ACDF) are the most common surgery performed in athletes. Because the surgery: safely decompresses the neurologic tissue, distracts the foramen, corrects kyphosis, stops motion to allow neurologic healing and protects the level from future injury. The downsides to fusion include: time for healing (6-12mo), risk of non-union (5%), lack of motion and risk for adjacent level pathology (5-10%). [6-8] In our surgical experience, we utilize anterior instrumentation with an interbody cage. The anterior plate will increase fusion rates but it is not known whether it will return a player to sport faster. Our choice of interbody graft has been autologous tricortical iliac crest or a titanium coated PEEK cage with autologous cancellous iliac crest bone graft.

In the general population, artificial disc replacement has shown improved results compared to fusion in terms of: quicker recovery and return to work (3-6mo), lower re-operation, maintenance of motion, and higher success for two-level cervical degenerative disc disease. [9,10] In athletes, posterior foraminotomy/discectomy has a quicker and higher rate of return to play than fusion, but also has a significantly higher rate of reoperation at the index level (46.2% vs. 5.8%).[7] Cervical laminoplasty may be appropriate for congenital stenosis over multiple levels. We have very limited experience with posterior cervical laminectomy and fusion.

FUSION

Return to professional sports after cervical fusion has been reported in the range of 71-87%.[6,11,12] Watkins et al., reported on 26 professional athletes who underwent 27 ACDF surgeries.[6] By sport categorization, there was 13 NFL, 5 NHL, 5 MLB, 3 NBA and 1 MLS. Twenty-six out 27 (96.3%) showed clinical and radiographic evidence of fusion. Twenty out 25 eligible players returned to play (80%). Average time to return to play in a professional game was 9.5 months. The incidence of adjacent level pathology after a single-level fusion was 8%.

Evaluation of fusion healing occurs six to nine months after surgery. We believe that a single level asymptomatic non-union does not disqualify an athlete to return to play. A player with a stable cartilaginous non-union may return to play but would have a higher chance of becoming symptomatic. If there is a solid fusion with a stable area of myelomalacia,

Figure 1: Myelomalacia on T2 MRI sagittal image.

Table 2: Risk assessment.

· Chance for Improvement in Everyday Life
· Chance of Return to Play
· Risk of Failure of Surgery
· Risk for Adjacent Level Disease o Risk for Chronic Pain o Potential Need for Future Surgery o Risk of Catastrophic Injury

the athlete may return to play with low risk to future injury at the index level.[11] If there were a non-union with a persistent area of myelomalacia, return to play generally would not be recommended.

Data is lacking on the safety of return to sport after a two-level neck fusion. There is a report of a professional rugby player and two military men that successfully returned after two-level ACDF.[13] Conversely, Andrews reported on two rugby players that had persistent pain after a two-level fusion.[14] Additionally, there is a catastrophic case report of a rugby player two years after a two-level ACDF at C5-C6 and C6-C7, in which the player suffered a C3-C4 facet dislocation and complete impairment with C5 cord injury.[15] This demonstrates the significant risk and return after multi-level fusion to a collision or contact sport.

In professional sports, in which head contact is probable and inherent in the sport such as football and other collision sports, return to play after two-level ACDF is generally not recommended.[16] In a non-head-contact sport (baseball or basketball), a player may be cleared to return to sport after a two-level neck fusion. However, at times we have not recommended a two-level neck fusion in a player in order to return to sport. In other words, if they are relatively asymptomatic with life outside of sports, sometimes we do not recommend a two-level neck fusion in order to have a chance to return to sports. While there is some data on adjacent level pathology after multi-level neck fusion for degenerative disc disease, there is no data on 20 to 30-year-old people after traumatic disc herniations undergoing multi-level fusions. Our concern is the risk for long-term lack of mobility, adjacent level pathology, and chronic pain.

POSTERIOR FORAMINOTOMY

Posterior foraminotomy is an alternative to fusion, especially in multi-level pathology and has shown durable long-term results in the general population.[17,18] We may choose to do a foraminotomy if the patient has significant multi-level disease where the risk for adjacent level pathology is more significant after a fusion. In our experience, the foraminotomy is most effective if the patient gets relief of radicular symptoms with shoulder abduction.

In patients referred to us, we have seen one recurrent disc herniation with radiculopathy after posterior discectomy and two cases of fracture after foraminotomy in professional football players. The fractures occurred in the lateral masses at the index level and both fractures healed with conservative care. The players (*linebacker and defensive back*) did not return to professional competition. The important factor in foraminotomy is probably the method used for the foraminotomy. The more bone removed, the greater the risk of recurrent injury at that level.

We have used a minimally invasive decompressive technique, preserving a majority of the facet joint, detaching the ligament and decompressing the undersurface of the joint as a minimal bone removal technique for burners and stingers in professional athletes.[19] We have not used posterior foraminotomy and discectomy for disc herniations in professional athletes, which we believe requires more bone removal. Additionally, on our surgical patients, we have had players that sustain repetitive blows to the head (such as offensive lineman) that have had difficulty after posterior foraminotomy.

ARTIFICIAL DISC REPLACEMENT

Artificial disc replacement has shown promising results in the general population with adequate treatment of myelopathy[20,21] and improved results for radiculopathy compared to fusion.[9,10] The stability of an artificial disc replacement in a head-contact sport is undetermined at this point. Although rare, there have been reports of failures after artificial disc replacement.[22,23] An artificial disc replacement may be acceptable in contact sports such as baseball, but the risk for violent collisions still exist and pose a risk for dislodgement.

SUMMARY

Choosing between a fusion, artificial disc replacement and posterior foraminotomy depends on many factors. In our practice, if an athlete has a functional neurologic deficit and normal adjacent segments and a fusion has the best chance of treating the immediate pathology with low risk of additional problems. If an athlete has multi-level pathology and/or kyphosis, the risks after fusion increases and therefore posterior foraminotomy may be a more ideal treatment. The stability of an artificial disc replacement in a head-contact sport is undetermined at this point, although success compared to fusion and the extremely low-incidence of catastrophic failures in the general population makes this a viable treatment option.

Tables 3 and 4 are guidelines for return to play in collision and contact sports. There are differences in every injury and every sport. It takes a player, a team and a physician to return that player safely and effectively to a high-performance sport after cervical spine injury.

CASE STUDIES

Figure 2 is of an NFL defensive lineman with a disc herniation C5-C6 causing a C6 radiculopathy who underwent an ACDF at C5-6. At the index surgery he also had an asymptomatic C6-C7 bulge.

He returned to play and then developed symptoms from C6-C7. He is currently still playing but having neck symptoms from the C6-7 level.

Figure 3 is a college football player who had a transitory quadriparetic event that was brief and resolved. He had a disc herniation at C3-4.

Table 3: Collison sports: return to play (RTP) after surgery.

• ACDF: 1 level = Probable RTP
• Foraminotomy: 1, 2 or 3 Level = Probable RTP
• ACDF: 2 level = Not Likely RTP
• ADR: 1 Level = Depends on Risk for Potential Injury to Index Level
• Laminoplasty = Not Likely RTP

Table 4: Contact sports: return to play (RTP) after surgery.

• Foraminotomy: 1, 2 or 3 Level = Most Likely RTP
• ACDF: 1 level = Most Likely RTP
• ACDF: 2 Level = Probable RTP
• Laminoplasty = Possible RTP
• ADR: 1 Level = Probable RTP
• ADR 2 Level = Possible RTP

Figure 2: Sagittal MRI showing C5-6 ACDF with an asymptomatic C6-7 disc bulge.

He was then pain-free with a normal examination. Because of the kyphotic deformity and disc injury at C3-C4, we have recommended that he stop the sport. He had surgery with another doctor which did not correct the kyphotic deformity (Figure 4) but did decrease his risk of future problems. We advised against a return to college football.

Figure 5 is an NBA guard that presented with a transitory quadriparetic episode, treated with a C3-C4 ACDF that resolved the spinal cord compression and kyphotic deformity (Figure 6).

After five years of playing in the NBA after ACDF, a benign contact occurred that produced a transitory quadriparetic episode secondary to a cord contusion at the level below the prior surgery (Figure 7).

We recommended retirement.

Figures 8-11 are an NCAA basketball player with multiple episodes of transient quadriparesis whose cervical spine demonstrates congenital stenosis.

This patient underwent a 4-level cervical laminoplasty and returned to play without the symptoms. In the determination of whether someone can return to play after cervical laminoplasty, the guidelines are ill-defined at this time. It would be contraindicated in the collision sport.

Figure 3: Sagittal MRI showing disc herniation at C3-C4.

Figure 4: Sagittal CT post C3-C4 fusion with residual kyphosis.

Figure 5: Sagittal MRI of disc herniation at C3-C4.

Figure 6: Sagittal MRI one year post C3-C4 fusion.

Figure 7: Sagittal MRI five years post C3-C4 fusion, with myelomalacia at C4-C5.

Figure 8: Sagittal MRI of NCAA basketball player with transient para-paretic event.

Figure 9: Axial MRI showing congenital stenosis.

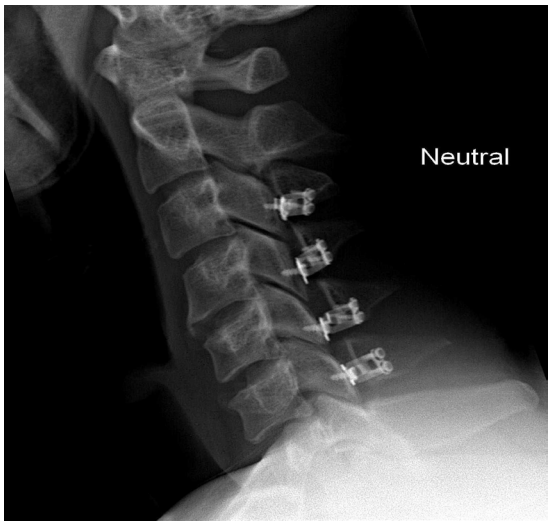

Figure 10: Lateral X-ray after cervical laminoplasty.

Figure 11: Sagittal MRI after cervical laminoplasty.

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