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Outcomes After Anterior Cervical Discectomy and Fusion in Professional Athletes

BACKGROUND: Significant controversy exists regarding when an athlete may return to contact sports after anterior cervical discectomy and fusion (ACDF). Return-to-play (RTP) recommendations are complicated due to a mix of medical factors, social pressures, and limited outcome data.

OBJECTIVE: The aim of this study was to characterize our diagnostic and surgical criteria, intervention, postoperative imaging results, and rehabilitation and report RTP decisions and outcomes for professional athletes with cervical spine injuries.

METHODS: Fifteen professional athletes who had undergone a 1-level ACDF by a single neurosurgeon were identified after a retrospective chart and radiographic review from 2003 to 2012. Patient records and imaging studies were recorded.

RESULTS: Seven of the 15 athletes presented with neurapraxia, 8 with cervical radiculopathy, and 2 with hyperintensity of the spinal cord. Cervical stenosis with effacement of the cerebrospinal fluid signal was noted in 14 subjects. The operative level included C3-4 (4 patients), C4-5 (1 patient), C5-6 (8 patients), and C6-7 (2 patients). All athletes were cleared for RTP after a neurological examination with normal findings, and radiographic criteria for early fusion were confirmed. Thirteen of the 15 players returned to their sport between 2 and 12 months postoperatively (mean, 6 months), with 8 still participating. The RTP duration of the 5 who retired after full participation ranged from 1 to 3 years. All athletes remain asymptomatic for radicular or myelopathic symptoms or signs.

CONCLUSION: After a single-level ACDF, an athlete may return to contact sports if there are normal findings on a neurological examination, full range of neck movement, and solid arthrodesis. There may be an increased risk of the development of adjacent segment disease above or below the level of fusion. Cord hyperintensity may not necessarily preclude RTP.

KEY WORDS: Anterior cervical discectomy and fusion, Cervical fusion, Neurapraxia, Professional athletes, Spinal injury

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Cervical spine injuries in contact sports can range from minor strains to catastrophic spinal cord injuries.^{1–3} Noncatastrophic cervical spine injuries associated with transient myelopathy (neurapraxia), and/or radiculopathy often require additional investigation and potentially surgical intervention.¹ There are additional pressures and considerations with high-profile athletes regarding any surgical intervention for a cervical spine injury. The effect of the injury on

an individual's career and risk of further injury during violent contact must be considered when determining return to play (RTP).

Factors determining RTP for professional athletes after cervical spine surgery are complex and relate, in part, to the type and extent of injury, surgical procedure, and postoperative recovery. Other factors that may come into play include nonmedical issues, such as loss of pay, medical liability concerns, and outside influences from the media, team, and player representatives. Relatively few professional athletes require cervical spine surgery during their active career, which limits available outcome data for RTP. Guidance

ABBREVIATIONS: ACDF, anterior cervical discectomy and fusion; CCN, cervical cord neurapraxia; NFL, National Football League; RTP, return to play

in making such decisions is sparse. Thus, despite the frequency of cervical spine–related injuries among athletes in contact sports, no consensus exists as to a standard guideline for return to preinjury activity level.⁴

Nonetheless, several authors have reported experiential guidelines and management algorithms that support no contraindication to return to contact sports after a single-level anterior cervical fusion if an individual has a solid arthrodesis, an absence of neurological deficits, and normal cervical spine range of motion.⁴⁻⁹ These recommendations are based mostly on expert opinion resulting from clinical practice experience, with only 3 retrospective series on the topic.¹⁰⁻¹²

Here, we report a series of 15 professional athletes who underwent anterior cervical discectomy and fusion (ACDF) by a single surgeon, representing a spectrum of preoperative cervical spine pathologies. The purpose of this paper is to characterize our diagnostic and surgical criteria, type of surgical intervention, and postoperative neurological imaging results and rehabilitation and also report our subsequent RTP decisions and outcomes.

PATIENTS AND METHODS

Approval to conduct this study was obtained after review of the research protocol by the University of Pittsburgh Institutional Review Board. We performed a retrospective chart and radiographic review in a consecutive series of 15 professional athletes who underwent surgery by a single surgeon (JCM) for cervical spine pathology between 2003 and 2012. Patient data were gathered regarding age, height, and weight, as well as the sport and position played. The signs, symptoms, and mechanism of injury were summarized. Neurological imaging studies were also reviewed for all athletes to ascertain any degree of spinal stenosis, evidence of a single herniated disc without stenosis, and the level of disease. Operative reports were reviewed to determine the level of operation, the type of arthrodesis, and whether a cervical plate was used. Finally, the long-term outcome was analyzed to document time to RTP, years played after surgery, and the reason for retirement, if any.

Surgical Criteria

All patients underwent ACDF by a single neurosurgeon for the treatment of symptomatic single-level disease with (1) pain or sensory symptoms that did not respond to conservative therapy; (2) motor, sensory, or spinal cord signs on physical examination; and (3) history of radiculopathy or neurapraxia with magnetic resonance imaging (MRI) demonstrating focal spinal stenosis caused by a herniated disc and/or osteophytes.

Rehabilitation and RTP

All patients were discharged from the hospital either the same day or the following morning. Progressive ambulation and light physical activity was initiated the first week. During the second week, increased lower extremity aerobic activity was permitted. The use of a stationary bike, treadmill, light elliptical exercise, and full range of motion with light weights all depending on comfort level were permitted. By the third week, increased flexibility, endurance, and progressive weight training was allowed. By the fourth week, most athletes had returned to nearly full aerobic activity and at least 50% of their previous weight-training capabilities.

Aerobic strength and flexibility conditioning were thereafter progressively increased. With full return to neurological function and the demonstration of arthrodesis, light contact drills were permitted until the athlete, trainer, surgeon, and all involved within their respective organizations were satisfied that a full recovery had occurred before return to full contact participation and competition.

RTP Criteria

Before clearing the athletes for RTP, postoperative imaging studies were performed for all athletes to assess fusion at the procedure site. In all cases, we ordered dynamic flexion/extension studies that demonstrated no movement. In others, early bony bridging at the vertebral body interface was seen, and there was no movement on dynamic imaging studies of the cervical spine. Images were assessed by the author and an independent radiologist. In the patient with the polyetheretherketone cage, bridging bone was difficult to ascertain. However, the absence of movement on flexion/extension films and the rigidity of the 4-screw plate and the 8-week recovery period in a completely asymptomatic athlete supported our decision for return to full conditioning and subsequent contact. Those patients with focal spinal stenosis all underwent postoperative MRI to confirm adequate decompression before RTP. Those athletes with focal radiculopathy caused by herniated discs did not have postoperative MRI before clearance. Last, the absence of all neurological deficits and a full range of motion were confirmed on neurological examination.

RESULTS

Descriptive Data

The clinical characteristics and demographic data of the 15 professional athletes who underwent ACDF are summarized in Table 1. Overall, 16 operations were performed on the 15 professional athletes. One of the players underwent a second ACDF for adjacent level disease after the first fusion. Seven were National Football League (NFL) players, 4 of whom made the Pro Bowl at least once. Eight of the athletes were professional wrestlers. All injuries occurred during athletic competition or

TABLE 1. Composite General Characteristics of the Group of 15 Professional Athletes^a

Characteristic	Football (NFL)	Wrestling	Total
No. of athletes	7	8	15
Mean age ± SD, y	31.3 ± 3.9	29.0 ± 5.7	30.3 ± 4.8
Mean height ± SD, in.	74.3 ± 3.0	72.6 ± 4.0	73.4 ± 3.6
Mean weight ± SD, lb	273.0 ± 64.0	223.4 ± 35.6	246.5 ± 55.2
Mean body mass index ± SD	34.4 ± 5.7	29.7 ± 3.6	31.9 ± 5.1
Level of fusion, no.			
C3-4	4	N/A	4
C4-5	1	N/A	1
C5-6	2 ^b	7	9
C6-7	1	1	2

^aNFL, National Football League.

^bOne of the football players returned with disc degeneration and a herniated nucleus pulposus at the level below a previous fusion after returning to play.

other sport-related activities. The mechanism of injury in all of the football players involved axial loading with either flexion or extension; in other words, blocking or tackling with the head. In the cohort of professional wrestlers, 1 experienced a disc herniation during weight training, spontaneous onset of radicular pain developed in 3, and the remainder were either thrown to the mat or had their neck vigorously wrenched. The overall average age of the cohort was 30.3 ± 1.3 years (range, 22-40 years). The mean age of the group of football players was 31.3 ± 1.3 years (range, 22-36 years) and of the professional wrestlers, it was 29.0 ± 2.3 years (range, 22-40 years). The average weight for the cohort was 243.3 ± 14.0 lb, with the lightest athlete (a wrestler) weighing 180 lb and the heaviest athlete (an offensive lineman) weighing 370 lb.

Case specifics are summarized in Table 2. Four of the football players played defense (2 cornerbacks, 1 defensive ends, and 1 defensive tackle), and 3 were offensive players (1 fullback, 1 offensive guard, and 1 offensive tackle). All 7 of the football players presented with transient neurapraxia, characterized by paresthesia in the extremities. Several of the patients with neurapraxia had been misdiagnosed as having a “burner/stinger” or a brachial plexopathy. Two of those athletes had quadriparesthesia, and 6 experienced bilateral upper or lower extremity paresthesias. Sensory abnormalities lasted for less than 15 minutes in 6 patients, between 15 minutes and 24 hours in 1 patient, and longer than 24 hours in another patient.

Six of the 7 patients with neurapraxia had abnormal findings on neurological examination. Abnormalities included hyperactive reflexes throughout (3 patients), positive Lhermitte’s sign (2 patients), and weak biceps or triceps (3 patients), with some having more than 1 finding. Eight of the athletes presented primarily with symptoms of radiculopathy. Five of the athletes presenting with a radiculopathy had weak biceps or triceps and diminished sensation in the appropriate nerve root distribution, and the remaining 2 had normal examinations. Additionally, 1 patient (patient 14) with a C5-6 disc herniation had mild triceps weakness. We believe this to be caused by the cross-innervation of the C6 and C7 nerve roots to the triceps muscles. We are uncertain about the cause of the mild deltoid weakness in patient 15, who had a left C5-6 disc herniation. This may have been attributed to pain at the time of examination. Regardless, symptoms resolved postoperatively.

All of the athletes had a single-level abnormality that correlated with the clinical findings caused by discogenic disease. In 13 of the patients, MRI or myelography demonstrated focal spinal spondylosis and stenosis, and the other 2 patients had an isolated herniated disc ipsilateral to the radiculopathy (Figure 1). Patient 3 presented with focal spinal spondylosis and stenosis in both instances. Two athletes also had hyperintensity in the spinal cord at the same level as the compression (Figures 2 and 3). The ACDFs were performed at C3-4 (4 patients), C4-5 (1 patient), C5-6 (8 patients), and C6-7 (2 patients). One athlete initially had surgery at the C4-5 level and then returned after a second injury for decompression and fusion at the C5-6 level.

Outcome Data

Thirteen of the athletes returned to their respective sport. The overall mean time for return to participation after ACDF was 6 months (range, 2-12 months). Of the football players, 2 played for another 3 years, 1 for an additional 2 years, and 2 are still playing 1 or more years postoperatively. One player retired after RTP after sustaining a disc herniation adjacent to the initial level of fusion. The defensive back played for 2 years (27 games) and then retired after sustaining a disc herniation at the C5-6 level, which was below the previous fusion at C4-5. Despite being cleared for RTP from a neurological standpoint, 2 other football players retired before ever returning to play because of orthopedic injuries. All of the professional wrestlers returned to play. Five continue to wrestle with an average duration of 2.5 years to this point in time after surgery. One chose to retire after RTP secondary to persistent, chronic neck pain without radiculopathy, and another because of age.

DISCUSSION

Athletic injuries to the cervical spine account for 10% of cervical spine injuries in the United States.^{13,14} Fortunately, catastrophic cervical spinal cord injuries are relatively uncommon during athletic participation.⁴ One of the most frequently reported and studied neurological injuries in contact athletics is cervical cord neurapraxia (CCN). CCN is estimated to occur in 7 per 10 000 elite football players and typically presents as temporary bilateral burning paresthesia that can be associated with varying degrees of motor deficits.^{11,15-18} Recent data in American football has also suggested that approximately 0.2 per 100 000 participants at the high school level and 2 per 100 000 participants at the collegiate level are diagnosed with CCN.^{19,20} The condition is usually caused by hyperflexion or hyperextension in a compromised or stenotic spinal canal.^{11,21} Cervical degenerative disc disease is commonly cited as a cause of neural compression and symptoms after contact sport-related cervical injury. Osteophyte formation, in addition to degenerative disc disease, can also cause cervical stenosis, which may precipitate symptoms with cervical spine injury in athletes.

This review focuses exclusively on the professional athlete in whom management generally is associated with more complex RTP issues and other considerations. Professional athletes, in particular, often obtain several consultations regarding consideration for surgical management in the setting of cervical spine injury/disease. Frequently there are conflicting opinions concerning surgical approaches and RTP clearance, even among these experts. Although the relationship between cervical stenosis, high-energy mechanisms, and neurological injuries has been detailed in the literature,^{5,18,21-28} the risk of spinal cord injury after cervical spine surgery is less well-known. Cervical spine surgery, by itself, is not considered an absolute contraindication to return to contact sport. Several authors have reported through experiential guidelines and management algorithms that there is no contraindication to RTP after a single-level anterior cervical fusion if an individual has a solid arthrodesis, absence of neurological deficits, and normal cervical range of motion.^{3-10,24,29} Overall, these

TABLE 2. Individual Case Details^a

Case	Age, y	Sport/ Position	Mechanism of Injury	Signs	Symptoms	Imaging	Time to RTP, mo	Outcome
1 ^b	29	Football/ FB	Axial loading, as ball carrier	Weakness in left triceps, hyperreflexia	Transient quadriparesis (grade III)	C6-7 HNP, effacement of CSF signal	10	Played 3 y more
2 ^b	26	Football/ CB	Lateral flexion while avoiding blocker	Normal findings on examination	Transient quadriparesis (grade I)	C4-5 HNP with stenosis	2.25	Played 2 y more, C5-6 HNP, retired ^e
3 ^b	32	Football/ OG	Axial loading while blocking	Normal findings on examination	Bilateral UE paresthesia (grade I)	C3-4 HNP with stenosis	9	Played 3 y more
4	28	Football/ OT	Axial loading while blocking	Normal findings on examination	Bilateral UE, right LE paresthesia (grade I)	C5-6 HNP with stenosis	9	Still playing, 1 y postoperatively
5	36	Football/ CB	Axial loading while tackling	Weakness in left triceps, Hoffman, hyperreflexia	Transient quadriparesis (grade I)	C3-4 HNP with stenosis	6	Still playing, 1 y postoperatively
6	35	Football/ DE	Axial loading, cervical flexion while tackling	Lhermitte's sign	Bilateral UE paresthesia (grade I)	C3-4 HNP with severe stenosis	—	Retired ^c
7	35	Football/ DT	Axial loading, cervical flexion while tackling	Weakness in right deltoid and biceps, ^d Lhermitte's sign, hyperreflexia	Bilateral UE paresthesia (grade I)	C3-4 HNP with stenosis, cord hyperintensity	—	Retired ^c
8	27	Wrestling	Weight training	Weakness in right triceps and right grip	Right UE pain	C5-6 HNP with stenosis	2.75	Still wrestling 3.5 y postoperatively
9	40	Wrestling	Spontaneous onset	Normal examination	Right UE numbness/paresthesia, neck pain	C5-6 HNP with stenosis; syrinx C4-7	12	Wrestled 1 y more
10	23	Wrestling	Thrown to mat and struck back of head and neck	Weakness in left triceps	Left UE pain/numbness, neck pain	C5-6 HNP with stenosis; cord hyperintensity	5	Still wrestling, 3 y postoperatively
11	22	Wrestling	Grabbed by neck during match	Normal findings on examination	Intractable neck pain	C5-6 HNP with stenosis	3	Wrestled 4 mo more
12	31	Wrestling	Unknown, during wrestling match	Weakness in left triceps	Left UE pain, neck pain	C5-6 HNP with stenosis	3	Still wrestling 2.5 y postoperatively
13	31	Wrestling	Progressive onset	Weakness in right biceps	Intractable right UE pain	C5-6 right HNP	4	Still wrestling 1 y postoperatively
14	31	Wrestling	Spontaneous onset	Weakness in left triceps	Left arm pain	C5-6 left HNP	3	Still wrestling 1 y postoperatively
15	27	Wrestling	Spontaneous onset	Weakness in left deltoid, triceps, and biceps	Neck pain, left UE pain	C5-6 left HNP with stenosis	2	Still wrestling

^aRTP, return to play; FB, fullback; HNP, herniated nucleus pulposus; CSF, cerebrospinal fluid; CB, cornerback; OG, offensive guard; UE, upper extremity; OT, offensive tackle; LE, lower extremity; DE, defensive end; DT, defensive tackle.

^bPatient was from previous cohort.¹⁷

^cPatient had previous brachial plexus injury.

^dCleared to return to play, retired secondary to other causes.

^ePatient returned to play for 2 years and then sustained disc herniation at level below previous fusion; underwent C5-6 anterior cervical discectomy and fusion and then retired afterward.

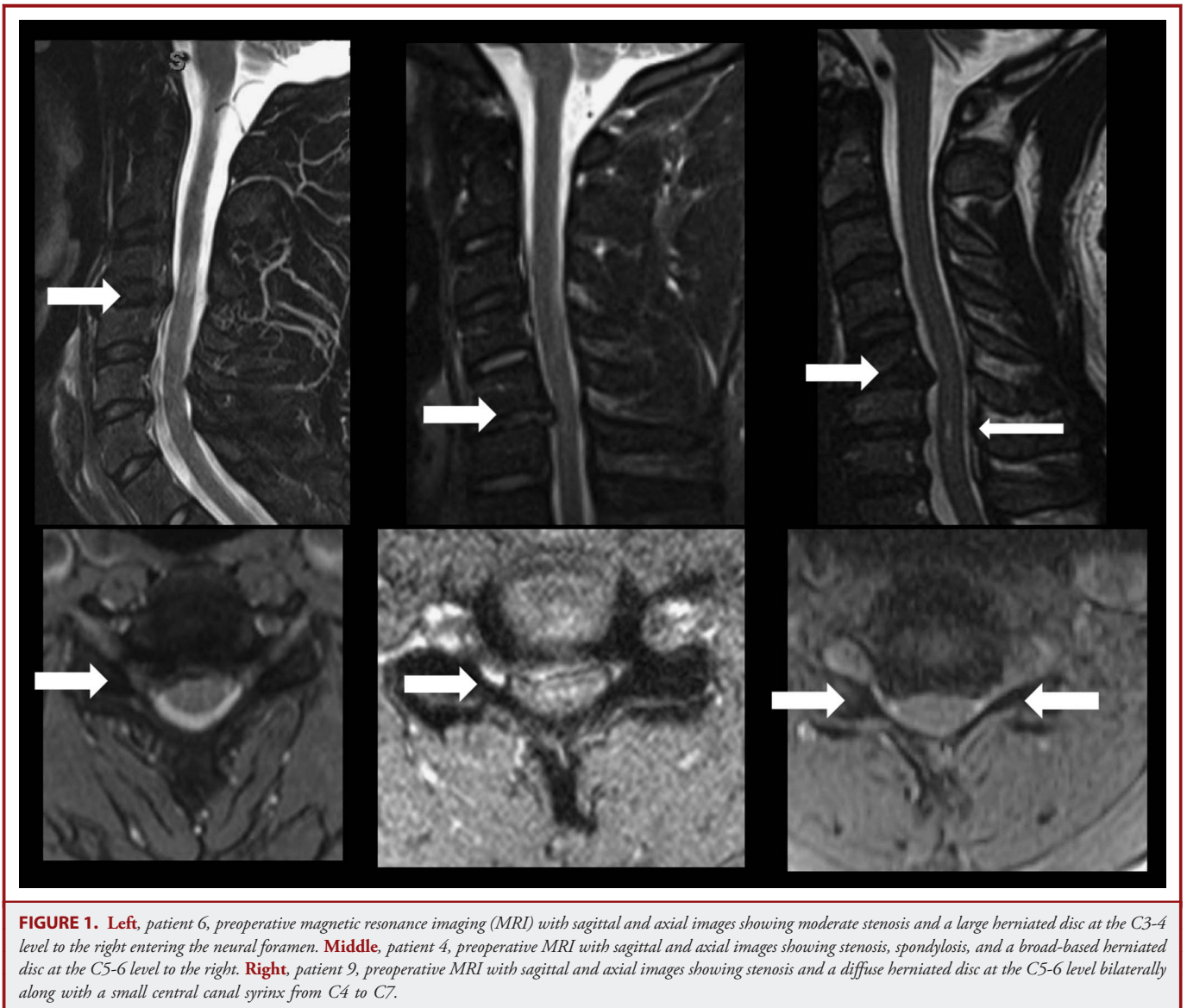


FIGURE 1. *Left*, patient 6, preoperative magnetic resonance imaging (MRI) with sagittal and axial images showing moderate stenosis and a large herniated disc at the C3-4 level to the right entering the neural foramen. *Middle*, patient 4, preoperative MRI with sagittal and axial images showing stenosis, spondylosis, and a broad-based herniated disc at the C5-6 level to the right. *Right*, patient 9, preoperative MRI with sagittal and axial images showing stenosis and a diffuse herniated disc at the C5-6 level bilaterally along with a small central canal syrinx from C4 to C7.

recommendations are primarily based on expert opinion resulting from clinical experience and indirect literature on the topic.

In 1997, Torg and Ramsey-Emrhein⁸ set forth one of the earliest recommendations regarding RTP in the setting of cervical fusion. They reported on their analysis of 1200 postinjury cervical spine lesions documented by the National Football Head & Neck Injury Registry. Although ACDF was not discussed specifically, nor professional athletes, there is a discussion on the management of patients with Klippel-Feil anomaly, the eponym applied to the congenital fusion of 2 or more cervical vertebrae, as well as those with C1-2 fusions. The review concluded that having a high cervical fusion above C3 is an absolute contraindication to returning to contact sports.⁸ On the other hand, they noted that

fusion of 1 or 2 interspaces at C3 and below in an individual with full cervical range of motion and an absence of occipital cervical anomalies, instability, disc disease, or degenerative changes should present no contraindication to RTP.⁸ These recommendations were based on work by Pizzutillo,³⁰ who reported that neurologic signs or symptoms rarely develop in children with Klippel-Feil syndrome. Their review, however, did reveal more than 90 cases of neurological problems that developed as a consequence of associated occipital cervical anomalies that included late instability, disc disease, or degenerative joint disease. He also noted that more than two thirds of those Klippel-Feil syndrome patients who had neurological involvement had a single-level fusion of the upper area, whereas many of these patients with extension of their cervical

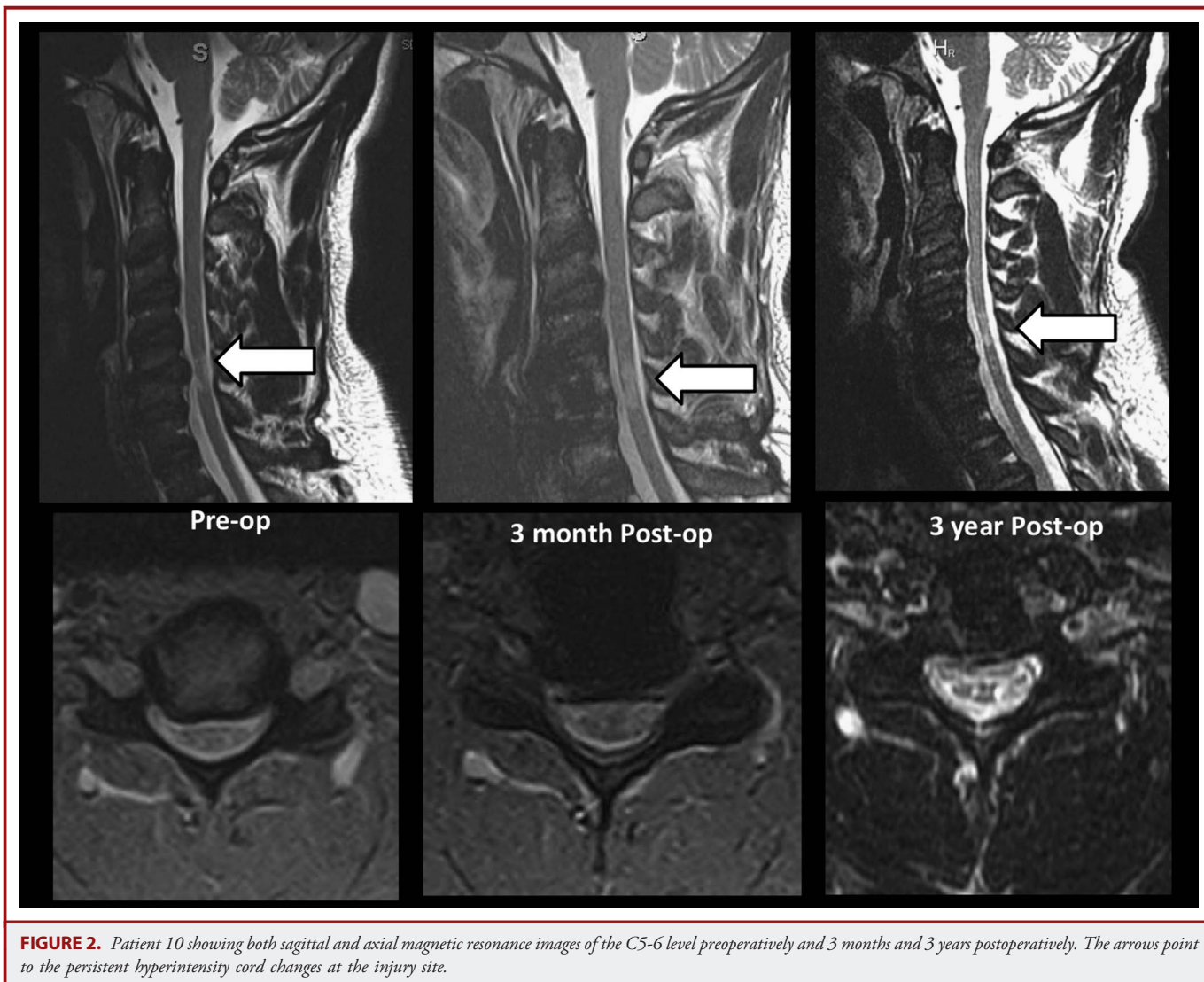


FIGURE 2. Patient 10 showing both sagittal and axial magnetic resonance images of the C5-6 level preoperatively and 3 months and 3 years postoperatively. The arrows point to the persistent hyperintensity cord changes at the injury site.

fusions 5 to 7 levels below C3 had no associated neurological loss.³⁰ So this recommendation is based more on indirect observational experience than any direct evidence of athletic participation in the setting of ACDF.

A more recent study also addressed return to contact sports after spinal surgery.²⁹ The authors provided a brief overview of RTP guidelines used successfully at their institution, although no specific outcome data or retrospective series are shared. They agreed that although the recommendations made by Torg et al^{7,8} were not based on specific statistical or outcome data, patients with a C1-2 fusion of any kind should be permanently restricted from participation in contact sports. They believed that this conclusion was logical given the delicacy of the ligamentous and bony structures at C1-2 and the potential devastating consequences of a high cervical spinal cord injury.²⁹ They also reported that in their

experience, posterior cervical foraminotomies below C1-2 should not be a contraindication to return to contact sports, but that more than a 2-level laminectomy was thought to be a contraindication because of an increased risk of destabilization.²⁹ Regarding the return to contact sports after ACDF, the authors reported that both 1- and 2-level fusions were not absolute contraindications to participation.²⁹ Based on their recommendations, those athletes with anterior fusions of more than 2 levels would be permanently excluded from contact sports because of concerns about junctional stresses around a lengthy construct and increased restriction of movement.

A general consensus has not emerged regarding whether athletes with greater than 1-level anterior cervical fusions are safe to participate in contact sports; however, RTP after a single-level ACDF, using modern plating techniques, has gained a broader

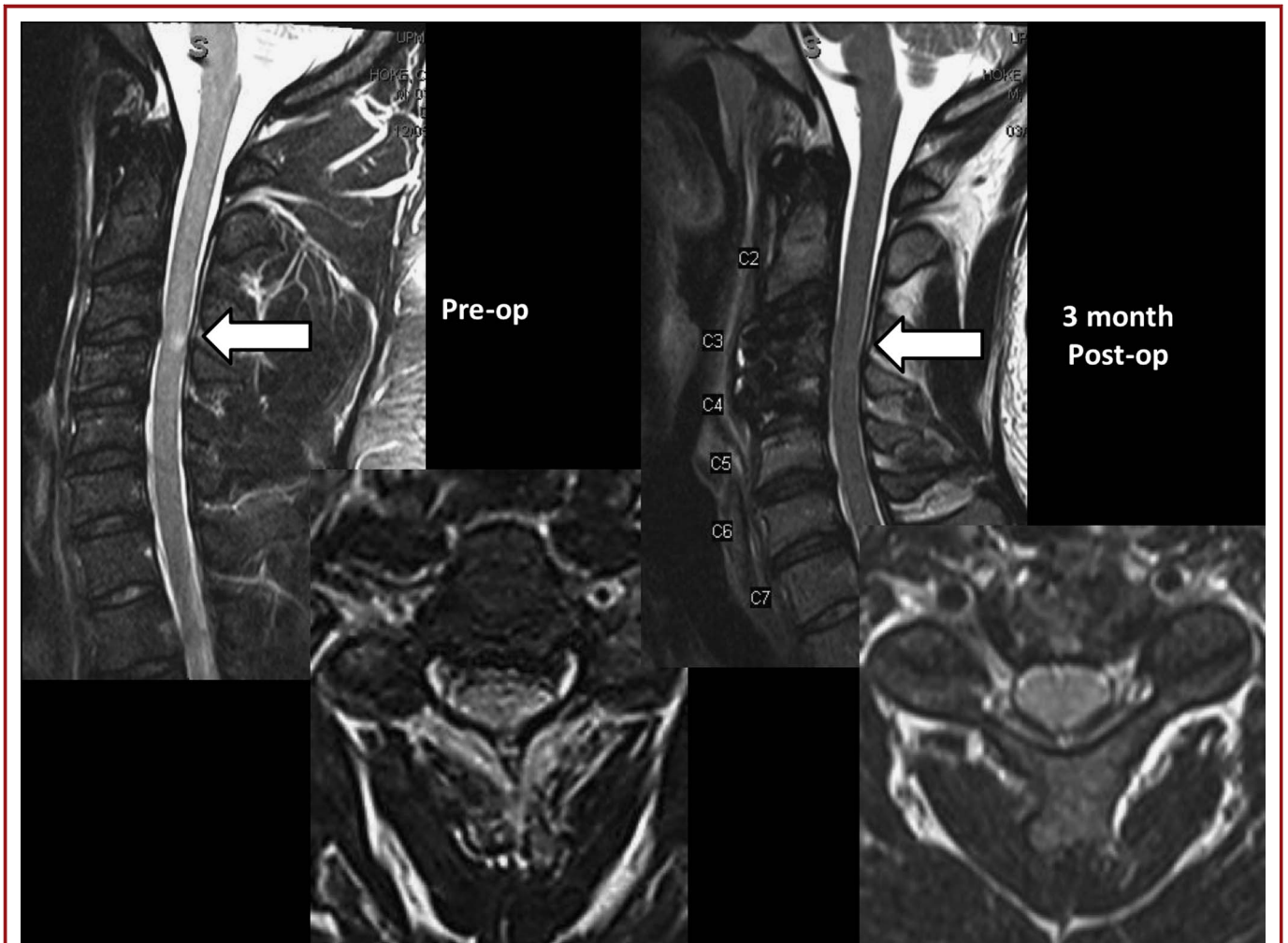


FIGURE 3. Patient 7 showing both sagittal and axial magnetic resonance images preoperatively and 3 months postoperative. The arrows point to the hyperintensity cord changes at the C3-4 level preoperatively and resolution of these changes at 3 months postoperatively.

consensus. Generally, if 2 levels are involved, this represents a relative contraindication to play. However, we recently encountered a professional wrestler with a 2-level fusion who wrestled for 8 years without symptoms until he experienced an episode of neurapraxia. MRI demonstrated severe spinal stenosis above the level of the previous fusion. Although neurologically normal, we counseled him to retire from wrestling, and he has elected to not pursue surgical intervention at this time. Most authorities continue to agree that it is safe to return to contact sports after a single-level ACDF in the setting of a solid arthrodesis (usually based on plain radiographs and/or computed tomography scan), normal range of motion of the cervical spine, and no residual neurological deficit. There is, however, no evidence-based literature supporting this recommendation in contact sports.

Although studies exclusively in elite athletes are rare, a group recently reviewed their experience with RTP after ACDF in

professional rugby players.¹⁰ This study retrospectively reviewed 19 professional rugby players who underwent ACDFs over a 5-year period. The aim of the study was to assess the safety and efficiency of ACDF in a high-energy contact sport setting and to document whether athletes were able to RTP. Seventeen of the 19 players had a single-level ACDF, and 2 had a 2-level fusion.¹⁰ Based on the case data, most of the surgeries were performed for radicular pain rather than myelopathic symptoms. Both of the patients who had a 2-level ACDF experienced difficulties after surgery and ultimately did not RTP. Thirteen of the 17 players who underwent a single-level procedure did return to contact sports, with the majority returning to participation within 6 months after the surgery. The authors concluded that return to contact sports for their rugby players seemed safe and reasonable. They further reported that 15% of those players cleared to return to the rugby field eventually

experienced cervical symptoms and 1 player eventually retired as a result. One criticism of the paper was that there was no description of outcomes with regard to neuroimaging.

The only other study investigating outcomes in elite athletes after ACDF was reported by Hsu¹² in 2011. This was a retrospective review that reported on NFL team medical records, newspaper archives, team injury reports, player profiles, and press releases to ascertain the outcome after nonoperative and operative treatments for cervical disc herniations in NFL athletes.¹² Of 99 players diagnosed with a cervical disc herniation, 53 were treated operatively and 46 nonoperatively. Overall, in the operative group, 32 players were confirmed to have had an ACDF (60.4%), 3 players were treated with a posterior foraminotomy (5.7%), and in 18 patients, the type of surgery was indeterminate from the sources available.¹² It is important to note that the number of levels and extent of cervical spinal pathology was not indicated. The study found that those NFL players who sustained cervical disc herniations and were treated successfully with surgery returned to play 72% of the time. Again, a clear subgroup analysis of outcomes in just the ACDF patients was not provided due to data sources and overall study design. Of the players who returned to play football after surgery, none sustained a spinal cord injury. Interestingly, during the study period, 5.3% of the players in the operative group underwent a second cervical operation either at the index or adjacent level, although details are lacking. Overall, despite its many limitations, the study still represents one of the first large-scale reviews of both operative and nonoperative management cervical disc herniation in the professional athlete.

Our current group of 15 patients represents one of the largest detailed case series of professional athletes who have undergone ACDF and were cleared to return to contact sport. The study builds from our previous small cohort of 5 elite athletes who presented with neurapraxia, of whom 3 professional athletes are included in this current series.¹¹ In this cohort of professional athletes, the acute onset of symptoms seen in 7 of the football players with acute neurapraxia and the 5e wrestlers with ring-related onset all had some degree of underlying degenerative spine disease at the time of diagnosis. The anterior cord compression, whether caused by an acute herniated disc fragment alone or associated with other degenerative changes, contributed to the athlete's symptoms and any existing neurological deficits.

Key Results

In our series, all 15 players were cleared to return to contact sport. Thirteen of the 15 players (87%) returned to contact sport on average 6 months after surgery. In our series, 1 athlete was forced to retire approximately 2 years after being cleared because of recurrent neurological deficit and cord compression below the level of the previous fusion. In retrospect, there were some signs of degenerative disc disease at this level on preoperative imaging before the initial C4-5 fusion. The potential risk of adjacent disc herniation is often cited as a concern for limiting RTP in contact sports after single-level ACDF. However, this athlete played without limitation for 2 years before the adjacent level herniation and repeat surgery. He has since

retired and has returned to normal functional status. Adjacent level disease is certainly well documented in the nonathlete population as well,³¹⁻³⁴ but unless there are documented signs of cervical instability, deformity, or significant cord or nerve root compression at that adjacent level, no long-term activity restrictions are typically advocated.^{10,11} A thorough review of the pertinent neuroimaging both pre- and postoperatively can help to identify associated nonsurgical degenerative disc disease above or below the level of stenosis, although it may not be possible to predict when or if an actual symptom-producing compression might occur.

Two other players immediately retired after surgery, although they had been cleared for RTP. Both cited advanced age and other cumulative orthopedic disabilities from long careers playing in the NFL as reasons to retire and not their recent ACDF. This is consistent with the rugby player study by Andrews et al¹⁰ that other factors beyond cervical fusion surgery can play a role in a player's decision not to return to contact sports.

Several other surgical considerations in these athletes may also be important for improved outcome and future spinal stability. It is our preference not to use autograft bone to avoid the well-documented potential morbidities associated with harvesting iliac crest bone grafts. Athletes who frequently no longer where hip pads, we believe that this has relevance. Allograft bone was used in all of our cases, except in 3 patients with allografts (2 tantalum cages and 1 polyetheretherketone cage). All surgeries incorporated a 4-hole cervical plate and variable angle self-tapping screw construct to provide maximal rigidity at the fusion site.

In 1 football player and in 1e wrestler, preoperative hyperintensity in the cord was seen on MRI at the level of stenosis. Both patients had normal findings on neurological examination with the exception of a positive Lhermitte's sign in the football player. The hyperintense area, in both cases, was believed to represent edema of the spinal cord. The literature on the significance of cord hyperintensity and what it actually represents has been inconclusive. In 2009, Chatley et al³⁵ concluded that patients with focal hyperintensity signal changes do not necessarily have a poorer prognosis compared with patients with no signal change. However, multisegmental MRI T2 cord hyperintensity was a predictor of poor outcome in terms of functional recovery rate. In this review, both players with localized hyperintensity were subsequently cleared for return to sport after complete resolution of symptoms, signs, and computed tomography scan evidence of fusion. The football player subsequently retired because of orthopedic concerns before RTP. Complete diminution in the intensity of the white matter signal on MRI was noted at 3 months postoperatively (Figure 3). The wrestler desired to return to his occupation postoperatively and was permitted to return to wrestling, and with 3 years of follow-up, he has continued to have no further cervical spine-related issues. MRI scanning of the wrestler at 3 months, at RTP, and recently at 3 years postoperatively still shows a small focal area of hyperintensity within the cord at the level of previous stenosis (Figure 2). In both cases, postoperative T2-weighted MRI scanning showed significant return of the surrounding cerebrospinal fluid signal at the level of the surgical site, indicating complete cord decompression.

Limitations

Just as with the other available studies in the literature regarding this topic, limitations of our current case series include the small number of cases and its overall retrospective design. Additionally, it should be noted that 4 athletes were operated on within the past 2 years, and it may be too early to draw definitive conclusions about their outcomes. They will continue to be followed. That being said, this study benefits from the clear determination of long-term outcomes in a focused patient population (professional athletes) who underwent single-level ACDF for a spectrum of cervical spine pathology by a single surgeon. It is possible that these findings and subsequent recommendations can be extended to the nonprofessional athlete involved in contact sports; however, this would need to be further validated in future studies.

CONCLUSION

There is currently little literature to help direct spine surgeons clearing athletes, let alone professional athletes, on when or whether to return to contact sports after a single-level ACDF. In this review of 15 professional athletes, we found that our outcomes supported the available recommendations that RTP after a single-level ACDF is generally safe and the risk of subsequent cervical spine-related injury low. The spectrum of pathology treated with ACDF in these athletes included cervical discogenic disease with both radicular and myelopathic syndromes. In all cases, canal dimensions were restored and the neurological compromise relieved. After a solid arthrodesis, absence of neurological deficits, full range of motion, and the absence of symptoms, the majority of athletes, as seen here, undergoing a single-level ACDF were able to be safely cleared for return to full-contact sports. As with all patients undergoing cervical fusion, there may be an inherent risk of adjacent segment degeneration and disease above or below the fused level. Athletes should be made aware of this risk and followed for this possibility. Furthermore, hyperintensity of the cord does not necessarily further preclude participation in contact sports.

Disclosures

Approval to conduct this study was obtained after review of the research protocol by the University of Pittsburgh Research Subjects Institutional Review Board. The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

The authors describe a small series of professional athletes engaged in contact sports who underwent a single-level anterior cervical discectomy and fusion (ACDF) and discuss their outcomes with a focus on subsequent return to play (RTP) criteria. Previous retrospective studies have cited RTP criteria in other contact sports such as rugby, but imaging criteria were not discussed. Another larger study also examined RTP in NFL players after operative and nonoperative treatment, but did not focus on ACDF outcomes specifically. Thus, this study does provide additional valuable information. Despite the small size of this series and the limited follow-up period, the authors are to be congratulated on a study that represents a substantial contribution to providing evidence-based support for returning players to contact sports after ACDF.

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Although the number of active professional athletes who require cervical spine surgery is limited, the results of this study are applicable to the larger number of nonprofessional athletes who undergo single-level ACDF and want to return to contact sports. The rehabilitation process and criteria for return to play (RTP) are well defined, and safe outcomes were noted in athletes who did RTP. Given the relatively small number of patients and the retrospective nature of the analysis, the results should be viewed cautiously. However, in the absence of randomized or prospective comparative studies, retrospective studies such as this provide the best available evidence. The authors should be congratulated for their efforts.

Khoi Than
Paul Park

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The authors address a somewhat controversial topic about when and whether to send a professional athlete back to their profession after a single-level anterior cervical discectomy and fusion. They demonstrate that, indeed, these professional players can be sent to their respective sports after an anterior cervical discectomy and fusion (ACDF). This reviewer, however, finds it surprising the short amount of time before the athletes went back to work—6 of the 15 players were sent back to work at 3 months or sooner. Most athletes had no problems playing when returning to their professional careers. This paper nicely documents that, indeed, professional athletes can return to their sport after a single-level ACDF and that this can be done safely and, surprisingly, relatively quickly.

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