

# Return to Play After Anterior Cervical Discectomy and Fusion in Professional Athletes

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**Background:** Data are limited on return to play after anterior cervical discectomy fusion (ACDF) in professional athletes.

**Purpose:** To determine the rate and time of return to play among professional athletes after ACDF.

**Study Design:** Case series; Level of evidence, 4.

**Methods:** This study involved the prospective and retrospective review of patient charts and diagnostic studies as well as an internet search to collect data on a consecutive series of professional athletes who underwent cervical fusion by 1 of the 2 senior authors between 1982 and 2016. Demographic data included sport, preoperative symptoms and radiologic findings, date of surgery, level of surgery, postoperative symptoms and radiologic findings, and confounding factors (eg, other orthopaedic injuries). An internet search engine was used to determine date of return to play and length of career after surgery.

**Results:** A total of 27 ACDFs were performed on 26 professional athletes: 12 National Football League athletes, 5 National Hockey League athletes, 5 Major League Baseball athletes, 3 National Basketball Association athletes, and 1 Major League Soccer athlete. Twenty-six procedures (96.3%) showed clinical and radiographic evidence of fusion, and 20 of 25 eligible players returned to play (80%). At the conclusion of this study, 2 players were still in the rehabilitation phase and expected to return at the start of the next National Football League season. The mean time to return to play in a professional game was 9.5 months (range, 5.0-20.2 months). Of 15 players who returned to play but had retired by the time of this study, the mean career length after fusion was 3.2 years (range, 0.1-8.0 years). Clinical follow-up ranged from 1 to 96 months, with a mean of 22.1 months and mode of 11 months.

**Conclusion:** After single-level ACDF, 80% of professional athletes were able to return to sport at approximately 9 months. The study findings will help athletes, physicians, and teams better predict outcome after ACDF surgery.

**Keywords:** athletes; cervical; fusion; ACDF

Cervical spine injuries are a common occurrence in every team sport, and they often entail difficult decisions with regard to treatment and return to play. The decision for surgery depends on multiple factors: symptoms, clinical

examination, radiologic studies, response to nonoperative care, age, underlying health, condition of adjacent spinal levels, sport, position, level of profession, athlete's desire to return, availability of job to resume, physician willingness to clear for return to sport, and risk of future injury. Typically, if a player fails conservative management and has a neurologic deficit that affects activities of daily living, surgery is indicated. Surgery may also be undertaken if a player has symptoms that affect the ability to play or if the risk of neurologic injury will be significantly decreased after successful surgery. The player's ability to play with and without surgery, the risk of future injury, and the potential complications of the surgery are all part of the decision-making process.

Cervical fusions for athletes are typically performed for either radiculopathy after a disc herniation or spinal cord compression owing to a disc herniation after a transient paraparetic event. The indications for surgery for radiculopathy after cervical disc herniation include failure of conservative management, weakness causing a functional deficit, and the decreased chance of future symptoms and

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Ethical approval was not sought for the present study.

increased chance of being able to play. The indications for surgery for spinal cord compression after a transient paraparetic event include persistent myelopathic findings, significant spinal cord compression, myelomalacia, and the diminished risk of future injury.

The purpose of this study was to determine the rate and time of return to play among professional athletes after anterior cervical discectomy fusion (ACDF).

## METHODS

This study involved the prospective and retrospective review of patient charts, diagnostic studies, and internet search results to collect data on a consecutive series of professional athletes who underwent cervical fusion by 1 of the 2 senior authors (R.G.W. IV, R.G.W. III) between 1982 and 2016. Demographic data included sport, position, date of injury, preoperative symptoms and radiologic findings, date of surgery, level of surgery, type of interbody graft, postoperative symptoms, radiologic findings, and confounding factors (eg, other orthopaedic injuries). An internet search engine was used to determine date of return to play and length of career after surgery.

Most patients were referred to our clinic by team physicians, head athletic trainers, player representatives, or other players. After examination of the player and review of diagnostic studies, the decision to operate was made by the player and surgeon, with consultation of appropriate parties.

A standard anterior approach to the cervical spine was performed. The neural elements were decompressed with 3.5 × magnification loupes until 2004 and subsequently with the use of a microscope. The type of interbody graft and instrumentation evolved over the course of the study—from iliac crest tricortical autograft with no plate, to allograft with iliac aspiration and plate, back to iliac crest tricortical autograft with plate, and finally to titanium-coated PEEK (polyetheretherketone) graft filled with iliac crest autograft and plate.

Postoperatively, patients were immobilized in a cervical collar from 2 to 12 weeks. With the rigidity of the fixation improving over the course the study, the period of immobilization was shortened. Since 2010, patients have worn a cervical collar for 2 weeks. Patients who were asymptomatic with radiographic evidence of stability were allowed to walk and use a recumbent bike and hands-free elliptical immediately after surgery. Physical therapy typically started 6 weeks postoperatively. Patients started with trunk stabilization exercises, building strength and endurance in the lumbar spine-stabilizing muscles.<sup>17</sup> They then progressed to chest-out posture and scapula stabilization exercises. The cervical spine rehabilitation program focuses on building strength and endurance of postural spine-stabilizing muscles rather than direct force on the cervical spine musculature. When patients reached level 3 of the 5-level trunk stabilization program (Figure 1) and completed chest-out posture exercises, they were allowed to run and start sport-specific exercises.

Return-to-play criteria included (1) status of at least 6 months postoperative; (2) normal examination results; (3) successful completion of the rehabilitation program; and (4) evidence of fusion and stability on radiographs, and preferably on computed tomography (CT). All radiographic studies were analyzed by the surgeon and an independent radiologist. Stable fixation was defined by no motion on flexion/extension radiographs and no evidence of radiolucency around fixation on CT and radiographs. If the player was asymptomatic with normal examination findings and imaging showed stable fixation, he sometimes returned to sport despite the lack of bridging bone throughout the interbody space between postoperative 6 and 12 months, depending on the sport and position.

## RESULTS

During the study period, 26 professional athletes underwent 27 surgical procedures (ACDF) by 1 of the 2 senior authors. The mean age was 28.1 years (range, 18.7-35.5 years). Distribution by sport was as follows: 13 NFL (National Football League), 5 NHL (National Hockey League), 5 MLB (Major League Baseball), 3 NBA (National Basketball Association), and 1 MLS (Major League Soccer). Distribution by spinal level was as follows: 3, C3-C4; 2, C4-C5; 17, C5-C6; and 5, C6-C7. Of the athletes with C3-C4 injuries, 2 were NFL players and 1 an NBA player. Primary pathology for surgery was 25 acute disc herniations and 2 persistent radiculopathies after posterior foraminotomy. Primary preoperative symptoms included radiculopathy (18 players) and spinal cord compression (9 players). The follow-up time of the study, including internet search for return-to-play data, averaged 11.6 years (range, 1.1-34.5 years). Clinical follow-up ranged from 1 to 96 months, with a mean of 22.1 months and a mode of 11 months. Every player was cleared by the surgeon before return to play. Sometimes this was via a telephone call not documented in the clinical follow-up.

Of the 27 procedures, 26 (96.3%) showed clinical and radiographic evidence of fusion. The mean time until radiograph evidence of fusion was 7.3 months (range, 4.1-12.9 months). One NHL player returned to play at 6.7 months despite imaging showing a lack of bony fusion. He was asymptomatic and had radiographic stability. He played for 4 seasons (without symptoms) before sustaining an acute injury that caused persistent neck pain. A CT scan at that time revealed a nonunion at the surgical level (Figure 2). The patient underwent posterior instrumentation and fusion and returned to play 7.8 months later (Figure 3).

Of 25 eligible players, 20 returned to play (80%). Two NFL players had a status of <1 year postoperative and were awaiting the start of the next season. Of the 5 players who did not return to play, preoperatively 3 had radiculopathy and 2 had myelopathy. There were no cases of catastrophic spinal cord injury after return to play.

Two athletes—an NBA and an NFL player—returned to play, then subsequently suffered adjacent-level disc herniations. The NBA player played for 6.2 seasons after C3-C4 fusion, then sustained a C4-C5 disc herniation after a minor collision. Increased T2 signal at the C4-C5 level

	Level 1	Level 2	Level 3	Level 4	Level 5
 <b>Dead Bug</b>	Supported Arms, Marching Legs, 2 Min. or Supported Legs, Extended Arms, 2 Min.	Unsupported, Alternate Opposite Arms & Legs, 3 Min.	Unsupported, Alternate Opposite Arms & Legs, 7 Min.	Unsupported, Alternate Opposite Arms & Legs, 10 Min. May Add Weights.	Unsupported, Alternate Opposite Arms & Legs, 15 Min. May Add Weights.
 <b>Partial Sit-Up</b>	Forward, Hands on Chest, 10 Reps.	Forward, Hands on Chest, 3 Sets x 10 Reps.	Hands Behind Head; Forward, Right, Left: 3 Sets x 10 Reps.	Weight on Chest: Forward, Right, Left: 3 Sets x 20 Reps.	Weights Overhead: Forward, Right, Left: 3 Sets x 30 Reps.
 <b>Bridging</b>	Double Leg Supported, 2 Sets x 10 Reps.	Double Leg Supported 2 Sets x 20 Reps. May Add Weights to Hips.	Single Leg Supported, Alternate Opposite Leg Extended, 3 Sets x 20 Reps, Each Side.	On Ball, Single Leg Extended, 4 Sets x 20 Reps, Each Side.	On Ball, Single Leg Extended, 5 Sets x 20 Reps, Each Side. With Ankle Weights.
 <b>Prone</b>	Alternating Arm or Leg Lifts, 1 Set x 10 Reps, Hold 2 Sec.	Alternating Opposite Arm and Leg Lifts, 2 Sets x 10 Reps, Hold 5 Sec. Each Side.	On Ball: Flies, Swim, Supermans: 2 Sets x 20 Reps, Hold 5 Sec.	On Ball: Flies, Swim, Supermans w/ Weights, 2 Sets x 20 Reps. Walkout/pushups 3 Sets x 5 Reps.	On Ball: Flies, Swim, Supermans w/ Weights, 4 Sets x 20 Reps. Walkout/pushups 4 Sets x 10 Reps.
 <b>Quadruped</b>	Alternate Arm or Leg, 1 Set x 10 Reps, Hold 2 Sec. Each Side.	Alternating Opposite Arm and Leg, 2 Sets x 10 Reps, Hold 5 Sec. Each Side.	Alternating Opposite Arm and Leg, 2 Sets x 20 Reps, Hold 5 Sec, Each Side.	Alternating Opposite Arm and Leg, 3 Sets x 20 Reps, Hold 5 Sec., w/ Weights.	Alternating Opposite Arm and Leg, 3 Sets x 20 Reps, Hold 15 Sec., w/ Weights.
 <b>Wall Slide</b>	45 Degrees, 10 Reps, Hold 5 Sec.	90 Degrees, 10 Reps x 20 Sec.	90 Degrees, 10 Reps x 30 Sec. Lunges 1 Min.	90 Degrees, Weights at Side, 10 Reps x 30 Sec. Lunges w/ Weights at Side 3 Min.	90 Degrees, Weights with Arms Extended, 10 Reps x 30 Sec. Lunges w/ Weights in Front 5 Min.
 <b>Ball</b>	Double Supported Leg Press, Arms at Side, 10 Reps, Hold 2 Sec.	Double Supported Leg Press, Arms Overhead, 10 Reps, Hold 2 Sec.	Arms on Chest, Ball Sit-ups, 20 Reps, Hold 2 Sec: Forward, Right, Left.	Weight on Chest, Ball Sit-ups, 30 Reps, Hold 5 Sec: Forward, Right, Left.	Weight in Extended Arms, 30 Reps, Hold 5 Sec: Forward, Right, Left. May Add: Pulleys, Weighted Stick.
 <b>Aerobic</b>	Walk: Land or Water.	10-20 Min: Walk, Bike, Elliptical, Swim.	20-30 Min: Run, Bike, Elliptical, Swim.	45 Min: Run, Bike, Elliptical, Swim.	60 Min: Run, Bike, Elliptical, Swim.
 <b>Sports</b>	None	Rotator Cuff Exercises, Scapular Stabilization, Light Throw, Flat Foot Shoot, Skate.	Rotational Exercises, Swinging, Shooting, Throwing, Striding on Field. Weight Room (Protected).	Sport-Specific Exercises, Short Sprints, Cutting, Practice with Team.	Gradual Return to Sport.



Figure 1. Five-level trunk stabilization program.



**Figure 2.** Postoperative computed tomography showing nonunion at C6-C7.



**Figure 3.** Radiograph after posterior fusion at C6-C7.

indicated injury to the spinal cord that was significant enough to recommend stopping the sport (Figure 4). The patient's symptoms resolved with conservative management. The NFL player sustained a C4-C5 disc herniation after playing 1.7 seasons with a C5-C6 fusion. He was treated with a C4-C5 fusion and was awaiting potential return to sport at the time of the study.

Four of 5 players who did not return to play were NFL players. Two NFL players were cleared to play for cervical spine but retired because of concomitant orthopaedic injuries. One NFL player was cleared to play but was waived by the team. One NFL player had a disability policy that allowed him to retire without risking further injury. One MLB player was cleared to play but was not signed by a team.



**Figure 4.** Magnetic resonance imaging after acute disc herniation at C4-C5.

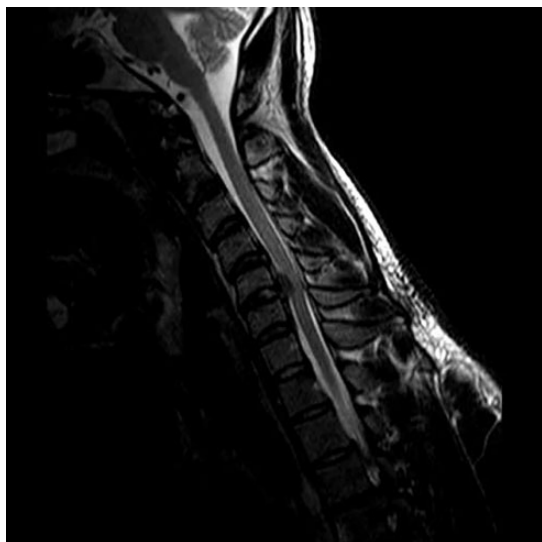
The mean time to return to play in a professional game was 9.5 months (range, 5.0-20.2 months). Three players returned between 5 and 6 months. Of the 20 players, 11 returned to play in the first possible game of the next season. Players who had undergone surgery earlier in the study period (ie, before 2005) tended to have a longer time until return to play. Excluding the 4 players with the longest return to play, which were all before 2005, the mean return to play was 8.0 months.

Mean return-to-play times can be misleading because players may be cleared to play but their sport may not be in season. Therefore, their actual return-to-sport date is delayed because of the lack of a game rather than the medical recovery. Therefore, for the players who returned to sport, we analyzed if their sport was in season at postoperative 6, 9, and 12 months and whether they had returned to play. Of the 7 players whose sport was in season at 6 months, 3 had returned to play (43%). Of the 18 players whose sport was in season at 9 months, 11 had returned to play (61%). Of the 24 players whose sport was in season at 12 months, 17 had returned to play (71%). The 3 players who took >12 months to return to play all had surgery before 2005.

There were 15 players who returned to play but had retired by the time of this study, the mean career length after fusion was 3.2 years (range, 0.1-8.0 years). Of this group, the 2 NBA players averaged 5.6 years, and the 7 NFL players averaged 2.3 years. Of the 5 players who were still playing at the time of this study, the mean career length after fusion to that point was 3.0 years (range, 1.0-6.0 years).

#### CASE EXAMPLE

A defensive back in the NFL sustained a cervical spine injury while tackling another player. He sustained a



**Figure 5.** Acute C5-C6 disc herniation with spinal cord compression.



**Figure 6.** Two-month postinjury magnetic resonance imaging showing persistent herniation and spinal cord compression.

temporary paraparetic event with burning pain, numbness, and tingling down both arms that lasted approximately 5 minutes. His examination result was neurologically normal. He had pain and stiffness in his neck that lasted 2 weeks, then completely resolved. Magnetic resonance imaging (MRI) showed a large C5-C6 disc herniation with significant spinal cord compression (Figure 5). Follow-up MRI 2 months later showed no improvement in the size of the herniation and degree of spinal cord compression (Figure 6). The decision was made to operate to increase the likelihood of the player being able to return to sport by the next season. The player returned to play at postoperative 10.3 months (Figure 7).



**Figure 7.** Ten-month postoperative computed tomography showing stable fixation and interbody fusion.

## DISCUSSION

Head contact sports are at greatest risk for a cervical spine injury. Certain positions in certain sports involve repetitive axial loading of the cervical spine, which may cause acute injury and/or chronic degenerative changes. Scher<sup>11</sup> showed that the front-line players in a rugby scrum sustain the largest loads and have higher rates of acute cervical spine injuries. Additionally, in a sample of NFL retirees aged 30 to 49 years, 36.6% self-reported a diagnosis of arthritis and neck pain, as opposed to 16.9% in the general population.<sup>18</sup> Our study corroborates these results, with NFL players being the largest group of athletes who underwent cervical fusion.

Underlying cervical stenosis increases the chance of having symptoms and potentially undergoing surgery after an acute disc herniation. Stenosis is typically determined by MRI or CT-myelogram. “Functional” spinal stenosis, defined as the loss of cerebrospinal fluid around the cord or deformation of the spinal cord, is generally more accurate and relevant than bony stenosis.<sup>3</sup> In the general population, cervical stenosis has been shown to increase the risk for permanent spinal cord injury after a fracture dislocation injury.<sup>6,9</sup> Among football players, cervical stenosis has been shown to increase the risk for recurrent episodes of neurapraxia.<sup>14</sup> However, episodes of neurapraxia as an independent factor have not been shown to increase the risk of permanent spinal cord injury.<sup>15</sup> Typically, asymptomatic cervical stenosis is not treated prophylactically with surgery.

Return to play after an episode of transient neurapraxia depends on the degree of stenosis, presence of spinal cord compression or signal abnormalities, severity of acute injury (ie, quadriplegia lasting >36 hours), signs and symptoms on examination, and risk for future injury. The

physician's job is to counsel the athlete on potential risks and to make a recommendation of treatment. Cervical fusions may be performed if the degree of stenosis, degree of symptoms, biomechanics of the spine, and patient demographics determine that the risk of future injury will be less after fusion than with nonoperative management.

After cervical fusion, the player's ability to return to sport depends on resolution of symptoms, radiologic evidence of stability and fusion, risk of future injury, and completion of the spinal rehabilitation program. At times, the player may have a successful fusion but may not return to sport because of multiple injuries at the end of his or her career or the desire to not risk future injury. Additionally, a player may be cleared to return to sport but may not get hired by a team.

A review of the literature by Dailey et al<sup>5</sup> suggested that "surgical fixation with single-level ACDF to eliminate single level neurologic compression causing radiculopathy or myelopathy is a strong recommendation as a treatment option to return to full contact sports play." This recommendation was based primarily on a cohort of 17 players who underwent ACDF, none of which suffered a catastrophic spinal cord injury after return to play. Additional reports support a low risk of return to play after a single-level ACDF.<sup>1,8,10,16</sup>

Maroon et al<sup>10</sup> reported on 7 NFL players and 8 wrestlers after single-level ACDF, with a return to play of 87% at a mean 6 months (range, 2-12 months). Of the NFL players, 5 returned to play (71%). The 2 players who did not return were cleared from a spinal perspective but retired because of orthopaedic injuries. One NFL player who returned to play subsequently retired after sustaining a disc herniation at an adjacent level.

In a study of 19 professional rugby players by Andrews et al,<sup>1</sup> 13 of 17 (76%) players who underwent single-level ACDF returned to play. Both players with 2-level ACDF had difficulties and did not return to play. Furthermore, 15% of the players undergoing single-level ACDF who returned to play experienced future symptoms.

In our study, 2 of the 20 players who returned to play (10%) sustained an adjacent-level disc herniation that was symptomatic. One required surgery, and the other was treated conservatively.

Hsu<sup>8</sup> reported on cervical spine injuries in NFL players based on an internet search, medical records, and team injury reports. Of 53 players with cervical disc herniations treated operatively, 32 had ACDF, 3 had posterior foraminotomy, and 18 had an unknown type of surgery. Of this operative group, 72% returned to play. Limiting factors attributed to the methodology of the study included a large number of players whose surgery information was unavailable, the lack of subgroup analysis of ACDF results, and the unknown spinal levels that were involved.

In the current study, there were 2 NFL players and 1 NBA player who underwent a fusion at C3-C4, which is a common level for disc herniation in NFL players. Gray et al<sup>7</sup> found that the highest incidences of disc herniations in NFL players were at C3-C4 and C5-C6 (23% each), followed by C4-C5 (21%). 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,<sup>4,13</sup> and a kyphotic segment increases the risk of a flexion injury. During a head-down tackle, the compressive impact may be up to 98 times the force of gravity delivered axially to the cervical spine.<sup>2</sup> A fusion of C3-C4 at the middle of a straight or kyphotic segment in a head-contact sport/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 fusing C3-C4 in a head-contact sport. In our study, neither of the NFL players with a C3-C4 fusion developed adjacent-level problems, but the 1 NBA player suffered a C4-C5 herniated disc on a routine play several years after the initial C3-C4 fusion.

Tempel et al<sup>12</sup> reported on 3 NFL players who underwent fusion at C3-C4 and who had a preoperative T2 hyperintense lesion in the spinal cord. Two of 3 successfully returned to play, and the third was awaiting final clearance. Of note, the authors concluded that "MRI T2 hyperintensity in contact sport athletes (treated surgically or nonoperatively) who are symptom-free with normal examination and no evidence of spinal instability may not be a contraindication to return to play."

Data are lacking on the safety of return to sport after a 2-level neck fusion. In a non-head contact sport (baseball or basketball), a player may be cleared to return to sport after a 2-level neck fusion. However, if a player is relatively asymptomatic with life outside of sports, sometimes we do not recommend undergoing a 2-level neck fusion to have a chance to return to sport. Andrews et al<sup>1</sup> reported on 2 players in a head-contact sport who struggled after a 2-level fusion.<sup>1</sup> We have had only 1 player on whom we performed a 2-level fusion, and we are still awaiting his potential return to sport. While there are some data on adjacent-level pathology after multilevel neck fusion for degenerative disc disease, there are no data on 20- to 30-year-old patients who underwent multilevel fusions after traumatic disc herniations. Our concern is the risk for long-term lack of mobility, adjacent-level pathology, and chronic pain.

Clearance for return to sport after cervical fusion can be complicated by confounding factors. Owing to insufficient data, residual kyphotic deformity, fusion at C3-C4, 2-level fusions, adjacent-level susceptibility to injury, and residual area of myelomalacia or syrinx (traumatic or congenital) are not fully understood factors. The risks of future injury and long-term sequelae need to be discussed and determined by the surgeon and player on an individual case basis.

Limitations of our study include retrospective chart review, short-term clinical follow-up, multiple surgical techniques owing to the long study period, confounding factors that caused some players to not return to sport despite their cervical spine being cleared, and no control group. Some players had only 1 month of clinical follow-up with the surgeon but were treated by the medical staff of the team after the surgery. Every player was cleared to play by the surgeon, sometimes via a telephone call that may not have been included in the clinical documentation. We relied

on internet data for return-to-play information for these individuals.

Our study confirms current literature findings that approximately 80% of professional athletes are able to return to sport at 9 months after a single-level ACDF. Factors that need to be considered and studied in greater detail include kyphotic deformities, congenital stenosis, multi-level pathology, and long-term outcome, including post-career quality of life.

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