Return to Play in Athletes Receiving Cervical Surgery: A Systematic Review

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Abstract

Study Design Systematic review.

Clinical Questions Among athletes who undergo surgery of the cervical spine, (1) What proportion return to play (RTP) after their cervical surgery? (2) Does the proportion of those cleared for RTP depend on the type of surgical procedure (artificial disk replacement, fusion, nonfusion foraminotomies/laminoplasties), number of levels (1, 2, or more levels), or type of sport? (3) Among those who return to their presurgery sport, how long do they continue to play? (4) Among those who return to their presurgery sport, how does their postoperative performance compare with their preoperative performance?

Objectives To evaluate the extent and quality of published literature on the topic of return to competitive athletic completion after cervical spinal surgery.

Methods Electronic databases and reference lists of key articles published up to August 19, 2015, were searched to identify studies reporting the proportion of athletes who RTP after cervical spine surgery.

Results Nine observational, retrospective series consisting of 175 patients were included. Seven reported on professional athletes and two on recreational athletes. Seventy-five percent (76/102) of professional athletes returned to their respective sport following surgery for mostly cervical herniated disks. Seventy-six percent of recreational athletes (51/67) age 10 to 42 years RTP in a variety of sports following surgery for mostly herniated disks. No snowboarder returned to snowboarding (0/6) following surgery for cervical fractures. Most professional football players and baseball pitchers returned to their respective sport at their presurgery performance level.

Conclusions RTP decisions after cervical spine surgery remain controversial, and there is a paucity of existing literature on this topic. Successful return to competitive sports is well described after single-level anterior cervical diskectomy and fusion surgery for herniated disk. RTP outcomes involving other cervical spine diagnoses and surgical procedures remain unclear. Additional quality research is needed on this topic.

Keywords
- return to play
- cervical spine surgery
- athletes
- guidelines

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Study Rationale and Context

The diagnosis and surgical treatment of spinal disorders in athletic patients are relatively straightforward and well defined. Unfortunately, the decision to allow an athlete to return to competitive play after spinal surgery remains unclear. Furthermore, the regional differences in spinal anatomy and biomechanics make this decision even more challenging.

Standardized criteria for return to play (RTP) after spinal surgery do not exist. Previous authors have published guidelines for RTP after spinal injury, but their conclusions are obtained largely from expert opinion and experience rather than scientific evidence.[1,2] Most would agree that athletes who return to contact sports after spinal surgery should be asymptomatic and have a stable spine with normal neurologic function and range of spinal motion. There also must be adequate space for the neural elements.

The decision to clear an athlete to RTP after cervical spine surgery remains controversial. There is lack of consensus among experts and no strict guidelines for return to presurgery level of athletic competition. The burden remains with the treating physician to consider the risks of continued athletic performance after spinal surgery in patients who are reluctant to give up playing their chosen sport.

It is our opinion that a better understanding of the published literature can lead to more-informed choices by the physician with respect to athletic RTP. The purpose of this article is to review the existing literature with respect to return to athletic competition and performance after cervical spine surgery.

Clinical Questions

Among athletes who undergo surgery of the cervical spine:

1. What proportion RTP after their presurgery sport?
2. Does the proportion of those who RTP depend on type of surgical procedure (artificial disk replacement, fusion, nonfusion foraminotomies/laminoplasties), number of levels (one, two, or more levels), or type of sport?
3. Among those who return to their sport, how long do they continue to play?
4. Among those who return to their surgery sport, how does their postoperative performance compare with their preoperative performance?

Materials and Methods

Study design: Systematic review.
Search: PubMed and bibliographies of key articles.
Dates searched: Database inception to August 19, 2015.
Inclusion criteria: (1) Observational studies in peer-reviewed journals; (2) athletes of any sport undergoing cervical spine surgery; and (3) outcomes including the proportion of those who RTP.
Exclusion criteria: Athletes with cervical injury who did not receive surgical intervention.
Outcomes: (1) The proportion of those athletes who had cervical injury and who RTP; (2) the length of play after return; and (3) the postoperative performance compared with preoperative performance.
Analysis: Descriptive statistics.

Details about our methods can be found in the online supplementary material.

Overall strength of evidence: The overall strength of evidence across studies was not assessed. This systematic review is hypothesis generating.

Results

Study Characteristics

- We identified nine observational, retrospective series consisting of 175 patients who met the inclusion criteria and form the basis for this report (►**Table 1**; ►**Fig. 1**). Seven publications reported on professional athletes and two on recreational athletes.
- A series of recreational athletes reported by Saigal et al mostly received surgery for herniated disks,[3] and all the recreational snowboarders reported by Masuda et al had cervical fractures.[4]
- The athletes included are those who played professional American football (all positions), professional rugby, professional wrestling, professional baseball (pitchers), and various recreational sports. American football was the most frequently studied professional sport with a total of 66 athletes receiving cervical surgery.
- Among the professional American National Football League (NFL) football players, 37 played on defense (11 defensive linemen, 11 defensive linebackers, 15 defensive backs), 27 played on offense (11 offensive linemen, 2 tight ends, 6 wide receivers, 4 quarterbacks, 4 running backs), and 1 was a kicker. Additionally, there was 1 collegiate-level defensive linebacker.
- All professional athletes and most of the recreational athletes were young males.

Proportion Returned to Play (►Table 2)

- Seventy-five percent (76/102) of professional athletes returned to playing their sport following surgery for mostly cervical herniated disks. Among professional football players, 70% (46/66) returned to play,[5–8] and 88% (7/8) of Major League Baseball pitchers returned to play in the major leagues.[9]
- Saigal et al reported 76% (51/67) of recreational athletes age 10 to 42 years returned to play in a variety of sports following surgery for mostly herniated disks.[3] On the other hand, Masuda et al reported that no snowboarder returned to snowboarding following surgery for cervical fractures.[4]
- We found no description of RTP based on surgical procedure or number of surgical levels.

Postoperative Performance and Duration of Play (►Table 1)

- Six studies assessed performance and/or duration of play among professional athletes who returned to their sport following surgery.

Table 1 Study characteristics, return to play, performance, and duration

First author (year)	Demographics	Sport/position	Diagnosis	Surgery	RTP[a]	Time RTP following index surgery	Performance (versus before surgery)	Duration of RTP
Professional athletes								
Andrews (2008)[10]	$n = 19$ Age (mean): 28 (range, 22–37) y Male: 100% (19/19) F/U (mean): 17 mo (range, 7–60)	Professional rugby FRF ($n = 13$) SRF ($n = 1$) BRF ($n = 2$) Backs ($n = 3$)	Spondylosis ($n = 19$)	ACDF, 1 level ($n = 17$); ACDF, 2 level ($n = 2$)	14/19 (73.7%) By level of play Same level of play: 13/19 (68%) 1 level lower than original level of play: 1/19 (5%) By surgery level 2-level: 1/2 (50%) By position FRF: 9/13 (69%) All others: 5/6 (83%)	Same level of play ($n = 13$) 6 mo: 69% (9/13) 6–12 mo: 23% (3/13) $>$ 12 mo: 8% (1/13)	NR	NR
Hsu (2011)[5]	$n = 53$ Age: 28.4 y Male: 100% (53/53) F/U (mean): 10.4 y[b] NFL experience: 5.2 y BMI: 30.8	NFL DL ($n = 8$) OL ($n = 8$) LB ($n = 10$) DB ($n = 12$) RB ($n = 4$) TE ($n = 1$) WR ($n = 5$) QB ($n = 4$) Kicker ($n = 1$)	HNP ($n = 53$)	ACDF, 1 level ($n = 32$); postforaminotomy ($n = 3$); surgery type NR ($n = 18$); 2nd operation at the index or adjacent level ($n = 3$)	38/53[c] (72%) By position played[c] DB: 6/12 (50%)	NR	Performance score[c,d]: 1.74 versus 1.34 ($p = 0.17$) Percent games started[c]: 0.57 versus 0.55 ($p = 0.83$)	All ($n = 38$[c]) Average no. games played: 29.3 Average length of time played: 2.8 y DB ($n = 6$) Average no. games played: 17 Average length of time played: 1.9 y
Maroon (2007)[7,e]	$n = 2$ Age (mean): 24.5 y Male: 100% (2/2) F/U: NR	NFL: DE ($n = 1$) Collegiate football: LB ($n = 1$)	Neurapraxia ($n = 2$)	ACDF, without plate ($n = 1$); ACDF, with plate ($n = 1$)	2/2 (100%)	5–8 mo: 100% (2/2)	NR	NFL DE ($n = 1$): length of time played: 3 y Collegiate LB ($n = 1$): no. games played: 7
Maroon (2013)[6,e]	$n = 15$ Age (mean $\pm$ SD): 30.3 $\pm$ 1.3 (range, 22–40) y Male: 100% (15/15) F/U: NR	NFL ($n = 7$) CB ($n = 2$) DE ($n = 1$) DT ($n = 1$) FB ($n = 1$) OG ($n = 1$) OT ($n = 1$) Professional wrestling ($n = 8$)	Focal spinal spondylosis and stenosis ($n = 13$); isolated herniated disk ipsilateral to radiculopathy ($n = 2$)	ACDF, 1 level ($n = 15$); ACDF, 2 levels ($n = 0$); underwent a second ACDF at adjacent level ($n = 1$)	13/15 (87%) By sport NFL: 5/7 (71%) Wrestling: 8/8 (100%)	Mean 6 mo (range, 2–12): 100% (13/13)	NR	NFL ($n = 5$) Still playing $>$1 y duration at time of publication ($n = 2$) 2 y: $n = 1$ 3 y: $n = 2$ Wrestling Still wrestling $>$1 y duration at time of publication: ($n = 5$) $\leq$1 y: $n = 2$ NR ($n = 1$)
Meredith (2013)[8]	$n = 3$ Age: 27 (range, 25–28) y Male: F/U: minimum 1 y	NFL OL ($n = 1$) DB ($n = 1$) WR ($n = 1$)	Mild to moderate cervical disk herniation ($n = 3$)	ACDF, 1-level ($n = 3$)	1/3 (33%)	Returned the next season: 100% (1/1)	NR	NR
Roberts (2011)[9]	$n = 8$ Age (mean): 30.6 y Male: 100% (8/8) F/U: NR	MLB ($n = 8$)	Cervical disk herniation ($n = 8$)	ACDF, 1-level ($n = 7$) CDR ($n = 1$)	7/8 (88%)	Average 13.1 $\pm$ 9.6 mo: 100% (7/7)	Before surgery ($n = 8$); after ($n = 7$) ERA: 4.21 $\pm$ 0.87 versus 8.95 $\pm$ 7.02 ($p = 0.14$) IP: 64.3 $\pm$ 30.7 versus 32.9 $\pm$ 38.1 ($p = 0.09$)	Mean 28 $\pm$ 35 mo ($n = 7$)

(*Continued*)

Table 1 (*Continued*)

First author (year)	Demographics	Sport/position	Diagnosis	Surgery	RTP[a]	Time RTP following index surgery	Performance (versus before surgery)	Duration of RTP
							WHIP: 1.43 ± 0.12 versus 2.07 ± 0.91 ($p = 0.14$) No. of games: 168 ± 225 versus 50 ± 84 No. of mo: 67 ± 44 versus 28 ± 35	
Tempel (2015)[11,e]	$n = 2$ Age (mean): 28.5 (range 26–31) y Male: 100% (2/2) F/U: NR	NFL: TE ($n = 1$) Professional wrestling ($n = 1$)	Disk herniation with stenosis ($n = 1$); spondylosis with disk herniation ($n = 1$)	ACDF, 1-level ($n = 2$)	1/2 (50%)	9 mo: 100% (1/1)	NR	Wrestling: still wrestling at time of publication ($n = 1$)
Recreational athletes								
Saigal (2014)[3]	$n = 67$ Age: mean NR (range, 10–42 y) Male: 82% (89/109)[b] F/U: NR	Recreational sports[f] Football ($n = 32$) Soccer ($n = 14$) Basketball ($n = 12$) Baseball/softball ($n = 11$) Track and field ($n = 5$) Martial arts ($n = 5$) Tennis ($n = 5$) Wrestling ($n = 4$) Hockey ($n = 2$) Volleyball ($n = 3$) Other (NR) ($n = 15$)	Mostly herniated disks with at least one known fracture; other pathologies not described ($n = 67$)	Instrumented fusion ($n = 15$); instrumented fixations ($n = 2$); instrumented fixation with likely fusion ($n = 1$); noninstrumented ($n = 49$)	51/67 (76%) By surgery type Instrumented: 13/18 (72%) Noninstrumented: 38/39 (97%) p for instrumented versus noninstrumented = 0.010	0–1 mo: 6% (3/51) 1–3 mo: 37% (19/51) 3–6 mo: 35% (18/51) 6–12 mo: 22% (11/51) By surgery type Instrumented 0–1 mo: 0% (0/13) 1–3 mo: 8% (1/13) 3–6 mo: 46% (6/13) 6–12 mo: 46% (6/13) Noninstrumented 0–1 mo: 8% (3/38) 1–3 mo: 47% (18/38) 3–6 mo: 32% (12/38) 6–12 mo: 13% (5/38)	NR	NR
Masuda (2015)[4]	$n = 6$ Age (average): 21.7 (range, 17–26) y Male: 100% (6/6) F/U (mean): 46 mo	Recreational snowboarding ($n = 6$)	Cervical, burst fracture ($n = 4$); cervical, anterior fracture-dislocation ($n = 2$)	Posterior fusion ($n = 6$)	0/6 (0%)	Time to return: (none returned to snowboarding)	NR	All procedures: 0/0 (0%)

Abbreviations: ACDF, anterior cervical diskectomy and fusion; BRF, back row forward; CB, cornerback; CDR, cervical disk replacement; DB, defensive back; DL, defensive lineman; DE, defensive end; DT, defensive tackle; ERA, earned run average; F/U, follow-up; FB, fullback; FRF, front row forward; HNP, herniated nucleus pulposus; IP, innings pitched; LB, linebacker; MLB, Major League Baseball; NFL, National Football League; NR, not reported; OG, offensive guard; OL, offensive lineman; OT, offensive tackle; RB, running back; QB, quarterback; RTP, return to play; SD, standard deviation; SRF, second row forward; TE, tight end; WHIP, walks plus hits per innings pitched; WR, wide receiver.

[a]RTP definitions: Hsu (2011)[5]: being on the active roster for at least one NFL season postintervention; Maroon et al (2013)[6]: full contact participation and competition; Roberts (2011)[9]: being on the active roster for at least one MLB season postintervention; Andrews et al (2008),[10] Maroon et al (2007),[7] Meredith (2013),[8] Tempel (2015),[11] Saigal (2014),[3] and Masuda et al (2015): RTP not defined.

[b]Demographic data are for entire study population, which includes those who did not receive operative treatment or received an operative treatment not of interest.

[c]Outcomes are inclusive of a variety of operation types, including ACDF and posterior foraminotomy, as well as indeterminate operations.

[d]Measured using a standardized, previously published scoring system based on pertinent statistics important to an individual player's position; this was then normalized for the duration of each career with the number of games played to calculate performance score for players (except defensive lineman) with at least 2-year follow-up after injury.

[e]Maroon et al (2007),[7] Maroon (2013),[6] and Tempel (2015)[11] contain overlapping populations; only new cases are represented in each study.

[f]Distribution of represented sports among patient population includes those also receiving cranial surgery ($n = 41$) and surgery for peripheral nerve lesions ($n = 1$) in addition to the spine surgery patients ($n = 67$) of interest.

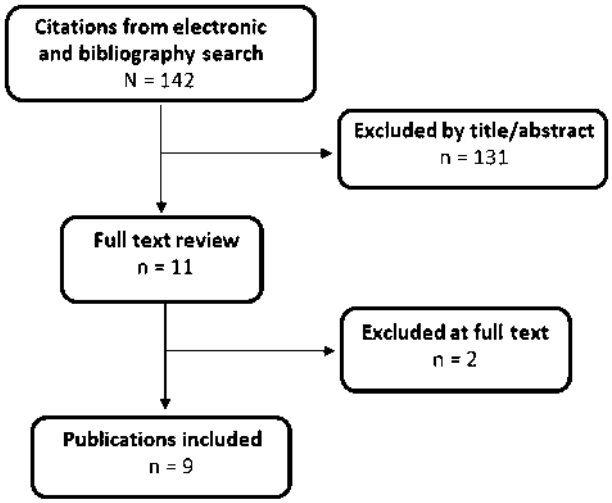

Fig. 1 Flowchart showing results of literature search.

National Football League

- Hsu compared a performance score among non–defensive linemen with at least 2-year follow-up after surgery using a standardized, previously published scoring system.[5] The system is based on pertinent statistics important to an individual player's position and normalized for the duration of each career with the number of games played. They reported a higher score for performance prior to surgery (1.74 versus 1.34), though the difference was within the realm of chance ($p = 0.17$). They found no difference in the proportion of games started (57% before surgery and 55% after surgery). The average number of games played was 29 after surgery, and the average length of time played was 2.8 years. Maroon et al found a similar average length of time played (3 years).[7] Age at diagnosis and number of years in the NFL were negative predictors for career length in years after treatment ($p = 0.003$). The performance score before diagnosis was a positive predictor of games played ($p < 0.005$) but not years played after diagnosis. There was no association between outcomes after treatment and body mass index, height, weight, number of Pro Bowls, or year of surgery.

Rugby

- One study reported that 93% (13/14) of rugby players who returned to play following surgery did so at the same level of play; 69% returned by 6 months and 84% returned by 1 year.[10]

Table 2 Frequency of return to play for professional athletes by sport

Professional sport	Return to play
Rugby	74% (14/19)
Football[a]	73% (48/66)
Wrestling	100% (9/9)
Baseball	88% (7/8)

[a]Includes one collegiate-level football player.

Major League Baseball

- One report of seven pitchers who returned to Major League Baseball compared pre- versus postoperative performance. Earned run average was 4.21 ± 0.87 preoperatively versus 8.95 ± 7.02 postoperatively ($p = 0.14$); innings pitched, 64.3 ± 30.7 versus 32.9 ± 38.1 ($p = 0.09$); and walks plus hits per inning pitched, 1.43 ± 0.12 versus 2.07 ± 0.91 ($p = 0.14$). These pitchers continued pitching for an average of 28 months.[9]

Wrestling

- Most wrestlers in two publications who returned to wrestling were active in their sport > 1 year at time of publication.[6,11]

Illustrative Case Report

A 32-year-old professional hockey player sustained a violent collision with another player during a hockey game. He noted the immediate onset of severe neck pain, and he was removed from the arena on a stretcher and transported to a level one trauma facility. He remained neurologically normal. Initial computed tomography imaging revealed an isolated right C5–C6 cervical fracture subluxation injury (►**Fig. 2**). Magnetic resonance imaging demonstrated some posterior ligamentous injury, but no

Fig. 2 Initial injury computed tomography imaging showing an isolated right C5–C6 cervical fracture subluxation injury.

Fig. 3 Initial injury magnetic resonance imaging demonstrated some posterior ligamentous injury, but no evidence of spinal cord injury or cervical stenosis.

evidence of spinal cord injury or cervical stenosis (►**Fig. 3**). The player was treated surgically with C5–C6 anterior cervical diskectomy and fusion using an allograft and a titanium plate. He was discharged from the hospital on postoperative day 1, and his postoperative course was uneventful.

At 6 months postoperation, the player was asymptomatic. He expressed the desire to return to his job as a professional hockey player. He was able to demonstrate normal neurologic function and an excellent range of cervical motion on physical examination. Follow-up radiographs at postoperative 6 months demonstrated solid allograft interbody anterior cervical diskectomy and fusion (ACDF) graft healing with no evidence of residual spinal instability (►**Fig. 4A** and **4B**). Additionally, a postoperative computed tomography scan was also performed at postoperative 6 months and clearly demonstrated the solid ACDF fusion and normal alignment of the cervical spine (►**Fig. 5**).

He received medical clearance to return to professional hockey play at 6 months after his surgery. The player continued to play professional hockey and reported the same level of preinjury performance for an additional 3 years after his surgery. He retired from professional hockey uneventfully at the age of 36. He still remains active in recreational hockey play.

Discussion

- The majority of the existing literature on this topic reports successful return to athletic competition, including contact sport participation, after single-level ACDF surgery for cervical herniated disk. There is a lack of data describing successful RTP after surgery for other cervical diagnoses including fracture and spinal cord injury.
- The data suggests that few patients RTP before 6 months. Six months provides adequate time for healing and further stability with interbody graft fusion. Our case example demonstrated solid graft healing at 6 months postoperatively.
- There is currently no quality information to guide RTP decisions after cervical total disk replacement (TDR). Only one report describes the successful return to noncontact sport after single-level cervical TDR in one patient. The

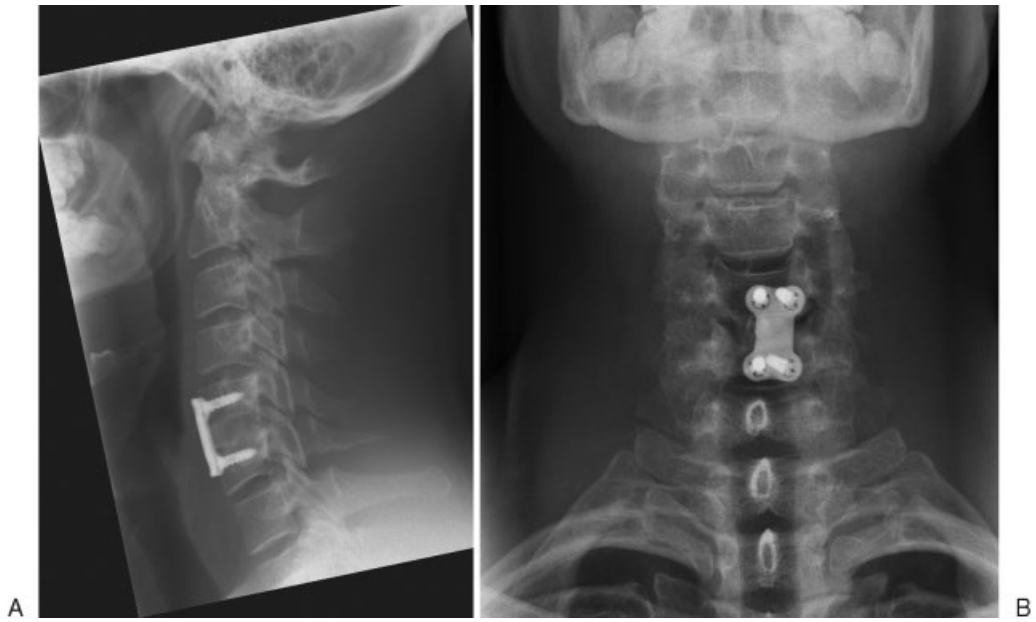

Fig. 4 Six months' postoperative lateral (A) and anteroposterior (B) radiographs demonstrating solid allograft interbody anterior cervical diskectomy and fusion graft healing with no evidence of residual spinal instability.

Fig. 5 Computed tomography scan 6 months postoperatively showing solid C5–C6 interbody allograft fusion and normal alignment of the cervical spine.

complications and risks with athletic participation after TDR remain unknown.
- Poor data exists evaluating the level of athletic performance after cervical spine surgery.
- There is no quality data reporting successful RTP in contact sports after multiple-level cervical spine surgery.
- Postsurgical catastrophic neurologic injury after RTP was beyond the scope of this review. However, we are familiar with at least one study that noted successful return to NFL football in a series of four players who had single-level anterior cervical spinal surgery for cervical spine stenosis and cord contusion injury. At 2 years' follow-up, two athletes developed new contusions, but none of the four had permanent neurologic sequelae.[12]

Strengths

- As far as we know, this review is the first to include all studies reporting on a proportion of both professional and recreational athletic patients returning to play following cervical spine surgery.

Limitations

- There is a paucity of existing quality literature assessing the proportion of athletes returning to the sport following cervical surgery. We only identified nine studies with 175 total patients.
- Studies in this systematic review include small series of athletic patients that may or may not represent a cohort of patients. To determine the cumulative incidence of athletes who return to their sport following cervical surgery, one would need to capture an entire cohort of athletes in a sport who receive surgery and follow them over time to determine the outcome.

Conclusions

RTP decisions after cervical spine surgery remain controversial, and there is a paucity of existing literature on this topic. Successful return to competitive sports is well described after single-level ACDF surgery for herniated disk. RTP outcomes involving other cervical spine diagnoses and surgical procedures remain unclear. Additional quality research is needed on this topic.

Disclosures
Robert W. Molinari: none
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Editorial Perspective

With increasing professionalization of sports along with a dramatic surge in global popularity of sporting events over the last decades, only recently has an increasing focus been placed on serious sports-related injuries associated with high-impact sports, such as American football, rugby (both union and league), Fédération Internationale de Football Association (FIFA) style football, and hockey. Sports-related blunt head trauma and its ill effects on short- and long-term health to its bearers have received an increasing amount of attention with substantial damages now being recognized, especially with American football.[1,2] As the field of sports medicine grapples to establish the true incidence of head injuries and its management for contact sports, it stands to reason that an attempt be made at this time to assess the status quo of our knowledge base regarding sports-related cervical spine pathology and the ability of affected players to RTP after neck injury and treatment within their high-end and physically demanding sports disciplines.

This article by Molinari et al provides a helpful summary of our current knowledge base, and a considerable insight from this study is how limited the current published data really is. Although some reviewers voiced understandable concerns about publishing a systematic review with apparent holes in the evidence basis, this very discovery can be of great importance if it helps direct new areas of research. This study was endorsed by the majority of reviewers as important. Hopefully, this article with its attempt at comprehensively collecting and assessing the available peer-reviewed world literature in a structured fashion will do just that.

The authors' findings overall show a relatively encouraging RTP rate with some sports-specific differences being apparent. In general and for most sports with the exception of snowboarding, a single-level cervical fusion or decompression seems to be compatible with RTP within about 1 year from time of surgery onward. There is some early evidence to suggest a decrement in performance in certain sports such as baseball and professional.

As stated earlier, we lack a lot of important data, such as the baseline neurologic status of patients prior to and following surgery, persistent radiographic spinal stenosis or cord signal changes, as well as alignment and degeneration-related structural factors. Longer-term outcomes data such as secondary neurologic decline or rates of further spine surgery is not yet available, but hopefully greater urgency toward transparency of data especially for athletes performing in professional and high-end collegiate leagues will prevail, similar to the greater awareness of head injuries in sports.

This article will hopefully prompt a dialogue among leaders in the field of sports medicine, such as being represented by the senior author of this study, to start an overdue, more-formal discussion on the question of when is it safe to return to play after a neck injury and a similar question for patients who have received some form of neck surgery. Following the lead of the head injury task forces, a good baseline might be reached by answering the following five questions explicitly or implicitly raised by Molinari et al in their illustrative case report.

- What constitutes a structurally stable neck?
- When is a neck reconstruction surgery (such as fusion, laminoplasty, disk arthroplasty, or decompression surgery alone) "solid"?
- What is an acceptable clinical neurologic status (radiculopathy, myelopathy) for RTP and how do we objectively test for such?
- What is the role of MRI findings in RTP, such as space available for the cord, cord signal changes, and cord compression?
- Are there position- or sports-specific exemptions for RTP or RTP restrictions?

Along these lines, developing a national sports-related spinal cord injury registry in countries with organized sports, such as Canada has done with the International Collaboration on Repair Discoveries project activities, would seem to be a desirable next step.[3]

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