National Football League Head, Neck and Spine Committee's Concussion Diagnosis and Management Protocol: 2017-18 season

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ABSTRACT

One of the National Football League's (NFL) Head, Neck and Spine Committee's principal goals is to create a 'best practice' protocol for concussion diagnosis and management for its players. The science related to concussion diagnosis and management continues to evolve, thus the protocol has evolved contemporaneously. The Fifth International Conference on Concussion in Sport was held in Berlin in 2016, and guidelines for sports concussion diagnosis and management were revised and refined. The NFL Head, Neck and Spine Committee has synthesised the most recent empirical evidence for sports concussion diagnosis and management including the Berlin consensus statement and tailored it to the game played in the NFL. One of the goals of the Committee is to provide a standardised, reliable, efficient and evidence-based protocol for concussion diagnosis and management that can be applied in this professional sport during practice and game day. In this article, the end-of-season version of the 2017–18 NFL Concussion Diagnosis and Management Protocol is described along with its clinical rationale. Immediate actions for concussion programme enhancement and research are reviewed. It is the Committee's expectation that the protocol will undergo refinement and revision over time as the science and clinical practice related to concussion in sports crystallise

INTRODUCTION

The identification and management of sport-related concussion (SRC) has become one of the most hotly debated and intensely researched sports medicine topics of the 21st century. Perhaps no other sports medicine injury, in terms of its immediate and potentially long-term effects, has garnered the attention of the public, the media, sports participants and clinicians and researchers in the neurological sciences. Indeed, SRC is the only injury governed by a protective state law advocating for sports-related safety for school-age children and has been passed in all 50 states in the USA. It is estimated that anywhere from 1.6 to nearly 4 million SRCs occur annually in the USA,[1] and visits to emergency departments for the evaluation and treatment of SRCs among young children doubled from 1997 to 2007.[2] The interest in SRC has intensified steadily since the 1990s, and has given rise to concussion-related position statements by professional medical organisations,[3–5] state laws[6] and the eventual formation in 2000 of an international consensus group (Concussion in Sport Group; CISG) dedicated to the establishment of international guidelines for the identification and management of concussion in sports.[7–11]

The National Football League (NFL) began its efforts to address SRC with the establishment of the Mild Traumatic Brain Injury Committee in 1994.[12] In 2010 the committee was reconstituted as the Head, Neck and Spine (HN&S) Committee, with co-chairmen H Hunt Batjer and Richard G Ellenbogen. The HN&S Committee published protocols regarding diagnosis and management of concussions in 2013.[13]

The influx of recent research related to SRC has been astounding. In fact, the CISG, at its 2016 meeting in Berlin, reported that nearly 60 000 published papers on SRC were identified[14] and screened as the basis for the eventual systematic reviews that were published. Given the increase in the SRC knowledge base and the new CISG guidelines, the NFL HN&S Committee reviewed and updated its protocols related to concussion.

The initial HN&S Committee's Concussion Diagnosis and Management Protocols, which were provided to all teams prior to the start of the 2017 season, can be found at: https://www.playsmartplaysafe.com/focus-on-safety/protecting-players/nfl-head-neck-spine-committees-protocols-regarding-diagnosis-management-concussion/.

We present below the protocols in effect at the end of the 2017–18 season, including those changes made in-season.

THE NATIONAL FOOTBALL LEAGUE HEAD, NECK AND SPINE COMMITTEE'S CONCUSSION DIAGNOSIS AND MANAGEMENT PROTOCOL

Introduction

Overview of injury

Concussion is an important injury for the professional football player, and the diagnosis, prevention and management of concussion are important to the NFL, its players and member clubs, and the NFL Players Association (NFLPA). The NFL's HN&S Committee has developed a comprehensive set of protocols regarding the diagnosis and management of concussions in NFL players.

The diagnosis and management of concussion is complicated by the difficulty in its identification as well as the complex and individual nature of its management. Ongoing education of players, NFL

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team physicians, club neuropsychologists, and certified athletic trainers (ATCs) regarding concussion is important, recognising the evolving advances in concussion assessment and management. The objective of these protocols is to provide medical staff responsible for the healthcare of NFL players with a guide for diagnosing and managing concussion.

This document updates and supersedes the initial NFL HN&S Committee's Protocols Regarding Diagnosis and Management of Concussion issued in July 2013.[13]

Concussion defined

For the purposes of these protocols, the term 'concussion' is adapted from and defined as follows[11]: sports-related concussion (SRC) is a traumatic brain injury induced by biomechanical forces. Several common features that may be utilised in clinically defining the nature of a concussive head injury include the following:

1. SRC may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head.
2. SRC typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, signs and symptoms can evolve over a number of minutes to hours.
3. SRC may result in neuropathological changes, but the acute clinical signs and symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.
4. SRC results in a range of clinical signs and symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive features typically follows a sequential course. However, in some cases symptoms may be prolonged.
5. The clinical signs and symptoms cannot be explained by drug, alcohol or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction, etc) or other comorbidities (eg, psychological factors or coexisting medical conditions).

Potential concussion signs (observable)

- Any loss of consciousness
- Impact seizure/posturing of limbs
- Slow to get up following a hit to the head ('hit to the head' may include secondary contact with the playing surface)
- Motor coordination/balance problems (stumbles, trips/falls, slow/laboured movement)
- Blank or vacant look
- Disorientation (eg, unsure of where he is on the field or location of bench)
- Amnesia, both anterograde and retrograde
- Clutching of head after contact
- Visible facial injury in combination with any of the above

Potential concussion symptoms

- Headache
- Dizziness
- Balance or coordination difficulties
- Nausea
- Amnesia, both anterograde and retrograde
- Cognitive slowness
- Light/sound sensitivity
- Disorientation
- Visual disturbance
- Tinnitus

NFL HN&S Committee's Concussion Protocol

Emergency action plan

At each football stadium throughout the USA that hosts an NFL team, an Emergency Medical Action Plan (EAP) is developed, written, discussed, practised and reviewed by every club's medical staff for all practice and game venues, as well as for conditioning and training sites. Each EAP establishes the protocols that the medical staff must follow in the event of significant injury, including head trauma. The practical importance of establishing an EAP includes identifying the closest, most capable medical centre near the football stadium/venue for management of traumatic injuries of all physiological systems. In addition, by identifying a specific healthcare facility, the designated emergency medical technicians serving on game day have a well-recognised trauma facility to which to transport the patients, as well as on-field physicians who are accredited to practice medicine at that facility, thereby making the transport a clinically productive and efficient process.

The EAP must include a list of approved certified Booth ATC Spotters (ATC Spotters) for the stadium and a list of certified and approved emergency room physicians who serve as medical liaisons for the visiting team. The EAP is submitted and approved by an expert designated by the parties and confirmed by the NFL Chief Medical Officer and the NFLPA Medical Director. The EAP is sent to the visiting club's medical team in advance of all games to ensure they can easily access these personnel when they need them for their patients.

Pre-season

Education

Players and club personnel are provided with, and must review, educational material regarding concussion, including the importance of identifying and reporting signs and symptoms to the medical staff. The educational material provides basic facts about concussion, including signs and symptoms, as well as why it is important to report symptoms promptly. Additionally, players are educated and encouraged to report to the medical staff concussion signs and symptoms that their teammates may experience. The goal is to provide broad education to every participant in the game of football, so that a culture change can continue to evolve to one of self-awareness and self-reporting of symptoms.

Pre-season assessment

a. Physical examination: The team physician uses the pre-season physical examination to review and answer questions about a player's previous concussions, discuss the importance of reporting any concussive signs or symptoms, and explain the specifics regarding the concussion diagnosis and management protocol. Team doctors also explain the various roles of the participants in the concussion protocol (eg, Unaffiliated Neurotrauma Consultants (UNC), Independent Neurotrauma Consultants (INT) and Club Neuropsychologists.
b. Neuropsychological testing: Every player must undergo a baseline physical examination as part of his pre-season physical examination which includes a traditional neurological examination and Baseline NFL Locker Room Comprehensive Concussion Assessment. This baseline information is used in evaluating the player if he subsequently sustains a concussion during the season. Each player is required to have a baseline

neuropsychological test. Computerised forms of neuropsychological testing can be used, but it is also acceptable to perform standard paper and pencil testing or to utilise a combination of the two (known as the 'hybrid' model). For quality assurance purposes, Club Neuropsychologists will review baseline neuropsychological test results during the pre-season for the detection of invalid protocols and for determination of the need for test re-administration.

Game day concussion diagnosis and management

Definitions/responsible parties

Unaffiliated Neurotrauma Consultants (UNCs): These consulting physicians work with the team's medical staff and assist in the diagnosis and care of the concussed player. During games, each team is assigned a UNC by the NFL HN&S Committee and approved by the NFL Chief Medical Officer and the NFLPA Medical Director. For all playoff games and the Super Bowl, a third sideline UNC is added to serve as a backup who can step in immediately should one of the original two UNCs be absent from the sideline while attending to a more severely injured player. In addition, another centralised UNC monitors the video broadcast feeds of all games. The centralised UNC will contact the team medical staff on the sideline or the ATC Spotter should they observe any signs or symptoms warranting further evaluation.

Each UNC is a physician who is impartial and independent from any Club, is board certified or board eligible in neurology, neurological surgery, emergency medicine, physical medicine and rehabilitation, or any primary care Certificate of Added Qualification (CAQ) sports medicine certified physician, and has documented competence and experience in the treatment of acute head injuries (as evidenced by no less than monthly treatment of such patients).

A UNC is present on each sideline during every game and is: (i) focused on identifying symptoms of concussion and mechanisms of injury that warrant concussion evaluation; (ii) working in consultation with the Head Team Physician or designated concussion team physicians to implement the concussion evaluation and management protocol (including the Locker Room Comprehensive Concussion Assessment Exam) during the games; and (iii) present to observe (and collaborate when appropriate with the team physician or his concussion physician designee) the Sideline Concussion Assessment Exams performed by club medical staff. The UNC is also present for sideline evaluations for neuropraxia ('stingers' or 'burners') and other potential neck injuries.

The UNCs also are available to assist in transportation to a medical facility based on the EAP in which that consultant has medical privileges for more advanced medical evaluation and/or treatment as needed. The team physician/UNC unit is co-located for all concussion evaluations and management both on and off the field. Should the UNC be unavailable to participate in the sideline evaluation (eg, the UNC is treating another player in the locker room or accompanying an injured player to the hospital in accordance with the EAP), the club physician may request to conduct the assessment with the second UNC who is present on the opposing team's sideline. The UNC may present his/her own questions or conduct additional testing and assists in the diagnosis and treatment of concussions. Regardless, the responsibility for the diagnosis of concussion and the decision to return a player to a game remains ultimately within the professional judgement of the Head Team Physician or the team physician assigned to managing concussion.

In essence, the UNC acts as an independent 'co-pilot' or consultant for the team physician 'pilot' role. Each UNC files a standardised report of his/her activity following each game focused on the specifics of the observed and/or suspected concussions. The report is then reviewed for quality assurance purposes by the NFL Chief Medical Officer and NFLPA Medical Director, and feedback and education are provided subsequently to augment the physician quality improvement process.

Booth Certified Athletic Trainer Spotter (ATC Spotter): Two certified athletic trainers are assigned to a stadium booth with visual and camera access to multiple views of video and replay to aid in the recognition of injury (ATC Spotters). ATC Spotters follow the NFL Concussion Protocol and are charged with monitoring the game, both live and via video feed, to identify players who may require additional medical evaluation. Prior to the start of the game, ATC Spotters introduce themselves to the medical staff for both teams to discuss protocol and to confirm that all communication devices are operational. The ATC Spotters, UNCs and the team physician communicate in 'real time' by radio communication. The ATC Spotters are also connected to the on-field game officials by radio communication. The teams' medical personnel can initiate communication with the ATC Spotter to clarify the manner of injury. The sideline medical staff can review the game film on the sidelines to obtain information on particular plays involving possible injury.

When the ATC Spotter observes a player who is clearly unstable or displays any other potential concussion signs (defined above) following a mechanism of injury (eg, a hit to the head or neck), he/she contacts the team physician and UNC by radio to ensure that a concussion evaluation is undertaken on the sideline. The club medical staff verifies to the ATC Spotter that the evaluation has been performed.

The ATC Spotter notes the time of: (i) his initial contact with the club medical staff and UNC alerting them of the need for further evaluation, and (ii) the time of the communication from the club medical staff and UNC confirming that an evaluation has been performed. This information is conveyed in the ATC Spotter's report following the game. If the ATC Spotter observes a player who has been flagged for medical evaluation return to the game prior to receiving the confirmation from the team's medical staff that an evaluation was conducted, the ATC Spotter calls a medical timeout (see below). For purposes of clarity, this is intended to serve as a redundant communication from the ATC Spotter with the team physician or UNC to confirm that a concussion evaluation has been performed. If no such confirmation is provided, the ATC Spotter is empowered to call a medical timeout to assure the concussion evaluation occurs. ATC Spotters file a report of their activity following each game for review by the NFL Chief Medical Officer and NFLPA Medical Director.

Game day symptoms/return to play

'No-Go' signs and symptoms: If a player exhibits or reports any of the following signs or symptoms of concussion, he is removed immediately from the field of play and transported to the locker room. A player who exhibits or reports any of the following signs or symptoms is considered to have suffered a concussion and is not returned to participation (practice or play) on the same day under any circumstances.

- Loss of consciousness
- Confusion
- Amnesia
- Impact seizure/posturing of limbs

All players demonstrating gross or sustained vertical instability (eg, stumbling or falling to the ground when trying to stand) must

undergo a Locker Room Comprehensive Concussion Assessment where an evaluation for a concussion can be conducted.

Medical timeout

In the event the ATC Spotter (i) has clear visual evidence that a player is manifesting overt signs of disorientation, is clearly unstable, or displays other obvious sign of concussion; and (ii) it becomes apparent that the player will remain in the game and not be attended to by the club's medical or athletic training staff, then the ATC Spotter can take the following steps:

a. If the player does not receive immediate medical attention, the ATC Spotter can contact the Side Judge over the Official-to-Official communication system to identify the player by his team and jersey number.
b. The ATC Spotter can contact the medical staff of the player involved and advise that the player appears to need medical attention.
c. The ATC Spotter remains in contact with the medical staff until the medical staff confirms that a concussion evaluation has occurred or is underway. It is the ATC Spotter's responsibility to confirm that a concussion evaluation has occurred prior to the player returning to play. As detailed above, if an ATC Spotter observes a player returning to the game without receiving express confirmation that an evaluation has occurred, the ATC Spotter can signal to the official for a medical timeout.

On being called by the ATC Spotter, the Side Judge may immediately stop the game, attend to the player in question, and await the arrival of the club's medical personnel to ensure player safety (ie, the player is escorted off the field). No communication via coach-to-player headsets is permitted during the stoppage, no member of the coaching staff may enter the playing field, and no player other than the player receiving medical attention may go to the sideline unless a substitute player has replaced him. The goal is to separate the coaching player replacement decisions from the medical decisions.

Once removed from the field, the team medical staff conduct an evaluation of the player as required by the governing protocols before making any decision regarding the player's eligibility to return to play. The medical staff makes the return-to-play decision consistent with the NFL protocols. In no instance does this evaluation period last less than one play, unless there is an extended delay unrelated to the player's removal from the game (ie, timeout, 2 min warning, penalty, etc). An injury timeout is not charged to a team who has a player removed during this process.

Following the game, the UNC and team physician document each step outlined above and their conclusions regarding the player's status. The UNC's report details each evaluation, including interactions with players and members of the club medical staff, and is sent to the NFL Chief Medical Officer and NFLPA Medical Director following the game again for quality assurance purposes.

Madden Rule

On game day, per the Madden Rule, a player diagnosed with a concussion: (a) must be removed from the field of play; (b) his helmet is removed from the player's possession; (c) he is escorted to the locker room by team medical personnel; and (d) he is observed in the locker room by qualified medical personnel. The Madden Rule protects the player by providing a quiet environment, with appropriate medical supervision, to permit the player time to recover without distraction. Once a player is diagnosed with a suspected concussion, he is not permitted to meet or talk to the press until he is medically cleared, again with the goal to protect the player.

Additional evaluations and follow-up

A player diagnosed with concussion has the entire sideline examination (as well as the NFL Locker Room Comprehensive Concussion Assessment) performed on the day of injury, as tolerated medically. The components of the NFL Locker Room Comprehensive Concussion Assessment can be performed at different times on the day of the injury depending on the individual situation (eg, an exception can be made for a player who is transported to the emergency department), and an assessment is repeated prior to discharge home or prior to transportation home following an away game. A player diagnosed with concussion will be given 'take home' educational information (eg, signs and symptoms for which to watch, emergency phone numbers) as well as follow-up instructions. The NFL Locker Room Comprehensive Concussion Assessment is repeated the following day on all players assessed on game day to monitor for the development of concussion symptoms.

Even if a player has normal findings on an initial concussion assessment and is returned to practice or play, he is to be checked periodically during practice or play and again before leaving the venue. Performing serial concussion evaluations occur in each suspected concussion case and may be useful because concussive injury can evolve and may not be apparent clinically for several minutes or hours. Components of the NFL Locker Room Comprehensive Concussion Assessment are to be utilised in the performance of such evaluation.

i. The results of subsequent examinations by the team physician are communicated to the UNC in the spirit of 'concussion team' cooperation and patient safety.
ii. Should the sideline examination reveal a change in the player's condition during game play, the team physician/UNC team is re-assembled, and they perform a subsequent Locker Room evaluation.
iii. We recognise that players may be able to equal or exceed their performance under the Locker Room Comprehensive Concussion Assessment compared with their baseline level yet still have a concussion, underscoring the importance of the physicians' knowledge of the player. If there is any doubt about the presence of a concussion, regardless of the quantitative Locker Room ?format change here?

Comprehensive Concussion Assessment results, the player is removed from practice or play. A player diagnosed with concussion will be given 'take home' educational information (eg, signs and symptoms for which to watch, emergency phone numbers) as well as follow up instructions.

NFL Sideline Concussion Assessment (Sideline Survey): If a player exhibits or reports a sign or symptom of concussion (defined above) or a concern is raised by the club's athletic trainer, team physicians, ATC Spotter, coach, teammate, game official or UNC (collectively referred to as 'game day medical personnel'), the player is immediately removed to the sideline medical tent (or stabilised on the field), as needed, and undergoes the entire NFL Sideline Concussion Assessment. The team physician/UNC unit is co-located for all concussion evaluations and management both on and off the field. The UNC may present his/her own questions or conduct additional testing and shall assist in the diagnosis and treatment of concussions.

This initial survey takes several minutes and, at a minimum, consists of the following:

i. A review of the 'NO-GO' criteria reviewed above (loss of consciousness, confusion, amnesia, impact seizure/posturing of limbs), which, if present, requires the player to be brought to the locker room without a chance for return to play that day
ii. Inquiry regarding the history of the event
iii. Review of concussion signs and symptoms (see above)
iv. Maddocks' questions[15]
v. Video review of the injury (detailed below)
vi. Focused neurological examination, inclusive of the following:

- Cervical spine examination (including range of motion and pain)
- Evaluation of speech
- Observations of gait
- Eye movements and pupillary examination.

The above medical evaluation is (i) conducted inside a HIPAA compliant medical evaluation tent on the sideline and (ii) performed using the tablet or other technology assigned by the NFL, and completion of each component of the Sideline Survey is checked off the list for completeness. The team physician and the UNC review available video of the suspected injury event. If any elements of the sideline assessment are positive, inconclusive,or suspicious for the presence of a concussion, the player is escorted to the locker room immediately for the complete NFL Locker Room Comprehensive Concussion Assessment. Also, if the player demonstrates worsening or progressing symptoms at any point, he is brought to the locker room for the complete NFL Locker Room Comprehensive Concussion Assessment. The player is accompanied by, at least, the team physician best qualified to evaluate concussion and the UNC. The UNC may present his/her own questions or conduct additional testing.

If, on completing the Sideline Survey, the medical staff (team physician/UNC) concludes that the player did not sustain a concussion, then the player may return to play when finally cleared by the team physician. Suggested best practices for concussion assessment include periodic checks by the team physician, UNC or others with the player to determine whether he has developed any of the signs or symptoms of concussion that would necessitate a subsequent locker room evaluation.

UNC Involvement in Sideline Concussion Assessment

1. The team physician consults in private with (i) the members of his/her team's medical staff designated to identify, diagnose and treat concussions; (ii) the UNC and, as necessary, (iii) the club's ATC, prior to making his/her decision regarding whether the player will return to the game.
2. If the team physician determines that the player shall not return to play (based on the criteria listed above) and therefore there is no need to complete the Sideline Concussion Assessment, the team physician and the UNC accompany the player to the locker room to evaluate the player using the NFL Locker Room Comprehensive Concussion Evaluation[4] for serious injury, treat the player or activate the EAP if indicated.
3. The team physician remains responsible for all final decisions regarding return to play. However, the team physician consults with his/her UNC team member prior to reaching his/her decision. If the UNC disagrees with the team physician's decision to return the player to play or remove the athlete, the UNC is given an opportunity to explain the basis of his/her opinion. This is discussed in a collegial fashion in private as to why the player should or should not be returned to the game. The team physician has to make the final return to play or removal decision and then communicate his final decision to the player. The NFL HN&S Committee looks at the relationship between the UNC and team physician as a collaborative co-pilot/pilot relationship. Although the team physician is responsible for all final decisions, he/she has the advantage of utilising the extra set of eyes and consultative neurological experience of the UNC to make a more informed decision on the diagnosis of concussion. To date, diagnostic disagreements have been exceedingly rare. We believe that this is a result of the collaborative culture that has developed between the UNCs and team physicians, the robust nature of the current examination and the fact that there is time to discuss the clinical assessment among the medical team.

NFL Locker Room Comprehensive Concussion Assessment (Locker Room Exam): The NFL Locker Room Comprehensive Concussion Assessment (Locker Room Exam) is the standardised acute evaluation that has been developed by the NFL's HN&S Committee to be used by teams' medical staffs and designated UNCs to evaluate potential concussions during practices and on game day. This evaluation is based on the Standardised Concussion Assessment Tool (SCAT5) published by the International Concussion in Sport Group,[11] modified for use in the NFL, and consistent with the SCAT5.[15] The NFL Locker Room Exam can be administered and repeated as needed to aid in the diagnosis of concussion, even if there is a delayed onset of symptoms. The ongoing use of the Locker Room Exam, in conjunction with the pre-season baseline testing, provides a comprehensive and detailed picture of each athlete's injury and recovery course. Being able to compare the results from the NFL Locker Room Exam with the baseline information obtained in the pre-season (SCAT and neuropsychological test data) improves the value of this instrument. Clubs maintain all NFL Locker Room Exams (including the SCAT5) and a copy is available to both the player and the team medical staff.

In all circumstances, the team physician responsible for concussion evaluation (or other physician designated by the team physician such as a neurosurgeon or team neurotrauma specialist) assesses the player in person in conjunction with the UNC. The team physician is responsible for determining whether the player is diagnosed as having a concussion.

The athlete may have a concussion despite being able to complete the NFL Locker Room Comprehensive Concussion Assessment 'within normal limits' compared with their baseline, due to the nature of concussive injury and possible limitations (for example, practice effects) of the Locker Room Exam. Such limitations underscore the importance of the team medical personnel knowing the athlete at their baseline and the subtle deficits in their personality and behaviours that can occur with concussive injury. It is not uncommon that an ATC or team physician will remove a player because, although he performs at his baseline level on the Locker Room Exam, he is deemed to not be at neurobehavioral baseline (eg, behavioural agitation, emotional dyscontrol) according to the team medical personnel who know him best.

The signs and symptoms of concussion listed above, although frequently observed or reported, are not an exhaustive list. The NFL Locker Room Exam is intended to capture these elements in a standardised format. The neurocognitive assessment in the NFL Locker Room Exam is brief and does not replace more formal neuropsychological test procedures. A balance assessment is an important

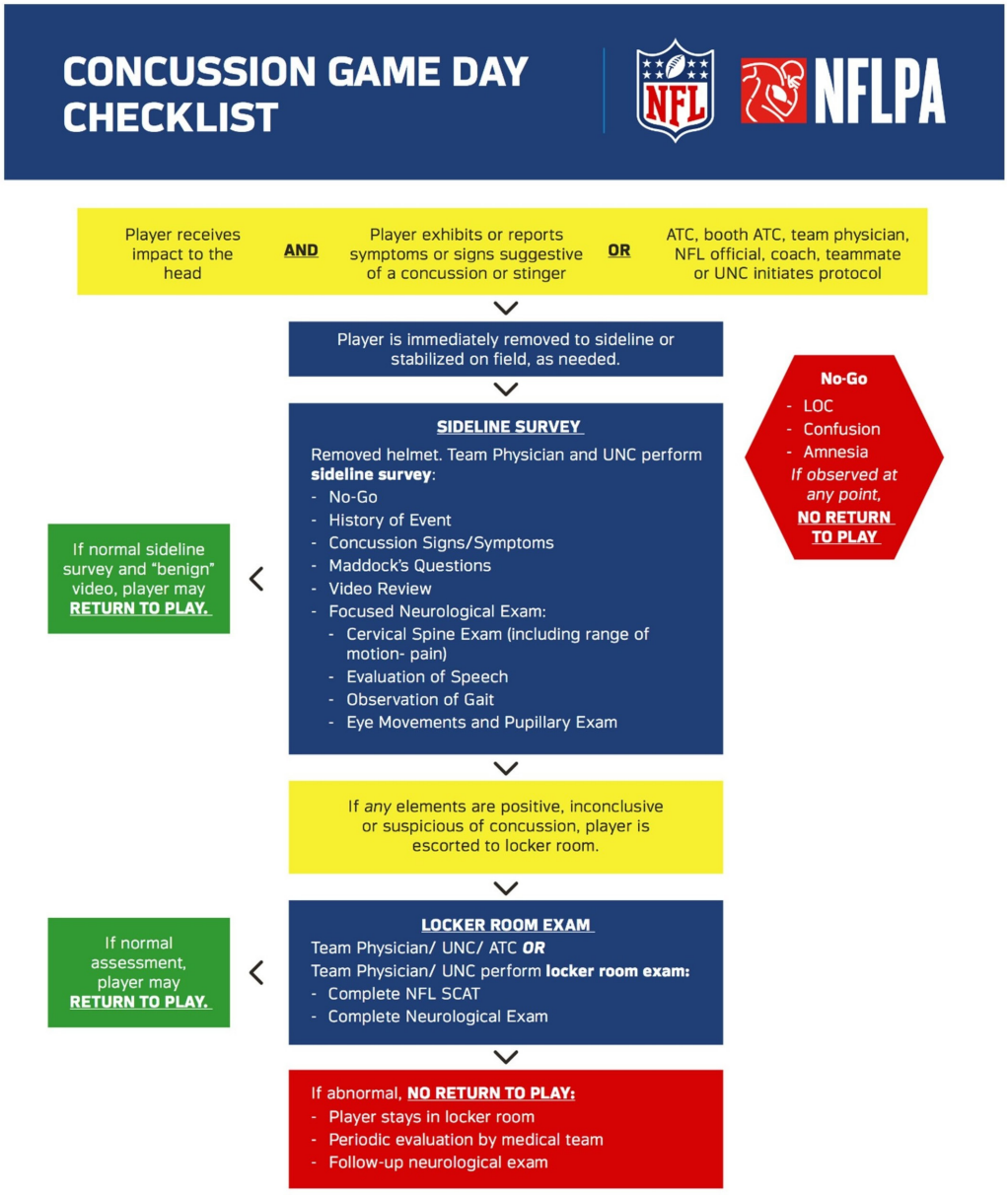

Figure 1 NFL Concussion Game Day Checklist.

component of the NFL Locker Room Exam, and has been validated as a useful adjunct in assessing concussive injury.[15]

NFL Concussion Game Day Checklist

The NFL Concussion Game Day Checklist provides a clear summary of the steps required by NFL HN&S Committee's Concussion Diagnosis and Management

Protocol, with regard both to Sideline Survey and the Locker Room Exam. The NFL Concussion Game Day Checklist is described in figure 1. The application of the NFL

Concussion Game Day Checklist to evaluate potential concussions during NFL pre-season and regular season games is mandatory. Designated medical personnel (team physicians and athletic trainers, UNCs and ATC Spotters) complete their designated steps in the NFL Concussion Game Day Checklist and record the same using the designated technology (ie, X2 system on tablet or other technologies which may be developed for league-wide use). A club medical team's failure to properly apply the NFL Concussion Checklist may subject their club to disciplinary action(s).

Return to Participation Protocol

Introduction

Each player and each concussion is unique and recovery time varies from athlete to athlete. Therefore, there is no set time-frame for return to participation or for the progression through the steps of the graduated exertion programme set forth below. The decision to return a player (hereinafter referred to as the 'player-patient') to participation remains within the professional judgement of the Head Team Physician or team physician designated for concussion evaluation and treatment, performed in accordance with these protocols. All return to full participation decisions are confirmed by the Independent Neurological Consultant (INC; see step 6 below).

Table 1 An example of a graduated exertion protocol

Steps	Activity	Objective
1. Rest and recovery	Routine daily activities as tolerated	Recovery
2. Light aerobic exercise	10–20 min on a stationary bike or treadmill with light to moderate resistance supervised by the team's athletic trainer. No resistance training or weight training. Duration and intensity of the aerobic exercise can be gradually increased over time if no symptoms or signs return during or after the exercise	Cardiovascular challenge to determine if there are recurrent concussion signs or symptoms
3. Continued aerobic exercise and introduction of strength training	With continued supervision by the athletic trainer, increase the duration and intensity of the aerobic exercise (eg, more intense or longer time on the bike or treadmill, introduction of running and sprinting) and introduction of non-contact sport-specific conditioning drills (eg, changing direction drills, cone drills). Introduction of strength training supervised by the athletic trainer	Progress cardiovascular exercise, add strength training and more complex movements to determine if there are any recurrent concussion signs or symptoms
4. Football-specific activities	Participation in all non-contact activities for the typical duration of a full practice	Increasing football-specific demands to determine if there are any recurrent concussion signs or symptoms. Add the cognitive load of playing football
5. Full football activity/ clearance	Full participation in practice and contact without restriction	Tolerance of all football activities without any recurrent concussion signs or symptoms

This table is adapted from McCrory *et al*[11] and serves as a guideline. Specifics will depend on each player's situation. There is no set timeline for return to play or progression through the protocol.

Independent Neurological Consultant (INC)

The INC must be impartial and independent from the player's club, and be board certified or board eligible in neurology, neurological surgery, emergency medicine, physical medicine and rehabilitation, or any primary care CAQ sports medicine certified physician, and has documented competence and experience in the treatment of acute head injuries (as evidenced by no less than monthly treatment of such patients). Each club must designate one INC at the start of the league year, which must be approved by the NFL Chief Medical Officer and NFLPA Medical Director. For the avoidance of doubt, a UNC may serve as an INC. Neither a UNC nor an INC may have any affiliation with an NFL team.

The INC is informed when a concussion occurs so that consultation at a medically appropriate time is arranged. The team physician consults with the INC as often as desired during the player-patient's concussion recovery period. The INC is consulted specifically to answer the question of the player-patient's neurological health and his final and full return to competitive participation (see step 6in the text below). The final clearance for return to play is a decision made by the team's medical staff, but must be confirmed by the INC following review of relevant medical records and face-to-face medical evaluation. After a player-patient has been diagnosed with a concussion, he is monitored daily, or more frequently if clinically indicated in the opinion of the team physician, through the Return to Participation Protocol (see table 1). Team medical staff take into consideration the player-patient's current concussive injury, including an in-depth consideration of past exposures, medical history, family history and future risk in managing the player-patient's care.

After having been diagnosed with a concussion, the player-patient progresses through the following protocol to return to participation. A player with a concussion diagnosis proceeds to the next step in the protocol only after he has demonstrated tolerance of all activities in his current step without recurrence of signs or symptoms of concussion being observed or reported. Should the activities of a step trigger recurrence of signs or symptoms of concussion, those activities should be discontinued and the player-patient returned to the prior step in the protocol. The player-patient must remain at his pre-concussion baseline level of signs and must not experience any worsening of symptoms during the exertion itself, as well as for a reasonable period of time afterwards. What constitutes a reasonable amount of time shall be determined on a case-by-case basis by the team physician. The rate of progression through the return to play steps will depend on the time required for a player-patient to return to baseline status, along with consideration of other individual medical factors. Communication between the medical staff and the player-patient is essential to determining the progression through the steps of the protocol.

Step 1: Rest and recovery

This is the step involving relative physical and cognitive rest. In general, the player-patient is prescribed a brief period of rest, limiting or, if necessary, avoiding activities (both physical and cognitive) which increase or aggravate symptoms until his signs and symptoms subside, and his neurologic examination (conducted by a team physician) is essentially normal. There is currently insufficient evidence that prescribing complete rest for an extended period of time is therapeutic. After a brief period of rest during the acute phase post injury, the player-patient can be encouraged to become gradually and progressively more active (stretching, balance activity, limited and medically supervised exercise, etc) while staying below their cognitive and physical symptom-exacerbation thresholds (ie, activity level should not bring on or worsen their symptoms). Should additional signs or symptoms present, the team physician should consider external consultation or additional diagnostic examinations.

Once the player-patient has returned to his baseline level of signs and symptoms and neurological function, he may be cleared by a team physician to proceed to the next step. Neurocognitive testing is administered to assess the player-patient's level of cognitive function and identify any acute/subacute deficits that would affect his ability to resume normal activities. Neurocognitive testing can be introduced any time after completing step 1 or during steps 2 or 3 as long as it is completed prior to the initiation of contact activities. The timing of neurocognitive testing is up to the discretion of the team physician with consultation from the Club Neuropsychologist. All neurocognitive tests are interpreted by the team's Club Neuropsychologist, with the results communicated to the team physician.

Step 2: Light aerobic exercise

Step 2 is the initiation of a graduated exercise programme. Under the direct oversight of the team's medical staff, the player-patient begins graduated cardiovascular exercise (eg, stationary

bicycle, treadmill) and may also engage in dynamic stretching and balance training. The duration and intensity of all activity may be gradually increased as long as the player-patient remains at baseline while performing the activity and for a reasonable period thereafter. If there is recurrence of signs or symptoms, the activity should be discontinued. The player-patient may attend regular team meetings and engage in film study as long as signs or symptoms are not provoked. If neurocognitive testing was not administered after step 1, it should be administered during steps 2 or 3. If a player-patient's initial neurocognitive testing is not interpreted as back to baseline by the club neuropsychologist, the tests will be repeated at a time interval agreed on by the team physician and club neuropsychologist. Additionally, a comprehensive evaluation of potential non-injury related causes of any noted neuropsychological decrement should be performed by the team physician. An athlete may be allowed to participate in non-contact activities even if the neurocognitive testing is interpreted as abnormal. The player-patient is not to proceed to contact activities until the neurocognitive testing is interpreted as having returned to baseline level by the club neuropsychologist or, if a decrement persists, until the team physician determines that the decrement is not due to the concussion. The need and time interval for additional testing is determined by the team physician in consultation with the club neuropsychologist and based on the clinical status of the player-patient. Once the player-patient demonstrates his ability to engage in cardiovascular exercise without recurrence of signs or symptoms, he may proceed to the next step.

Step 3: Continued aerobic exercise and introduction of strength training

The player-patient continues with supervised cardiovascular exercises that are increased and may mimic sport-specific activities, and supervised strength training is introduced. Some may consider this step as a continuation of step 2. If neurocognitive testing was not administered after step 1 or during step 2, it should be administered during step 3. If a player-patient's initial neurocognitive testing is not interpreted as back to baseline by the club neuropsychologist, the tests are repeated at a time interval agreed on by the team physician and club neuropsychologist. A player-patient may be allowed to participate in non-contact activities even if his neurocognitive testing is interpreted as abnormal. The player-patient should not proceed to contact activities until the neurocognitive testing is interpreted as back to their baseline level by the club neuropsychologist or, if a decrement is still present, until the team physician has determined a non-concussion related cause. The determination of when to proceed with contact activities is ultimately made by the team physician. Once the player-patient has demonstrated his ability to engage in cardiovascular exercise and supervised strength training without recurrence of signs or symptoms, he may proceed to the next step.

Step 4: Football-specific activities

The player-patient continues in cardiovascular conditioning, strength and balance training and participates in non-contact football activities such as throwing, catching, running and other position-specific activities. All activities at this step remain non-contact. (eg, no contact with other players or objects such as tackling dummies or sleds). If the player-patient tolerates all football-specific activity without a recurrence of signs or symptoms of concussion and his neurocognitive testing has returned to baseline, he is moved to the next step in the sequence.

Step 5: Full football activity/clearance

After the player-patient has established his ability to participate in non-contact football activity including team meetings, conditioning and non-contact practice without recurrence of signs and symptoms and his neurocognitive testing is back to baseline, the team physician may clear him for full football activity involving contact. Once cleared by the team physician, the player-patient may participate in all aspects of practice. If the player-patient tolerates full participation practice and contact without signs or symptoms and the team physician concludes that the player-patient's concussion has resolved, he may clear the player-patient to return to full team participation.

Step 6: Final clearance by the INC

The INC is informed when a concussion occurs so that consultation at a medically appropriate time can be arranged. The team physician consults with the INC as often as desired during the player-patient's concussion recovery period. The INC is consulted specifically to answer the question of the player-patient's neurological health and his final and full return to competitive participation. On clearance by the team physician (subsequent to successful completion of step 5 above), the player is then examined by the INC assigned to his Club. The INC is provided with a copy of all relevant reports and tests, including the player-patient's neurocognitive tests and interpretations. If the INC confirms the team physician's conclusion that the player-patient's concussion has resolved, the player-patient is considered cleared and may participate in his Club's next game.

Protocol violations

Any potential violation of the NFL's Concussion Diagnosis and Management Protocol is subject to review by the NFL Chief Medical Officer and NFLPA Medical Director. Protocol infractions may lead to disciplinary action(s).

Ongoing quality assurance process

All relevant team physicians, ATCs, UNCs, INCs, ATC Spotters and Club Neuropsychologists will: (1) attend an annual meeting where the Concussion Diagnosis and Management Protocols are reviewed; and (2) receive education and training specific to any modifications in the protocols. In the event that circumstances arise that warrant immediate consideration of a change in the protocols, the NFL's Chief Medical Officer and NFLPA's Medical Director, in conjunction with the HN&S Committee, are empowered to host conference calls with every UNC, ATC Spotter and relevant team medical staff members to review the changes to the protocol and the signs and symptoms of concussion.

SUMMARY

These protocols are designed for the diagnosis and management of concussion, including pre-season education and assessment, practice and game management and return to play requirements, and are designed to provide a comprehensive approach to concussion diagnosis and management for the NFL player.

Action needs

Diagnosing a SRC with specificity, sensitivity, and in real time continues to pose a challenge simply because concussion remains purely a clinical diagnosis based on an assessment of signs and symptoms along with an evaluation of cognitive, vestibular and oculomotor functions.[16] To date, there is no specific biomarker, biomechanical technology or neuroimaging technique that can

be utilised for the unequivocal diagnosis of a SRC.[17] Until such a biomarker, imaging technique or other technology can be developed, validated and found to be practical for real-time clinical use, the NFL HN&S Committee hopes to continue to foster a culture change and improve the safety of all sporting events. This culture change includes encouraging players, coaches and teammates to report symptoms of a concussion when they occur.

The HN&S Committee has adopted a practical 'evidence-based clinical process' around the diagnosis and management of concussion to provide guidance and reproducibility among our NFL medical teams. The advantage of this rigorous, reproducible, guidelines-based approach is that it easily lends itself to analysis and quality improvement as clinical data are compiled and analysed year to year. The Committee was also cognisant of the 'trickle down' effect professional sports may have on youth sports, and it is hoped that aspects of this concussion protocol may prove to have value in other sports and at other levels.

The protocol described above was in effect at the conclusion of the 2017–18 season and will be reviewed at least annually by the HN&S Committee and modified as the science and clinical practice of concussion diagnosis and management evolve. It is the goal of the NFL HN&S Committee to provide a state of the art, reproducible, evidence-based concussion protocol for the protection of the health, safety and welfare of its players.

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