A Review Paper

Head, Neck, and Shoulder Injuries in Ice Hockey: Current Concepts

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Abstract

Ice hockey is a fast-paced contact sport that is becoming increasingly popular in North America. More than 1 million men, women, and juniors are playing hockey in the United States and Canada. With players colliding forcefully with one another and with the boards surrounding the ice, injury rates are among the highest in all of competitive sports. Physicians caring for a hockey team should be aware of the more common injuries, involving the head, the neck, and the shoulder. In this review, we discuss evaluation and treatment of these hockey injuries, return to play, and, where applicable, prevention strategies.

On a surface of ice in Windsor, Nova Scotia in the middle of the 19th century, the modern game of ice hockey evolved.[1] A blend of hurley, a Gaelic sport, and lacrosse, from the native Mi'kmaq culture, the sport of ice hockey gained rapidly in popularity throughout Canada and is now the country's national sport. Hockey quickly spread to the United States and then Europe. It is presently played in 77 countries across the world.[2]

Hockey players can reach speeds of up to 48 km (~30 miles) per hour on razor-sharp skates on an ice surface surrounded by rigid plastic composite boards topped with plexiglass.[3] They use sticks made of wood, aluminum, or a composite material to advance a 6-ounce vulcanized rubber puck on the opposing goal, and this puck sometimes reaches speeds over 160 km (~100 miles) per hour. Older, male players are allowed to make physical contact with their opposing counterparts to separate them from the puck (body-checking). Not surprisingly, the potential risk for injury in hockey is high. At the 2010 Winter Olympics, men's ice hockey players had the highest rate of injury of any other competitors there—more than 30% were affected.[4] In the United States, an estimated 20,000 hockey players present to the emergency department (ED) with injuries each year.[5] In some leagues, game-related injury rates can be as high as 96 per 1000 player-hours (**Table 1**).

Hockey is played and enjoyed by athletes ranging widely in age. Youth hockey leagues accept players as young as 5 years. Hockey can become a lifelong recreational activity. In North America, old timers' leagues have many players up to age 70 years.[6] According to International Ice Hockey Federation data for 2016, more than 543,000 and 639,500 people play hockey in the United States and Canada, respectively.[2] Most of the rules, protective equipment, skates, ice surfaces, and goal sizes are the same in men's and women's hockey.[7] The major difference is in body-checking—this practice is not allowed at any age in women's ice hockey.

In this article, we review the evaluation and management of common head, neck, and shoulder hockey injuries for physicians who provide medical support and coverage for youth, amateur, and senior hockey teams.

Take-Home Points

- Hockey is a high-speed collision sport with one of the highest injury rates among all sports.
- Use of a helmet with visors or full-face shields significantly reduces the risk for eye injury.
- Broken portions of teeth should be found and placed in a protective medium such as saline, saliva, or milk for transport.
- A player with unresolved concussion symptoms should not be allowed to return to the ice.
- Shoulder dominance, which determines stick grip, is an important consideration in the treatment of shoulder instability in an ice hockey player.

Evaluation and Management of Common Hockey Injuries

Eye Injuries

Although eye injuries are less common than musculoskeletal injuries

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Table 1. **Ice Hockey Injury Rates From Numerous Studies: Rates of Injury Per 1000 Player-Hours and 1000 Athlete Exposures, Depending on Study Design**

Study	Play Level	Injury Rate			
		Practice: 1000 Player-Hours	Game: 1000 Player-Hours	Practice: 1000 Athlete Exposures	Game: 1000 Athlete Exposures
Lorentzon et al[65] (1988), *AJSM*	Swedish Elite	1.4	78.4	—	—
Stuart & Smith[66] (1995), *AJSM*	Junior A (USA)	3.9	96.1	—	—
Voaklander et al[67] (1996), *CJSM*	AMRL & OTL (Canada)	—	—	15.1	12.2
Mölsä et al[68] (1997), *AJSM*	Top 2 levels (Finland)	1.5	54	—	—
Ferrara & Schurr[69] (1999), *CJSM*	ECAC & Hockey East NCAA (USA)	—	—	2.5	14.7
Pinto et al[70] (1999), *CJSM*	Junior A (USA)	4	83	—	—
Flik et al[3] (2005), *AJSM*	ECAC & NCAA (USA)	—	—	2.2	13.8
Emery & Meeuwisse[71] (2006), *AJSM*	Minor/Youth Hockey (USA)	Combined rate practice & game	4.13	—	—
Kuzuhara et al[72] (2009), *JAT*	Japanese Elite League	11.7	74.3	—	—
Rishiraj et al[73] (2009), *JSMPF*	Canadian College Hockey	—	—	1.1	8.2
Agel & Harvey[7] (2010), *CJS*	NCAA Men (USA)	—	—	2.2	18.7
Agel & Harvey[7] (2010), *CJS*	NCAA Women (USA)	—	—	2.9	12.1
Brooks et al[6] (2014)	High School Hockey (USA)	—	—	2-2.6	4.2-6.1
Tuominen et al[74] (2015), *BJSM*	IIHF World Championships (game data)	—	52.1	—	14.2

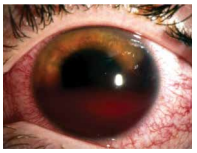
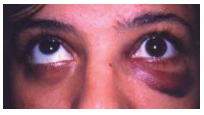
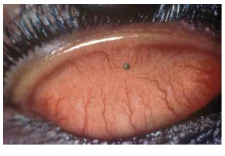
Abbreviations: AAP, American Association of Pediatrics; *AJSM, American Journal of Sports Medicine*; AMRL, Adult Men's Recreational League; *BJSM, British Journal of Sports Medicine; CJS, Canadian Journal of Surgery; CJSM, Clinical Journal of Sports Medicine*; ECAC, Eastern Collegiate Athletic Conference; IIHF, International Ice Hockey Federation; *JAT, Journal of Athletic Training; JSMPF, Journal of Sports Medicine and Physical Fitness*; NCAA, National Collegiate Athletic Association; OTL, Old Timers League.

and concussions in hockey, they are a serious risk for recreational and competitive players alike. Furthermore, recovery may be difficult, and eye injuries can have serious lifelong consequences.[8] In hockey, the most commonly reported eye injuries are periorbital contusions and lacerations, hyphema, corneal and conjunctival abrasions, orbital fractures, and ruptured globes (**Table 2**).[9,10] Some of these injuries have the potential to cause permanent ocular damage and loss of sight. A clear understanding of how to correctly evaluate, triage, and manage ocular trauma is therefore essential for any physician providing primary medical care for hockey players and teams.

As a contact sport, hockey often involves high-impact, blunt-force trauma. The trauma in hockey results from collisions with other players, the boards, hockey sticks, and pucks. It is therefore not surprising that the most common ocular injuries in this sport are periorbital contusions. Although most contusions cause only mild swelling and ecchymosis of the soft tissues around the eye, there is potential for serious consequences. In a Scandinavia study, Leivo and colleagues[10] found that 9% of patients who sustained a periocular contusion also had a clinically significant secondary diagnosis, such as retinal tear or hemorrhage, eyelid laceration, vitreous hemorrhage, or retinal detachment. Although the study was hospital-based, and therefore biased toward more severe cases, its findings highlight the potential severity of eye injuries in hockey. Furthermore, the study found that the majority of players who sustained blunt trauma to the eye itself required lifelong follow-up because of increased risk for glaucoma. This is particularly true for hyphema, as this finding indicates significant damage to intraocular tissues.[10]

Players can also sustain fractures of the orbital bones, including orbital blowout fractures. Typical signs and symptoms of blowout fractures include

Table 2. **Common Ocular Injuries in Ice Hockey**[a]

Condition	Description	Treatment	Return to Play	Clinical Photograph
Hyphema	Rupture of blood vessels of the iris; gross blood or a clot in the anterior chamber of the eye	Remove player from the game; use of corticosteroids and cycloplegics is controversial	Do not return the player to the ice; ophthalmologist needs to clear the player to return	
Periorbital contusion	One of the most common facial injuries; swelling and bruising around the eye and eye socket	Concern for secondary eye injury; player's glaucoma risk will be higher	Because of high rate of secondary injury, ophthalmologist needs to clear the player to return	
Orbital blowout fracture	Periorbital edema, ecchymosis and restricted extraocular movements, and proptosis (abnormal protrusion of the eye)	Remove the player from the game and send to the emergency department for ophthalmologic evaluation; computed tomography findings and clinical signs and symptoms guide treatment	Do not return the player to the ice; ophthalmologist needs to clear the player to return	 
Ruptured globe	High-velocity blunt trauma, hyphema, 360° conjunctival hemorrhage, and leaking	Promptly refer the player to an ophthalmologist (send player to the emergency department) and place shield en route	Do not return the player to the ice; ophthalmologist needs to clear the player to return	
Corneal abrasion	Defect in the corneal epithelial surface; tearing, sharp pain, and foreign body sensation are common complaints	Stop contact lens use; topical diclofenac can be helpful for pain; combination of cycloplegic and antibiotic can expedite healing	Player may return to play if there is no functional or binocular loss of vision	
Corneal foreign body	Foreign material in the eye	Evert the eyelid and irrigate or use cotton bud; use of topical antibiotics is controversial, but topical antibiotics may have role in athletic setting	Player may return to play if there is no functional or binocular loss of vision	
Subconjunctival hemorrhage	Blood vessel ruptures underneath conjunctiva	Blood usually takes 7-10 days to resolve; do not rub the eye; eyedrops can be used to soothe pain; use of nonsteroidal anti-inflammatory drugs is discouraged	Player may return to play if there is no other ocular injury and vision examination is normal	

[a]Ocular trauma images provided by Steven E. Brooks, MD, New York, New York.

diplopia, proptosis or enophthalmos, infraorbital hypoesthesia, painful and decreased extraocular movement (particularly upgaze), and palpable crepitance caused by sinus air entering the lower eyelid.[11] If orbital fracture is suspected, as it should be in any case in which the injured player experiences pain with eye movement or diplopia, the player should be referred to the ED for computed tomography (CT) and ophthalmologic evaluation.[12] Continued participation seriously risks making the injury much worse, particularly should another impact occur. In addition, given the impact needed to cause orbital

fractures, consideration must be given to the potential for a coexisting concussion injury.

Severe direct trauma to the eye—from a puck, a stick, or a fist—can result in a ruptured globe, a particularly serious injury that requires immediate surgical attention. Signs and symptoms of a ruptured globe are rarely subtle, but associated eyelid swelling or laceration may obscure the injury, delaying proper diagnosis and treatment. More obvious signs include severely reduced vision, hemorrhagic chemosis (swelling) of the conjunctiva, and an irregular or peaked pupil. If a rupture or any significant intraocular injury is suspected, it is crucial to avoid applying any pressure to the globe, as this can significantly worsen the damage to the intraocular tissues. Use of a helmet with protective shields and cages attached markedly reduces the risk for such injuries.[13]

All eye injuries require prompt assessment, which allows for appropriate management and prevention of secondary damage.[14] Initial evaluation of a patient with ocular trauma should begin with external examination for lacerations, swelling, or orbital rim step-off deformity. The physician should also check visual acuity in order to assess for significant vision impairment (counting fingers or reading a sign in the arena; confrontation visual fields). This should be done before attending to any periocular injuries, with the uninjured side serving as a control. Next, the physician should assess the extraocular eye movements as well as the size, shape, and reactivity of the pupils. Particular attention should be paid to detecting any deficit in extraocular movement or irregularity in pupil size, shape, or reactivity, as such findings are highly suggestive of serious injury to the globe.[13] Hyphema (blood in anterior chamber of eye anterior to pupil) should be suspected if vision is reduced and the pupil cannot be clearly visualized. However, a bright red clot is not always apparent at time of injury or if the amount of blood is small. An irregular pupil, or a pupil that does not constrict well to light, is also a red flag for serious contusion injury to the eye, and requires ophthalmologic evaluation. It is important to keep in mind that blunt trauma severe enough to produce hyphema or an irregular and poorly reactive pupil is often associated with retinal damage as well, including retinal edema or detachment.

Minor injuries (eg, small foreign bodies, minor periocular contusions and lacerations) can often be managed rink-side. Foreign bodies not embedded in the cornea, but lodged under the upper eyelid, can sometimes be removed by everting the eyelid and sweeping with a moistened cotton swab or using diffuse, sterile saline irrigation.[11] Corneal abrasions generally cause severe pain, photophobia, and tearing and are easily diagnosed with use of topical fluorescein and a blue light. A topical anesthetic can be extremely helpful in this setting, as it allows for proper pain-free evaluation, but should never be used in an ongoing manner for pain relief. Small lacerations of the brow can be sutured with 5-0 or 6-0 nylon or closed with 2-Octyl cyanoacrylate tissue adhesive (Dermabond). Eyelid lacerations, unless very small, are best managed by an ophthalmologist; care must be taken to rule out injury to the deeper orbital tissues and eye. If serious injury is suspected, or the eye cannot be appropriately evaluated, it should be stabilized and protected with a protective shield or plastic cup, and the player should be transferred to an ED for appropriate ophthalmologic evaluation.[13]

Most eye injuries are accidental, caused by sticks or deflected pucks, but 18% are acquired in fights.[8] Use of visors or full-face cages effectively minimizes the rate of eye injuries.[8,13,15,16] In a cohort study of 282 elite amateur ice hockey players, the risk of eye injury was 4.7 times higher in players without face protection than in players who used half-face shields; there were no eye injuries in players who used full-face protection.[13] For visors to prevent eye injury, they must be positioned to cover the eyes and the lower edge of the nose in all projections.[10]

Dental Injuries

The incidence and type of facial and dental injuries depend directly on the type of face protection used.[11,17,18] In a study of face, head, and neck injuries in elite amateur ice hockey players, Stuart and colleagues[13] found game-related injury rates of 158.9 per 1000 player-hours in players without face protection, 73.5 in players who used half-face shields, and 23.2 in players who used full-face shields. Players who wore full-face shields had facial, head, and neck injury rates of only 23.2 per 1000 player-game hours.[13] Other studies clearly support the important role face shields play in lowering injury risk in hockey. Face and head injuries account for 20% to 40% of all hockey-related injuries,[3,16,19] and dental injuries up to 11.5%.[20] In a study from Finland, Lahti and colleagues[19] found that over a 2-year period, 479 hockey players sustained injuries, including 650 separate dental injuries. The most commonly diagnosed dental injury was an uncomplicated

crown fracture, and the most common cause was a hit with a hockey stick, which accounted for 52.7% and 40.3% of dental injuries in games and practices, respectively.[19]

In the management of dental fractures, the broken portions of teeth should be found and placed in a transportation-protective medium, such as saline, saliva, or milk,[16] which can improve functional and esthetic replacement outcomes.[21,22] Loose pieces of teeth should not be left in the player's mouth. The residual tooth should be stabilized and exposure to air and occlusion limited. Dental fractures can affect the enamel, the enamel and dentin structures (uncomplicated fracture), or enamel, dentin, and pulp (complicated).[23] Fractures involving only the enamel do not require urgent dental evaluation. Dentin or pulp involvement may cause temperature and air sensitivity.[23] If a tooth is air-sensitive, the player should be referred to a specialist immediately.[11]

Direct trauma can cause instability without displacement (subluxation) or complete displacement of the tooth from its alveolar socket (avulsion).[23] An avulsed tooth should be handled by the crown to avoid further damage to the root and periodontal ligament.[16,24] The tooth should be rinsed gently with saline and reimplanted in its socket, ideally within 5 to 10 minutes,[23] with the athlete biting down gently on gauze to hold the tooth in place. A 1-mL supraperiosteal infiltration of 1% or 2% lidocaine hydrochloride (1:100,000 epinephrine) can be given into the apex of the tooth being anesthetized (**Figure 1**). If reimplantation is not possible, the avulsed tooth should be transported in saline, saliva, or milk for emergent dental care.[16] If the tooth is driven into the alveolar socket, it should not be repositioned acutely but referred for dental evaluation.[11]

A player with a dental injury should be immediately evaluated for airway obstruction, and the injured area should be washed with sterile water and dabbed with gauze.[23] Dental injuries are often permanent and can cause complications later in life.[19] Therefore, it is imperative to manage dental injuries appropriately, especially as reimplanting a tooth within 30 minutes results in 90% probability of tooth survival, whereas a 2-hour delay reduces tooth survival to <5%.[12] Return to play should be individualized. For completely avulsed teeth that cannot be reimplanted, the player can return to play (with mouth guard protection) within 48 hours as long as there are no bone fractures.[24] Players who undergo reimplantation and splinting of avulsed teeth should wait 2 to 4 weeks before returning to play.[23] Use of mouth guards and face protection is directly associated with prevention of dental injuries; these protective devices should be worn in practice and competition.[16,19,23]

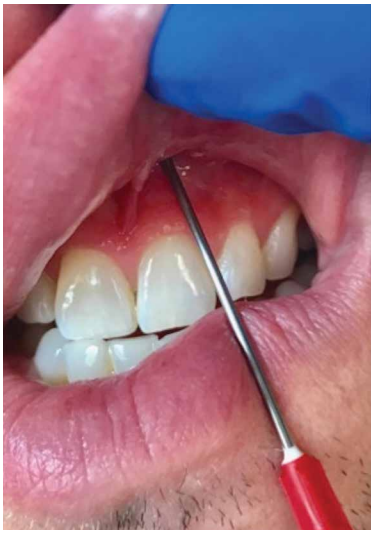


Figure 1. Location at the apex of the tooth to give a supraperiosteal injection. This is an ideal choice for anesthesia of a single tooth. The lip should be retracted by the clinician's non-injecting hand. Needle shown in this image is larger than recommended to emphasize the location of the injection.

Concussions

A concussion is a "complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces."[25] Concussion is largely a functional disturbance instead of a structural injury, owing to the rotational and/or shearing forces involved. Many studies have identified concussion as the most common type of injury in all of youth hockey.[26] Concussions account for up to 19% of all injuries in men's collegiate hockey.[3]

Concussion can be challenging to diagnose on the ice. The most important factor in concussion management is symptom reporting by the athlete.[27] Despite significant efforts in education and awareness, student athletes, especially hockey players, withhold reporting a possible concussion.[28] Reasons for underreporting include fear of letting down other players and coaches, thinking the injury is not severe enough to warrant evaluation, and fear of losing standing with the current team or future teams.[28] Physicians caring for hockey players should be aware of common symptoms and signs of concussion (**Table 3**). Concussions can result in abnormalities of balance, cognition, and vision.[29]

As postinjury concussion assessments are ideal when comparisons can be made with preseason (baseline) scores, preseason testing is becoming standard in professional, college, junior, and high school hockey. This testing involves the Sport Concussion Assessment Tool, 3rd edition (SCAT3), and the King-Devick (K-D) test.[30,31] Some youth leagues have baseline testing as well, though the frequency of baseline testing in their players is controversial,[32] as the adolescent mind's processing speed and memory increase exponentially.[33] For these younger athletes, it may be necessary to perform baseline testing more frequently than annually.[32] A physician can use baseline test results to help diagnose a concussion at the rink and then

track the athlete's recovery and help with return-to-play decisions.[29] Vision involves almost half of the brain's circuits,[34] including areas vulnerable to head impact. A neuro-ophthalmologic test can assess for irregularities in accommodation, convergence, ocular muscle balance, pursuit, and saccades.[29] The K-D test is a visual performance examination that allows easy and objective assessment of eye movements. Use of both the K-D test and the SCAT3 at the rink may increase the number of concussions detected.[29,35] We recommend that physicians use both tests to assess for concussion at the hockey rink.

Initial treatment involves a period of physical rest and relative cognitive rest. Acute worsening of symptoms warrants urgent imaging to rule out a subdural or subarachnoid bleed. Once a player is symptom-free, a graded return-to-play protocol should be followed (**Table 4**). After being asymptomatic at rest, a player usually takes at least 1 week to progress through the protocol.[25] In the event of a setback during the stepwise program, the player must return to the previous asymptomatic level after 24 hours of rest. Most concussions resolve quickly, without sequelae. Players with persisting symptoms may require medication, vestibular therapy, or other treatment. A player with unresolved symptoms should not be allowed to return to play.

Table 3. **Signs and Symptoms of a Concussion**

Signs	Symptoms
Loss of consciousness	Confusion
Altered mental status	Amnesia
Slurred speech	Headache
Slow to answer	Dizziness
Personality changes	Flashing lights
Vacant stare	Ear ringing
Photophobia	Light sensitivity
Poor coordination	Nausea
Gait instability/ataxia	Loss of balance
	Fogginess
	Sleep disturbances

On the prevention side, great efforts have been made to improve hockey helmets. (Some manufacturers claim to have made concussion-proof helmets, but there is no evidence supporting this claim.[6]) Numerous investigators have reported a lower overall injury rate in players who wear a helmet and a full-face shield.[6,13] In addition, rule changes aimed at decreasing head contact have been implemented to decrease the incidence of sport-related concussions.[36] Moreover, education on proper helmet use and wear should be emphasized. A study of the effects of hockey helmet fit on cervical motion found that 7 (39%) of 18 players wore a game or competition helmet so loosely that it could be removed without unbuttoning its chinstrap.[37] Improperly worn helmets cannot prevent injury as well as properly worn helmets can.

Cervical Spine Injuries

Whereas American football is associated with a higher annual number of nonfatal catastrophic neck injuries, hockey has a 3 to 6 times higher incidence of cervical spine injuries and spinal cord damage.[38,39] A Canadian Ice Hockey Spinal Injuries Registry review of the period 2006 to 2011

Table 4. **Graduated Return-to-Play Protocol for Concussions in Ice Hockey**[a]

Rehabilitation Stage	Functional Exercise	Objective of Stage
1. No activity	Complete physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, stationary bike keeping intensity <70% of maximum predicted heart rate	Increase heart rate
3. Sport-specific exercise	Skating drills in ice hockey	Add movement
4. Noncontact training drills	Progression to more complex ice hockey drills (passing drills)	Exercise and coordination
5. Full-contact practice	After being medically cleared, player can participate in normal hockey practice	Restore confidence and functional skills
6. Return to play on the ice	Normal game	—

[a]Adapted from consensus statement on concussion (McCrory et al[27]).

Table 5. **Summary of Return-to-Play Guidelines for Cervical Spine Injuries in Ice Hockey**[a]

No Contraindications	Relative Contraindications	Absolute Contraindications
Asymptomatic cervical disc herniation treated conservatively	Healed 2-level ACDF or posterior spinal fusion	History or examination findings of cervical myelopathy
1-level healed ACDF	≥3 stingers in same season	C1-C2 fusion
2 stingers within same season	Prolonged burner/stinger >24 hours	3-level cervical fusion
Healed C1-C7 fracture that meets general criteria; no sagittal malalignment	—	Asymptomatic ligamentous laxity >11° kyphosis compared with adjacent vertebrae or 3.5-mm movement on lateral flexion/extension views; C1-C2 hypermobility
Asymptomatic clay-shoveler fracture	Transient quadriparesis with recovery of full strength and ROM	Healed fracture with sagittal malalignment
Healed stable C1 or C2 fracture; normal ROM	—	Symptomatic disc herniation
Torg ratio <0.8 in an asymptomatic player	—	2 episodes of transient quadriparesis
	—	Spinal canal compromise from retropulsed bony fragments

[a]Table is a hybrid of Torg, Cantu, and Vaccaro's return-to-play guidelines for cervical spine injuries. Modified from *Sports Health*.[47]
Abbreviation: ACDF, anterior cervical discectomy and fusion; ROM, range of motion.

identified 44 cervical spine injuries, 7.3 per year on average.[40] Severe injury, defined as complete motor and sensory loss, complete motor loss and incomplete sensory, or complete motor loss, occurred in 4 (9.1%) of the 44 injured players. In hockey, a major mechanism of cervical spine injury is an axial load to the slightly flexed spine.[39] Of 355 hockey-related cervical spine injuries in a Canada study, 95 (35.5%) were caused by a check from behind.[40,41] The Canadian neurosurgeons' work led to rule changes prohibiting checks from behind, and this prohibition has reduced the incidence of cervical spine injuries in ice hockey.[38,40]

Team physicians should be comfortable managing serious neck and spine injuries on the ice. Initial evaluation should follow the standard ABCs (airway, breathing, circulation). The physician places a hand on each side of the head to stabilize the neck until the initial examination is complete. The goal is to minimize cervical spine motion until transportation to the hospital for advanced imaging and definitive treatment.[37] The decision to remove or leave on the helmet is now controversial. Hockey helmets differ from football helmets in that their chinstraps do not afford significant cervical stabilization, and the helmets have less padding and cover less of the head; in addition, a shockingly high percentage of hockey players do not wear properly fitting helmets.[37] In one study, 3-dimensional motion analysis of a hockey player during the logroll technique showed less transverse and sagittal cervical plane motion with the helmet removed than with the helmet (properly fitting or not) in place; the authors recommended removing the helmet to limit extraneous cervical spine motion during the technique.[37] However, 2 other studies found that helmet removal can result in significantly increased cervical spine motion of the immobilized hockey player.[42,43]

Recommendation 4 of the recently released interassociation consensus statement of the National Athletic Trainers' Association reads, "Protective athletic equipment should be removed before transport to an emergency facility for an athlete-patient with suspected cervical spine instability."[44] This represents a shift from leaving the helmet and shoulder pads in place. For ice hockey players with suspected cervical spine injury, more research is needed on cervical motion during the entire sequence—partial logrolls, spine-boarding, placement of cervical collar before or after logroll, and different immobilization techniques for transport.[37]

The athlete must be carefully transferred to a spine board with either logroll or lift-and-slide. Although an extrication cervical collar can be placed before the spine board is placed, the effectiveness of this collar in executing the spine-board transfer is not proven.[45] When the player is on the spine board, the head can be secured with pads and straps en route to the hospital.

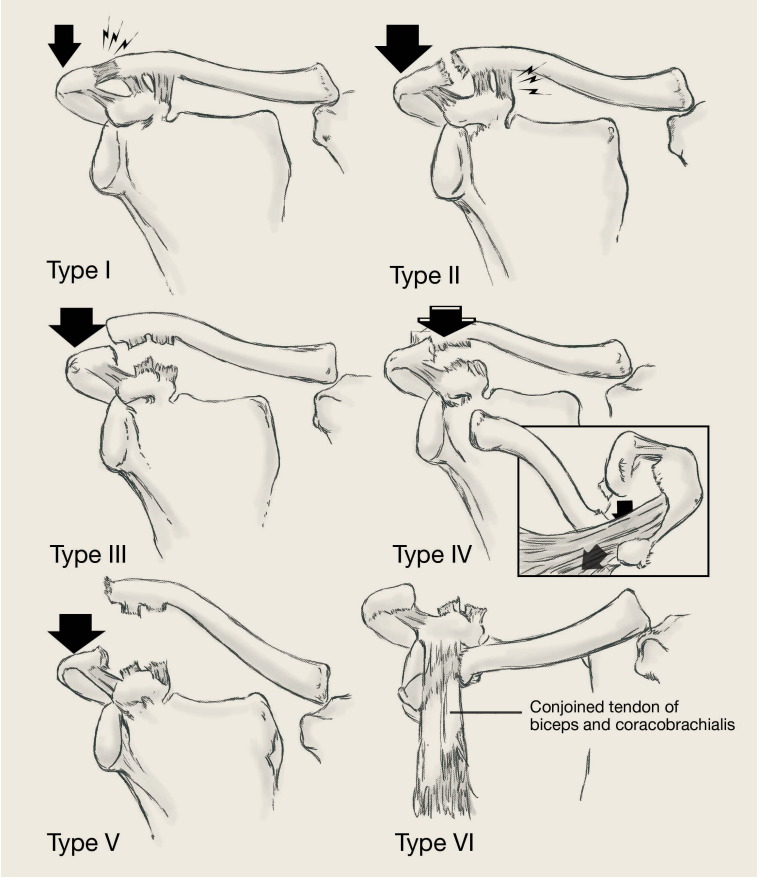


Figure 2. Rockwood classification of acromioclavicular joint injuries.
Modified from *Rockwood and Green's Fractures in Adults, Volume 1.*[75]

Figure 3. Fracture through a drill hole used for acromioclavicular reconstruction, after a patient returned to play.
Image provided by Gregory N. Lervick, MD, Edina, Minnesota.

Return-to-Play Criteria for Cervical Spine Injuries

There is no clear consensus on return-to-play guidelines for cervical spine injuries in athletes.[46] Although the literature lacks a standardized protocol, 4 fundamental criteria can be applied to a hockey player returning to the ice: The player should be pain-free and have full cervical neck motion, return of full strength, and no evidence of residual neurologic injury[47] (**Table 5**).

Shoulder Injuries

For hockey players, the upper extremity traditionally has been considered a well-protected area.[48] However, shoulder pads are considerably more flexible in hockey than in football and other collision sports. In addition, hockey gloves allow a fair amount of motion for stick handling, and the wrist may be in maximal flexion or extension when a hit against the boards or the ice occurs. Open-ice checking, board collisions, and hockey stick use have been postulated as reasons for the high incidence of upper extremity injuries in hockey. Researchers in Finland found that upper extremity injuries accounted for up to 31% of all hockey injuries.[49] More than 50% of these injuries resulted from checking or board collisions. Furthermore, study findings highlighted a low rate of injury in younger players and indicated the rate increases with age.[49,50]

In hockey players, the acromioclavicular (AC) joint is the most commonly injured shoulder structure.[51] The mechanism of injury can be a board collision or an open-ice hit, but most often is a direct blow to the shoulder. The collision disrupts the AC joint and can sprain or tear the coracoclavicular ligaments. The Rockwood classification is used to categorize AC joint injuries (**Figure 2**). Physical examination reveals swelling and tenderness at the joint. Skin tenting can occur with type III and type V injuries, and posterior deformity with type IV. We recommend initially obtaining anteroposterior (AP), scapular-Y, and axillary radiographs in cases of suspected AC joint injury. Weighted views are unnecessary and can exacerbate pain in acutely injured players.

Initial management involves icing the AC joint and placing a sling for comfort. Type I and type II injuries can be managed with progressive range-of-motion (ROM) exercises, strengthening, cryotherapy, and a period of rest. Treatment of type III injuries remains controversial,[52] but in hockey players these injuries are almost always treated nonoperatively. Return to play requires full motion, normal strength, and minimal discomfort. Players return a few days to 2 weeks after a grade I injury; recovery from grade II injuries may take 2 to 3 weeks, and recovery from grade III injuries, 6 to 12 weeks. Surgical treatment is usually required in type IV and type V injuries, but we have had experience treating these injuries nonoperatively

in high-level players. AC joint reinjury in hockey players is common, and surgical treatment should be approached cautiously, as delayed fracture after return to sport has been reported.[53] Special precautions should be taken in collision athletes who undergo AC joint reconstruction. In the anatomical reconstruction described by Carofino and Mazzocca,[54] 2 holes are drilled in the clavicle; these holes are a potential source of fracture when the collision athlete returns to sport (**Figure 3**). Some authors recommend drilling only 1 hole in order to minimize the risk, but doing so may come at the price of mild anteriorization of the clavicle with this nonanatomical technique. As the optimal surgical treatment for AC joints remains controversial, there is no consensus at this time.

Clavicle fracture is another common hockey injury.[55] Studies have shown clavicle fractures proportionally occur most often in people 15 to 19 years old.[49] The injury presents with pain and deformity over the clavicle; in more severe fractures, skin tenting is identified. Initial management of suspected clavicle fracture includes cryotherapy, sling, and radiographs. Radiographs should include an AP view and then a 45° cephalad view, which eliminates overshadowing from the ribs. Most clavicle fractures are successfully managed nonoperatively, though there is evidence that significantly displaced or comminuted fractures have better union rates and shoulder function when treated with open reduction and internal fixation.[56] After a clavicle fracture, return to skating and noncontact practice usually takes 8 weeks, with return to full contact occurring around 12 weeks.

Sternoclavicular injuries are relatively uncommon, but potentially serious. Special attention should also be given to adolescent athletes with sternoclavicular pain. Although sternoclavicular dislocations have been reported in hockey players, instead these likely are fractures involving the medial clavicle physis.[57] All athletes younger than 25 years carry a risk for this injury pattern, as that age is when the medial clavicle physis closes (**Figures 4A-4C**). Posterior sternoclavicular injuries should be taken to the operating room for closed versus possible open reduction with a cardiothoracic surgeon on standby (**Figure 4D**).

The shoulder is the most commonly dislocated major joint, and the incidence of shoulder dislocation in elite hockey players is 8% to 21%.[50,58] Anterior shoulder instability occurs from a fall with the shoulder in an abducted, externally rotated and extended position or from a direct anteriorly placed impact to the posterior shoulder. We recommend taking players off the ice for evaluation. Depending on physician comfort, the shoulder can be reduced in the training room, and the athlete sent for radiographs after reduction. If resources or support for closed reduction is not available at the rink, the athlete should be sent to the ED. Initial radiographic evaluation of a player with shoulder injury begins with plain radiographs, including a true AP (Grashey) view with the humerus in neutral, internal, and external rotation and an axillary view. The axillary radiograph is crucial in determining anterior or posterior dislocation. If the patient cannot tolerate the pain associated with having an axillary radiograph taken, a Velpeau radiograph can be used. This radiograph is taken with the patient's arm in a sling and with the patient leaning back 30° while the x-ray beam is directed superior to inferior.

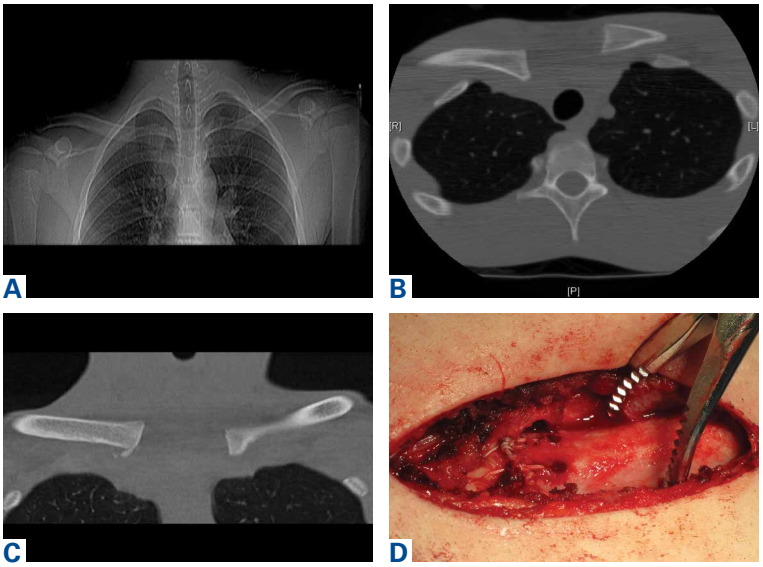


Figure 4. Posterior sternoclavicular physeal fracture in a 13-year-old hockey player who was checked into boards and then complained of sternal pain and shortness of breath while lying down. (A) Plain radiograph shows asymmetry of clavicle on right side versus left. (B) Axial computed tomography (CT) shows posterior displacement of right clavicle versus left. (C) Coronal CT shows physeal fracture fragment (see inferior aspect of right distal clavicular physis with associated incongruent fragment). (D) Open reduction of posterior sternoclavicular physeal fracture with figure 8 suture fixation.
Images provided by Simon Kelley, MD, Toronto, Canada.

CT is performed for a suspected osseous injury. CT is more accurate than plain radiographs in showing glenoid and humeral fractures in the acute setting as well as the amount of bone loss in the case of chronic instability. Magnetic resonance arthrography is the imaging modality of choice for the diagnoses of capsulolabral injury.

After shoulder reduction, treatment with a sling, cryotherapy, and a nonsteroidal anti-inflammatory drug is initiated. In a Minnesota study of nonoper-

ative management of shoulder instability, 9 of 10 hockey players were able to return to play the same season, and 6 of the 10 required surgery at the end of the season.[59] We usually recommend focusing initial physical therapy on joint rehabilitation with an emphasis on ROM and strength. We typically recommend players use a Sully brace when players return to the ice[59] (**Figure 5**).

Figure 5. Ice hockey player wearing Sully brace for anterior shoulder instability.

Compared with noncontact athletes, hockey players and other collision athletes are at increased risk for recurrence.[60-62] For collision athletes who want to continue playing their sport after recurrent instability, surgery is recommended. A shoulder instability study in Toronto found that more than 54% of 24 professional hockey players had associated Hill-Sachs lesions, but only 3 shoulders (12.5%) had glenoid defects.[50] Arthroscopic and open techniques both demonstrate good results, and identification of bone loss can help determine which surgery to recommend.[63] Hockey players can usually return to sport 6 months after shoulder stabilization.

Another important consideration in managing shoulder instability in hockey players is shoulder dominance, which determines stick grip. A left-handed player places the right hand on top of the stick for support, but most of the motion associated with shooting the puck—including abduction and external rotation—occurs with the left shoulder. Thus, a left-handed player with a history of previous left-side shoulder dislocation may dislocate with each shot, but a right-handed player with left shoulder instability may have considerably less trouble on the ice.[58]

Shoulder and rotator cuff contusions (RCCs) occur in hockey and other collision sports.[49,64] RCCs almost always result from a direct blow to the shoulder, and present with shoulder function loss, weakness, and pain. In some cases, RCCs that alter shoulder function can result in missed games and practices. RCC, an acute shoulder injury in an athlete with prior normal RC function, is followed by recovery of RC function—in contrast to tears, which can cause prolonged loss of function and strength.[64] RCCs can involve the enthesis, the tendon, the myotendinous junction, or the muscle belly (**Figures 6A, 6B**). On examination, a hockey player with RCC has decreased active ROM with weakness in external rotation with the arm in 90° of abduction and with scapular plane elevation. We recommend the treatment protocol outlined by Cohen and colleagues[64] (**Table 6**). Return to ice is allowed after full shoulder ROM and strength have returned. Average time missed is usually about 1 week.

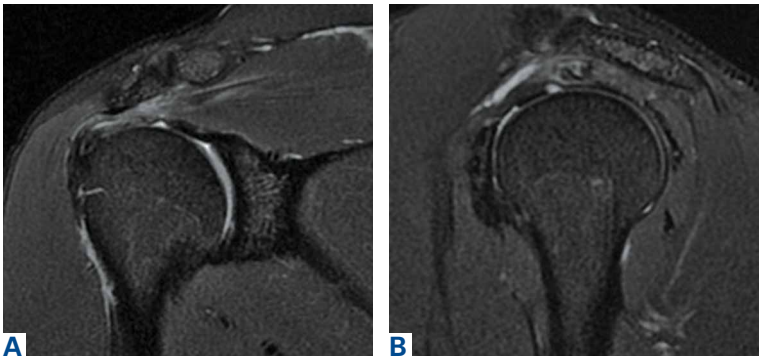


Figure 6. (A) Coronal and (B) sagittal T2-weighted magnetic resonance imaging shows rotator cuff contusion involving muscle and musculotendinous junction of supraspinatus tendon in a 27-year-old hockey player after a direct blow.
Images provided by Tony T. Wong, MD, New York, New York.

Summary

Hockey is a high-speed collision sport with one of the highest injury rates among all sports. Physicians caring for youth, amateur, and senior hockey teams see a range of acute head, neck, and shoul-

Table 6. **Recommended Protocol for Treating Rotator Cuff Contusions in Collision Athletes**[a]

After Injury	Treatment
0-2 days	Acetaminophen/oxycodone for 3 days; passive ROM to 90° forward flexion, scapular plane elevation, and abduction; cryotherapy and interferential stimulation; no NSAIDs; add pulse ultrasound (1 Mhz)
Day 3	If rotator cuff dysfunction persists: subacromial injection of 80 mg of triamcinolone acetonide and 8 mL of 0.5% bupivacaine without epinephrine
3 days to 1 month	Perform ultrasound 15 minutes per day and rehabilitation focused on active ROM; continue shoulder strengthening for 1 month

[a]Modified from *Am J Sports Med*.[64]
Abbreviations: NSAID, nonsteroidal anti-inflammatory drug; ROM, range of motion.

der injuries. Although treatment of eye injuries, dental injuries, and concussions is not always considered orthopedic care, an orthopedic surgeon who is covering hockey needs to be comfortable managing these injuries acutely. Quality rink-side care minimizes the impact of the injury, maximizes the functional result, and expedites the safe return of the injured player back to the ice.

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