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Computed Tomography is Diagnostic in the Cervical Imaging of Helmeted Football Players With Shoulder Pads

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Objective: Prospective, observational case series evaluating the value of cervical spine computed tomography (CT) scans in the initial evaluation of a helmeted football player with suspected cervical spine injury.

Subjects: Five asymptomatic male football players, fully equipped and immobilized on a backboard.

Design: Multiple 3.0-mm, helically acquired, axially displayed CT images of the cervical spine were obtained from the skull base inferiorly through T1, with images filmed at soft tissue and bone windows. Sagittal and coronal reformatted images were performed. Software was used to minimize metallic artifact.

Measurements: All series were reviewed by a Board-certified neuroradiologist for image clarity and diagnostic capability.

Results: Lateral scout films demonstrated mild segmental degradation, depending on the location of the metallic snaps overlying the spine. Anteroposterior scout films and bone window images were of diagnostic quality. The soft tissue windows showed minimal localized artifact occurring at the same levels as in the lateral scout views. This minimal beam-hardening streak artifact did not affect the diagnostic quality of the soft tissue windows. Reconstructed images were uniformly of clinical diagnostic quality.

Discussion: When CT scans were reviewed as a unit, sufficient information was available to allow reliable clinical decisions about the helmeted football player. In light of recent publications demonstrating the difficulty of obtaining adequate radiographs to evaluate cervical spine injury in equipped football players, helmeted athletes may undergo CT scanning without any significant diagnostic limitations.

Key Words: helmet removal, cervical spine, trauma, injury

Contact sports such as American football present a small but inherent risk of cervical spine injury. The potential exists for spinal instability as a result of cervical trauma, and full on-field assessment of the cervical spine is difficult.[1] The injured athlete with a protective helmet in place presents a unique clinical scenario.[2,3] The injured athlete must be handled cautiously until the extent of skeletal and neurologic injury can be defined. Medical and athletic training personnel must be aware of the injury patterns and equipment involved in these injuries to safely care for the injured helmeted athlete.

It is currently recommended that the helmet and shoulder pads remain in place during the initial clinical and radiographic evaluation of the helmeted athlete with a suspected cervical spine injury.[2–4] On arrival to a facility with radiographic capabilities, standard football equipment may preclude radiographic clearance, and initial radiographs have been shown at times to be inadequate for cervical spine clearance. Alternative methods of visualizing the cervical spine in the potentially injured helmeted athlete have been investigated. It has been suggested that computed tomography (CT) may be a viable alternative to evaluate these athletes. In this prospective observational case series, we evaluated whether CT of the cervical spine can be used in the initial evaluation of the helmeted football player with a potential cervical spine injury.

METHODS

Five male football players were fitted using the equipment (football helmet: Riddell, Chicago, IL; shoulder pads: Douglas Protective Equipment, Houston, TX) worn daily during the collegiate season at Lehigh University. Trained, full-time equipment managers from Lehigh University, with assistance from the certified athletic training staff, adjusted each helmet to the athlete, using the manufacturer's sizing and shape guidelines.[5] Face masks were removed from the helmets before the study.[6] The subjects represented various positions and body sizes (Table 1). All subjects were asymptomatic with a normal screening examination by the principal investigator (K.N.W.) at the time of the study. Subject 4 had a previous workup for stingers, with magnetic resonance imaging documenting mild degenerative disc disease and minimal C3–C6 foraminal narrowing. He was subsequently cleared for full participation. The other 4 subjects had no history of cervical spine injury or abnormality.

The subjects were immobilized by the principal investigator

Table 1. Subjects' Characteristics

Subject	Position	Height (ft, in) (cm)	Weight (lb), Mass (kg)	Age (y)
1	Offensive center	6′3″ (190.5)	290 (131.54)	21
2	Offensive tackle	6′4″ (193.04)	340 (154.22)	20
3	Defensive linebacker	5′11″ (180.34)	225 (102.06)	21
4	Defensive strong safety	5′11″ (180.34)	210 (95.25)	21
5	Offensive tight end	6′2″ (187.96)	245 (111.13)	22

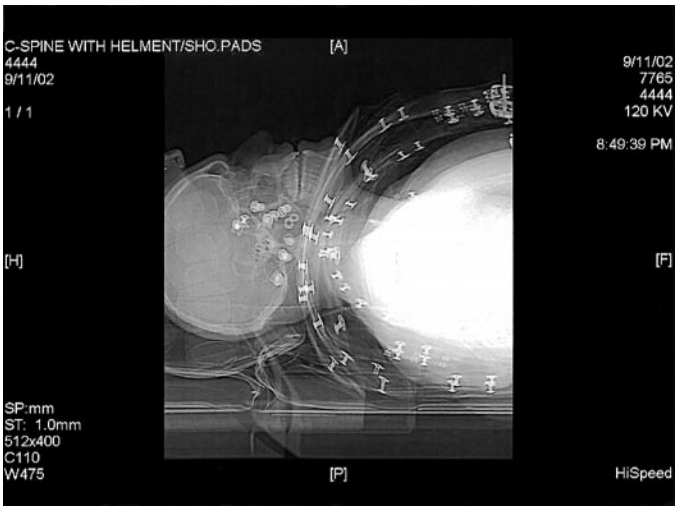

Figure 1. Lateral scout film from standard computed tomography (CT) examination. Note the numerous metallic snaps and clips overlying the upper cervical spinal column. The shoulders obscure the view of the cervicothoracic junction.

Figure 2. Anteroposterior scout view from standard computed tomography (CT) examination. Note numerous metallic snaps and clips. Few radiodense materials overlie the midline and cervical spinal column.

(K.N.W.) in the supine position according to Basic Trauma Life Support protocol.[7] Multiple 3.0-mm, helically acquired, axially displayed CT images (DXi light speed CT scanner, GE Medical Systems, Milwaukee, WI) of the cervical spine were obtained from the skull base inferiorly through T1. Data were reconstructed in soft tissue and bone algorithms, and images were filmed at soft tissue and bone windows. Sagittal and coronal reformatted images were obtained. Software using sequences and slice selection designed to minimize artifact associated with metals was implemented for data analysis (GE Medical Systems). Similar software packages are commercially available on most CT scanners as part of the normal operating package. All series were reviewed by a single Board-certified, fellowship-trained neuroradiologist (M.R.). Studies were evaluated for image clarity and diagnostic capability in this clinical setting. The criterion for determination of diagnostic quality was standard clinical practice, such as clearly identifiable anatomy and the absence of beam-hardening artifact and motion. By ''diagnostic quality,'' we refer to the decision that, in the opinion of the neuroradiologist, the images acquired accurately and completely defined the area of clinical interest and would have satisfactorily excluded a fracture had one been present. The Institutional Review Board at Saint Luke's Hospital, Bethlehem, PA, approved the study, and consent was obtained from each subject.

Figure 3. Axial computed tomography (CT) image, bone window, at C1–C2 level (same level as Figure 6). Streak artifact (arrows) from the external metallic clips does not interfere with evaluation of bone integrity.

RESULTS

Lateral scout films (Figure 1) all demonstrated mild segmental degradation, depending on the location of the metallic snaps overlying the spine. This metallic artifact was less obstructive than the shoulders in affecting spine visualization. Anteroposterior scout films (Figure 2) and all bone window images (Figures 3 and 4) were of full diagnostic quality. The soft tissue windows (Figures 5 and 6) showed minimal localized artifact occurring at the same levels as seen in the lateral scout views. This minimal beam-hardening streak artifact did not affect the diagnostic quality of the soft tissue windows.

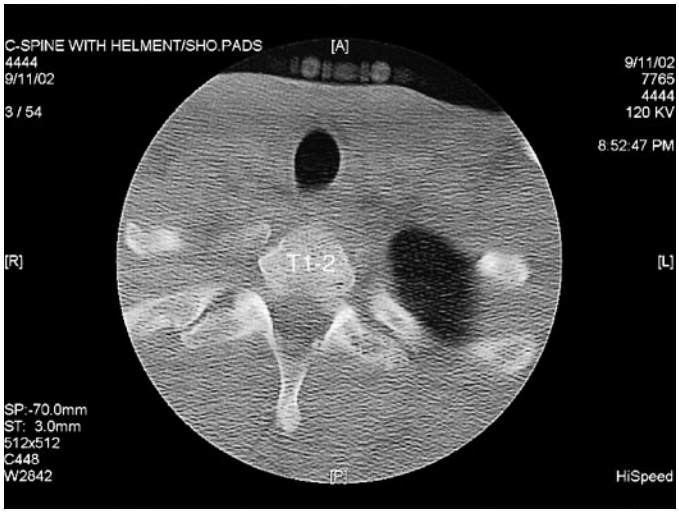

Figure 4. Axial computed tomography (CT) image, bone window, at T1–T2 level (same as Figure 5). Mild image degradation is due to the patient's large shoulders. Higher cervical levels are less affected. Films are fully diagnostic.

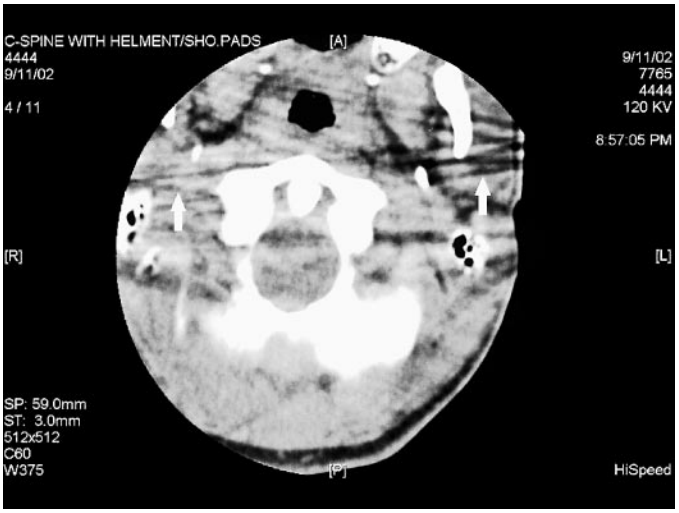

Figure 6. Axial computed tomography (CT) image, soft tissue window, at C1–C2 level. Note the streak artifact (arrows) from the external metal clips. Soft tissue details are preserved, allowing diagnostic film interpretation.

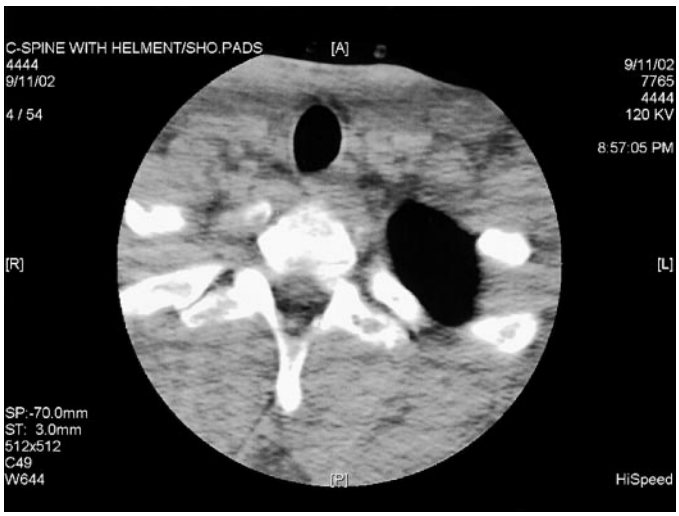

Figure 5. Axial computed tomography (CT) image, soft tissue window, at T1–T2 level. Mild image degradation (lack of sharpness) is due to the patient's large shoulders. Streak artifact is not present. Higher cervical levels are less affected. Films are fully diagnostic.

Figure 7. Two-dimensional midline reconstruction, bone window. Loss of detail from C6 inferiorly is due to the patient's large shoulders and not due to the presence of the shoulder pads. Axial computed tomography (CT) images are fully diagnostic in an area that has often been difficult to evaluate on conventional radiographs.

Reconstructed images (Figure 7) were uniformly of full diagnostic quality.

This study was performed on normal, asymptomatic volunteers, so the examinations demonstrated minimal abnormal findings: subject 1 had a mild disc bulge at C6–C7 without stenosis, subject 3 had mild degenerative disc changes at C5–C6, and subject 4 demonstrated mild congenital foraminal stenosis at C3–C4.

DISCUSSION

In this prospective, observational case series, we demonstrated that when CT scans were reviewed as a unit, sufficient information was available to allow reliable clinical decisions about the football player with helmet and shoulder pads in place. Standard acquisition CT techniques were used, and all study films were of diagnostic quality. The CT scanner was a 1-slice helical scanner; improved technology is available on the newer-generation multislice helical scanners to reduce beam-hardening artifact through the shoulders. Based on the data obtained in this study, helmeted players with suspected cervical spine injury may undergo CT scanning as the diagnostic procedure of choice, without any significant diagnostic limitations due to the presence of the helmet or shoulder pads.

The National Collegiate Athletic Association[8] and the Inter-Association Task Force for Appropriate Care of the Spine-Injured Athlete[6] both recommended that the helmet (without face mask) and shoulder pads remain in place during the initial clinical and radiographic assessment of the football player with a potential cervical spine injury.[2–4] Only after standard 3-view radiographs have been obtained and reviewed should helmet and shoulder pads be removed. The 3-view imaging provides

Table 2. Radiologic Screening of Athletes with Potential Cervical Spine Injuries

Study	Subjects (n)	Methods	Techniques	Limitations	Results	Recommendations
Davidson et al[13]	Male volunteers (20)	X-ray films	2-view radiograph series with and without football helmet and pads	2-film series; football players only	Poor visualization of C1–3, C6–7, C7–T1 interspaces with helmet and pads	Guidelines for helmet and pad removal are needed; football helmet and shoulder pads are impediments to x-ray visualization
Tierney et al[22]	Male volunteers (12)	MRI*	With and without football helmet and pads; measured sagittal space of cord, cord diameter	Clinically significant amount of sagittal space of cord and cord diameter unclear; football players only; altered equipment and backboard with all metal parts removed	Sagittal space of cord greater supine and with pads	Helmet and pads should be left on during spine-board immobilization
Tierney et al[23]	Male volunteers (14)	MRI	With and without football helmet and pads; measured Torg ratio, space available for spinal cord	Football players only; altered equipment and backboard with all metal parts removed; needs validation	Space available for spinal cord more accurate than Torg ratio to predict patients with spinal stenosis at risk for spinal injury	No recommendations for helmet removal and cervical spine injury management
Veenema et al[12]	Male volunteer (1)	X-ray films	Lateral scout film with and without football and hockey helmet and pads	1 film only; football and hockey player	Inadequate with football equipment; inadequate with hockey equipment at C7, C7–T1	Football helmets should be removed before radiographs; x-rays may be adequate in a hockey player if C7 and C7–T1 can be visualized
Waninger et al[14]	Male volunteer (1)	MRI	With helmet and shoulder pads in place	Equipment fitted by equipment managers	Sufficient field inhomogeneity and skew artifact to preclude adequate evaluation of all cervical structures	Current techniques play a limited role in the initial evaluation of the helmeted athlete with a neck injury
Waninger et al (current study)	Male volunteers (5)	CT†	With helmet and shoulder pads in place	Equipment fitted by equipment managers	Quality adequate for evaluation of cervical spine structures	Good modality in the initial evaluation of the helmeted athlete with a neck injury, with no significant diagnostic limitations due to the equipment

*MRI indicates magnetic resonance imaging.
†CT indicates computed tomography.

reliable screening for most patients with blunt trauma.[9–11] However, the protective helmets and shoulder pads worn by athletes may interfere with clearance of the cervical spine because of metal and plastic components that reduce visualization on screening radiographs. Proper visualization of the cervical spine by standard radiographs was not adequate in 2 studies of normal volunteers,[12,13] and one might expect radiographs to be even more problematic in actual injured players. Although these studies have been criticized for methodologic flaws and small numbers,[4] they do confirm what many experts have found clinically. It is quite difficult to visualize all 7 vertebrae while football equipment remains on the subject. Magnetic resonance imaging scans have been shown to have sufficient field inhomogeneity and skew artifact to preclude adequate evaluation of all cervical structures with the helmet and shoulder pads in place (Table 2).[14]

If radiographs are not adequate, some authors advocate that high-risk helmeted patients proceed directly to CT scanning with protective gear in place.[15] Spiral CT has become the standard for initial evaluation of acute cervical injury, especially in those with incomplete radiographic evaluation.[16] This technique has been recommended in unhelmeted patients with acute cervical spine trauma.[17,18] Lateral CT scout films have been used with good success in several study protocols.[19,20] Our findings demonstrate that CT may offer good-quality visualization of the cervical spine with football equipment in place.

Further validation with a larger number of subjects should be performed. These subjects were representative in size, and we would expect that the data collected would extrapolate to other players with similar equipment in place. Equipment based on individual size and body shape should fit uniformly. All equipment was fitted by experienced equipment managers with the assistance of certified athletic trainers. This may be a limitation, in that the results may not be applicable to athletes whose equipment is poorly fitted. Many football teams may not have experienced equipment managers or certified athletic trainers to guarantee adequate helmet and shoulder-pad fitting.

The large football player with helmet and shoulder pads fit well in the CT scanner, but spatial constraints may prohibit CT evaluation in other models of CT scanners. All subjects in this study were asymptomatic. However, there is no reason to suspect that these results would not extrapolate to symptomatic helmeted athletes. In 2002, only 6 cervical spine injuries were reported in helmeted football players, so a controlled study in helmeted athletes with actual cervical spine injuries would be difficult.[21]

Initial radiographic evaluation may be justified to bypass plain radiographs and proceed directly to CT in these patients. Existing protocols[6,8] recommending initial radiographs in these patients may need to be revised. Because helmet and shoulder pads may not allow adequate visualization of the entire cervical spine by standard radiographs, if immediate CT scanning is not available, the equipment may need to be removed or mechanically altered to allow adequate radiographic evaluation. CT scanning of the cervical spine in helmeted athletes may be the first diagnostic modality performed in these athletes, at least in selected cases when adequate radiographs may be difficult. Further studies may be necessary to confirm this treatment algorithm.

In summary, CT of the cervical spine in the helmeted football player is a viable diagnostic modality in the helmeted athlete, without any significant diagnostic limitations due to the presence of the surrounding equipment.

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