Flexion and extension radiographic evaluation for the clearance of potential cervical spine injuries in trauma patients

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Received: 8 May 2012 / Revised: 31 October 2012 / Accepted: 15 November 2012 / Published online: 13 February 2013
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Abstract

Background Flexion and extension radiographs are often used in the setting of trauma to clear a cervical spine injury. The utility of such tests, however, remains to be determined. We hypothesized that in patients who underwent a negative computed tomography (CT) cervical spine scan, flexion and extension radiographs did not yield useful additional information.

Methods We conducted a retrospective chart review of all patients admitted to a Level I trauma center who had a negative CT scan of the cervical spine and a subsequent cervical flexion–extension study for evaluation of potential cervical spine injury. All flexion–extension films were independently reviewed to determine adequacy as defined by C7/T1 visualization and 30° of change in the angle from flexion to extension. The independent reviews were compared to formal radiology readings and the influence of the

flexion–extension studies on clinical decision making was also reviewed.

Results One thousand patients met inclusion criteria for the study. Review of the flexion–extension radiographs revealed that 80 % of the films either did not adequately demonstrate the C7/T1 junction or had less than 30° range of motion. There was one missed injury that was also missed on magnetic resonance imaging. Results of the flexion–extension views had minimal effects on clinical decision making.

Conclusion Adequate flexion extension films are difficult to obtain and are minimally helpful for clearance of the cervical spine in awake and alert trauma patients.

Keywords Flexion extension · Cervical spine · Spine clearance

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Purpose

The potential of a missed cervical spine injury remains a feared complication in the blunt polytrauma patient. As a consequence, many patients brought to the hospital for evaluation after their injuries arrive in full spine precautions that include immobilization of the cervical spine. Cervical spine clearance is then attempted in the emergency department using the NEXUS criteria [1–3]. Using this approach, patients who cannot be cleared on clinical grounds undergo additional radiographic workup.

The approach to further workup is, however, controversial. Multiple imaging modalities, including plain films, computed tomography (CT) scans, magnetic resonance imaging (MRI), and flexion/extension views (F/E) have been investigated and used in various reported algorithms [3–12]. Of these imaging techniques, only flexion–

extension films are capable of demonstrating dynamic ligamentous stability.

At our institution, F/E X-rays have historically been utilized in awake and alert patients with continued cervical spine tenderness despite a negative read on CT imaging of the cervical spine. To obtain F/E views, the patient must be alert and able to cooperate with the examination. A physician or nurse practitioner is present with the patient and the patient is asked to flex and extend their neck after the collar has been removed. As the patient is not assisted in this exercise, the degree of movement is limited by the patient's effort, pain or neurological changes such as numbness or tingling in the extremities. Passive range of motion has been suggested as part of flexion–extension exams, especially in obtunded patients [13], but we have favored active range of motion in awake patients for safety reasons. Often the rationale in these cases is to have some radiographic information on these patients prior to discharge, as there is a historically low follow-up in this patient population. However, in the acute setting, patients may have significant neck spasm, and may not be capable of performing maximal flexion–extension. We suspect that this is often the case and that clinical decisions regarding clearance are being based on these inadequate films.

The goal of this study is to determine the relevance of flexion–extension radiographs in trauma patients when evaluating and managing potential cervical spine injuries.

Methods

After obtaining IRB approval, we conducted a retrospective review of blunt trauma patients at our Level I institution from 2004 to 2006, a time period when we routinely obtained flexion extension views. The spine clearance algorithm during that time period included flexion extension radiographs for patients with ongoing cervical pain and/or tenderness after a negative CT of the cervical spine. The cervical spine examination was conducted on morning rounds, with flexion extension films being ordered for patients with cervical tenderness. The flexion extension films were completed 12–24 h after the initial injury. Data was acquired from our trauma registry and the billing department using procedure codes for cervical CT scans and F/E X-rays. Inclusion criteria were admission to the trauma service, age ≥ 16 , and F/E X-rays done after a negative CT scan of the cervical spine. All patients had a Glasgow coma scale score (GCS) of 14 or 15 at the time of the flexion extension films and were able to cooperate with the examination.

We recorded the final official medical record radiographic interpretation as determined by an attending radiologist and dictated into our electronic medical record. The

results were categorized as negative (without radiographic findings or with degenerative changes only), inadequate/limited (as determined by the radiologist) or positive (any radiographic abnormality, including anterolithesis, subluxation, possible ligamentous injury or retrolithesis). All F/Es were obtained in a radiology suite with either a physician or a nurse practitioner present for patient positioning and removal of the cervical collar. The patient determined the range of motion during the F/E process.

A patient remained in a cervical collar if the F/E was inadequate/limited or there was a positive finding. Those with inadequate films had a follow-up MRI as per the algorithm used at the time. Those with positive findings were seen in the hospital by a spine specialist, either a neurosurgeon or orthopedic spine surgeon. All patients were given a follow-up appointment with trauma surgery and with a spine specialist if required.

Two independent reviewers trained in reading cervical spine radiographs reviewed all the F/E films using a picture archiving and communication (PACs) system. All films were initially evaluated for the presence of the 7th cervical (C7) and 1st thoracic (T1) vertebral junction. Those meeting these criteria were then measured for the degree of flexion and extension by measuring the angle from the posterior plate of C7 to the posterior plate of C2 (2nd cervical vertebra). A F/E was considered inadequate/limited if it did not include the C7/T1 junction or demonstrated less than 30° absolute change in motion from flexion to extension [14–17].

Results

During the study period, 2,057 patients had CT scans of the cervical spine. Of those patients, 1,000 met the inclusion criteria for the study (Fig. 1). The average age was 39.5 (range 16–99) and 53 % of the patients were male.

F/E X-rays demonstrated inadequate visualization of the C7 T1 junction in 769 patients (77 %) per the independent reviewers. An additional “swimmer's view flexion–extension” for better visualization of C7/T1 was done in 172 (22 %) of these patients. This additional view was conducted at the time of the F/E at the discretion of the radiology department.

Of the 231 F/E studies deemed by our independent reviewers to adequately visualize C7/T1, 198 (86 %) demonstrated adequate and extension as defined by a change of $\geq 30^\circ$. Only these 198 studies, or 19.8 % of the total, were adequate to make a definitive determination about the stability of the cervical spine. One of these studies (0.5 % of the adequate studies, 0.1 % of the total studies done) was abnormal (defined as having subluxation, anterolithesis, disc injury or retrolithesis). This patient was

Fig. 1 Review results

found to have an injury upon return to clinic with increased neck pain, further discussion in the conclusion.

Our independent review of the F/E studies was in many cases at odds with the official radiology readings. Our review found 80 % of the F/E studies to be inadequate for evaluation for instability ($n = 802$, 769 with inadequate visualization of the cervico-thoracic junction and 33 with inadequate flexion–extension) while only 23 % of the radiologist readings were interpreted as limited/inadequate.

Of the 769 studies that did not adequately demonstrate the cervico-thoracic junction by our review, 70 % had a negative attending radiology read while radiologist interpreted 26 % as limited or inadequate by radiology read. The remaining 4 % had radiology readings of anteriolithesis ($n = 15$), disc injury ($n = 1$), possible ligamentous injury ($n = 6$) and retrolithesis ($n = 1$).

Of the 33 F/E that by our review adequately showed C7/T1 but did not demonstrate adequate flexion–extension, the official radiology read was negative in 22 (67 %). In the

remaining 33 %, the radiological findings were limited ($n = 9$) or possible ligamentous injury/subluxation ($n = 2$). Radiologic reads of adequate versus inadequate flexion extension studies did not differentiate patients who were treated with Aspen collars (3.5 % adequate vs. 3.4 % inadequate) or a request for consultation from a spine specialist (8 vs. 7 %). No patients were found on F/E to have an unstable injury requiring surgical stabilization.

There was one false negative in this series that ultimately required surgical fixation, for an overall false negative rate of 0.001. The patient on initial presentation had a negative CT scan followed by a negative F/E and then a negative MRI. The radiological reading for the F/E stated that C1–C6 was well visualized, and the final radiological interpretation was that the F/E was negative. An MRI was done during the initial hospitalization, as the preliminary radiological report on the F/E was “inadequate because of poor patient performance secondary to pain”. The MRI reading was negative for any ligamentous injury but did

comment on a “small central disc herniation at C6–7.” The patient’s initial inpatient treatment consisted of a soft cervical collar after evaluation by a spine surgeon, with outpatient follow-up. Trauma clinic follow-up 2 weeks after discharge found the patient to be neurologically intact, wearing the soft collar and complaining of some tenderness with the removal of the collar. A spine clinic follow-up 1 month after the time of injury revealed kyphosis and possible instability on cervical spine films and the patient complained of upper thoracic pain. A flexion extension study done at that time demonstrated subluxation at C6/7 and an MRI revealed posterior ligamentous injury and neural foraminal narrowing at the posterior disc complex at C6–7. The patient underwent an urgent C6/7 anterior cervical discectomy and fusion for cervical instability and stenosis and did well postoperatively. Retrospective review of the F/E films determined them to be inadequate as they did not clearly show the C7/T1 junction. However, by our independent review clear ligamentous injury and subluxation of C6–7 was identified on the initial CT scan, X-ray and MRI.

Conclusions

Clearance of the cervical spine in trauma patients is of critical importance. Although the rate of missed injury is low (1.9–3.8 %) the consequences can be devastating [6, 8, 11]. Most trauma services use algorithms for cervical spine clearance but to date there is no universally accepted algorithm for clearance of the cervical spine. Much of the literature focuses on the specific utility of different radiologic modalities. Several studies have indicated that helical CT alone is sufficient to detect cervical spine injuries [5, 18]. Others have recommended the use of MRI acutely to detect ligamentous injuries, as they found that 60 % of flexion extension films are inadequate, consistent with the findings in our patient population [10]. MRI has also been suggested as the next step after CT scanning during the acute evaluation phase, reserving flexion extension studies for clinical follow-up after cervical tenderness subsides [15]. Many of these studies were done in the obtunded or altered patient; few address the dilemma of cervical spine clearance in the awake and alert patient with ongoing cervical tenderness [6, 7]. The EAST and NEXUS guidelines recommend flexion extension films for the awake and alert patient with continued cervical tenderness after negative plain films or CT scans [2, 19, 20]. The algorithms mandate that the flexion extension films be adequate and negative however those terms are not specifically defined.

Two previous studies specifically address the utility of flexion extension films in awake, alert patients in the trauma setting. Insko et al. [14] evaluated 106 patients and

found that 30 % of patients had inadequate motion to make the examination significant or useful. The authors found that in those with adequate studies, F/E had a low false negative rate for ligamentous injuries. Their conclusion was that further studies were required to critically evaluate cervical spine clearance protocols in trauma. The second study by Khan et al. [15] retrospectively reviewed flexion extension films in 311 trauma patients. Criteria for adequacy of F/E in this study were visualization of the C7/T1 junction, $\geq 30^\circ$ of motion from neutral, presence of a swimmer’s view and no evidence of rotation. F/E was found to be inadequate in 69 % of the patients reviewed, again consistent with the findings of the independent review in the present study. Khan [15] proposed the use of a hard cervical collar and follow-up on 7–10 days for patients with persistent neck pain after F/E.

The purpose of our study was to retrospectively evaluate the value of acute flexion extension studies after negative cervical spine CT in awake and alert blunt trauma patients with ongoing cervical tenderness. Adequacy of F/E was defined as adequate visualization of the cervico-thoracic junction and at least 30° of motion from neutral [12, 14]. Eighty percent of the F/E conducted in a 3-year period at our institution did not meet these criteria.

One reason for inadequate films in the acute period may be due to spasm and muscle strain. Our radiographic studies were conducted 12–24 h after injury, certainly still within a time frame when spasm and muscle strain could have been present in many patients. This limited motion may render flexion–extension studies unreliable in the early post-injury period and further highlights their limited utility. When the cervicothoracic junction was poorly visualized the radiology department chose to occasionally (22 %) obtain additional “swimmers flexion–extension” radiographs. While swimmer’s views allow better visualization of the C7/T1 junction, they are of limited utility in determining stability of the cervical spine and cannot be used alone for definitive clearance. This subjected the patients to additional radiation and did not impact clinical decision making.

An additionally problem with obtaining adequate films, is the lack of consensus regarding the definition of what constitutes an adequate study. Within the trauma literature, “adequate” is defined as 30° of change from a neutral position and the visualization of the C7 T1 junction. Definitions used by radiologists focus on vertebral body segmental changes that occur in flexion and extension; surprisingly radiology definitions also do not insist on visualization of the C7–T1 junction. Additionally, there is significant variability in radiology readings depending on whether the radiologist interpreting the films has special training in neuroradiology and/or musculoskeletal radiology. As part of our continuous quality improvement

initiatives, we have shared their data with our radiology department and have re-emphasized the basic metrics for adequacy in the Trauma, Orthopaedic and Neurosurgical literature.

The prevailing reason to obtain F/E films in the acute setting is to clear patients with poor follow-up and continued neck pain, without obtaining an MRI. In our patient

population, after excluding patients who died or were transferred to another inpatient facility, only 25 % of patients returned for a clinic follow-up with either the trauma service or a spine specialist. Even patients told they had a possible injury to their cervical spine and admonished to wear a hard collar as an outpatient followed up only 18 % of the time. Of the 25 patients with a possible

Fig. 2 Current guideline for clearance of the cervical spine

finding of possible injury on their flexion extension, one died from other injuries, 32 % ($n = 8$) treated with aspen collars and the remaining were cleared for any cervical spine injuries. 50 % ($n = 4$) of those treated with an aspen collar were returned for a clinic follow-up. All of the patients with clinical follow-up in this group were cleared of spine injury, and two of the four arrived to clinic without aspen collars. No patients with possible injury on the flexion extension per radiology had a readmission with cervical injury at this facility. Algorithms that require outpatient follow-up and re-examination for ultimate cervical spine clearance may be difficult, and are prone to poor follow-up and patient compliance.

This study is retrospective and done at a single Level 1 trauma center, with all of the limitations inherent in that methodology. Poor patient follow-up is another limitation and it is impossible to determine whether there were any further missed injuries beyond the one found on follow-up at our institution.

This study has changed the practice patterns at our institution (Fig. 2). While there is no universally accepted algorithm for cervical spine clearance in the awake symptomatic patient with ongoing cervical tenderness and a negative CT scan, our data suggests that acute flexion extension films are inadequate 70–80 % of the time. Even when they are read as positive, they only rarely result in significant changes in patient management. As a consequence, we do not rely on flexion–extension views for cervical spine clearance in the acute setting. After the cervical spine CT scan has been read by an appropriately trained musculoskeletal or neuro-radiologist, our guideline is to obtain upright lateral radiographs without a collar for those patients with persistent neck pain despite a negative CT scan. If kyphotic changes are seen, an MRI of the cervical spine is obtained. A consult with a spinal specialist is obtained for any positive MRI finding or questionable upright radiograph (Fig. 2). This allows us to assess the impact of gravity, and to evaluate the integrity of the posterior ligamentous complex. We do not obtain flexion–extension radiographs on any cervical spine in the acute setting, unless requested by the orthopaedic spine or neurosurgical consultation services. We also obtain MRI images for patients with significant pain, any question of ligamentous instability on CT or upright imaging, or who are unreliable. Additionally, we have instituted an education program for patients with cervicgia, and emphasize 10–14 day follow-up with a primary care physician, or the trauma service.

In conclusion, we have found that obtaining flexion–extension radiographs did not provide any additional clinically useful information. As a consequence, they are no longer routinely performed at this institution to clear the cervical spine in the acute setting.

Conflict of interest No funding was received for this manuscript and the authors have no conflicts to declare.

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