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Guidelines for initial management and assessment of spinal injury British Trauma Society, 2002

Working Party

Peter Oakley: Consultant in Anaesthesia and Trauma

Karim Brohi: Specialist Registrar in General Surgery

Alastair Wilson: Consultant Emergency Physician

Michael Bishay: Consultant in Trauma and Orthopaedics

Mark Brown: Consultant Spinal Surgeon

Otto Chan: Consultant Radiologist

Frank Cross: Consultant Vascular Surgeon

Stuart Matthews: Consultant in Trauma and Orthopaedics

Paula Richards: Consultant Musculoskeletal Radiologist

Malcolm Smith: Consultant in Trauma and Orthopaedics

John Templeton: Emeritus Professor of Traumatic Orthopaedics

1. Introduction

1.1. The need for spinal clearance guidelines

In the UK, there is considerable variation in how spinal injury is excluded. The practice has often been erratic, particularly in patients with a concomitant head injury. Most unconscious patients have been declared clear of a cervical spinal injury on radiographic findings alone. This judgement has often been based on a single plain film—the cross-table lateral view. In addition, evidence has been mounting about the limitations of plain films. In unconscious patients with a severe head injury, fractures of the odontoid process are often missed, even with a set of good quality plain films. Newer imaging methods, higher resolution devices and increasing expertise in their interpretation now allow better definition of the bony structures and the soft tissues. Meanwhile, the cost and morbidity of unnecessary over-investigation and prolonged immobilisation have been recognised.

A Working Party from the British Trauma Society has sought to draw together current evidence and produce a set of guidelines relevant to practice in the UK.

1.2. Statement of intent

The recommendations in this document are intended as guidelines. Adherence to them will not in itself guarantee a favourable outcome. The individual doctor may choose to institute alternative procedures on the basis of the particular needs of the individual patient, special training and experience, or new evidence in the literature. However, significant departures from these recommendations should be documented with an explanation in the individual case notes.

These guidelines focus on cervical spinal clearance though thoraco-lumbar clearance is addressed briefly. They will be reviewed and updated on the basis of new evidence before the end of 2005.

1.3. Identification of literature

The National Library of Medicine's Medline database was searched for the terms 'spine' in the title occurring with the text words 'trauma', 'injury', or 'radiology'. Studies whose primary topic was management and assessment of spinal injury were selected. Weight was given to those papers with more than 100 cases, a defined study population, prospective or retrospective cohort design and specific description of the studies obtained and the speciality of doctors interpreting them.

We are indebted to the Eastern Association for the Surgery of Trauma (EAST) and their 'practice management guidelines for identifying cervical spine injuries following trauma' (1998). We have adopted a similar methodology to allow continuity and coherence of methodology.

1.4. Classification of evidence

There have been no prospective randomised controlled clinical trials comparing methods of spinal immobilisation, handling or radiological evaluation. Hence, there is no Class I evidence and there are no formal standards of care.

There is a large body of literature on the incidence and patterns of cervical spine injury and the indications for and diagnostic impact of imaging. This evidence is based on prospective and retrospective observational and cohort

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studies. The guidelines presented here are based on this literature.

2. Spinal immobilisation

2.1. Indications

Very few studies define the criteria for identifying patients at risk from cervical spine injury. In this document, if the mechanism of injury is considered by the clinician attending the patient to be capable of causing spinal trauma, spinal precautions should be instituted. They should be maintained until a spinal injury can be excluded clinically, by appropriate radiological studies or by a combination of clinical evaluation and imaging, according to the guidelines described below. If the history is uncertain or inadequate, it is wise to institute precautions, especially if the patient has symptoms or signs attributable to a spinal injury or if the patient is unconscious or otherwise unable to communicate.

In general, stab injuries do not require spinal immobilisation. Gunshot wounds that have traversed the spinal column may produce unstable injuries and spinal precautions should be instituted in patients at risk. Gunshot wounds to the cranium alone are not associated with a risk of cervical spine trauma.

2.2. Techniques of immobilisation and patient handling

As soon as an indication for spinal precautions is recognised, manual in-line immobilisation should be instituted. An attendant holds the head firmly but gently so that the neck is in a neutral position. Specific immobilisation devices may be used subsequently, but their application should not take precedence over life-saving procedures.

The whole spine should be immobilised in a neutral position on a firm, tiltable surface. The cervical spine may be controlled manually or with a combination of a hard cervical collar, side head supports and strapping. It should be recognised that spinal immobilisation devices may interfere with the identification and management of life-threatening conditions. They should be removed for examination or for specific interventions, such as intubation. Manual in-line immobilisation should be re-instituted during such procedures.

2.2.1. Spine boards

Long spine boards are valuable for extrication from vehicles and transportation to hospital. During transfer, strapping should be applied to the shoulders and pelvis as well as the head, to prevent rotation occurring at the neck.

After arriving in hospital, the board should be removed promptly, as prolonged use can rapidly give rise to pressure injuries. It is difficult to justify leaving a spine board in place for more than one hour from its application at the scene of the accident. Patients may also be transferred to hospital on a scoop stretcher and/or a vacuum mattress. There is little place for a short spine board or other similar device in the prehospital environment.

2.2.2. Firm, tiltable trolley or bed

When the spine board or alternative transportation device is removed in the Emergency Department, the patient with an uncleared spine should be placed on a firm trolley, capable of being tilted head-down. Whether the patient is awake and cooperative or is unconscious, intubated and ventilated, the hard collar should be left in place and the head supports re-applied, pending further clinical and radiological assessment. If the spine remains uncleared after admission to a ward area, a firm bed, capable of being tilted head-down, is required. If a spinal injury has been identified, a specialist spinal turning bed may be required as part of definitive care.

2.2.3. Log rolling

The log roll is the standard manoeuvre to allow examination of the back and to transfer the patient on and off a spine board. Five people are required, one to hold the head and coordinate the roll, three to control the chest, pelvis and lower limbs, respectively, and one to perform any associated procedure (e.g. examining the back, clearing debris, removing clothing or the spine board itself). The person coordinating the roll should issue a 'ready-steady-go' instruction, according to local manual handling practice. The number of log rolls should be kept to a minimum. However, if the patient with an uncleared spine is admitted to the Intensive Care Unit, frequent turns will be necessary to facilitate chest physiotherapy.

2.2.4. Transfer slides

Rigid transfer slides (e.g. *Patslide*) are useful for transferring the patient from one firm surface to another (e.g. from the trolley to the CT scanner or operating table). Such transfers require a minimum of four people to perform, one to hold the head and coordinate the transfer, at least two to control the trunk and limbs, and one to control the rigid transfer slide itself. A sliding sheet (e.g. *Maxi Slide*) may also help to smooth the transfer across by reducing friction.

2.3. Special circumstances

2.3.1. If the neck is not initially in a neutral position

If the neck is not in a neutral position when the patient is first approached, a careful attempt should be made to achieve alignment. If awake and co-operative, the patient should be asked to move the neck actively into line. If unconscious or unable to co-operate, this may be done passively, but gently and cautiously by experienced personnel. If there is any pain, neurological deterioration or resistance to movement, the procedure should be abandoned and the neck splinted in the current position. If the patient is known to have a significant cervical spinal deformity prior to the accident, as in ankylosing spondylosis, extreme caution should be employed before attempting to move the neck into a neutral position.

2.3.2. If the patient is uncooperative or agitated

Patients who are agitated or restless due to shock, hypoxia, head injury or intoxication may be impossible to immobilise adequately. Forced restraint may risk further injury to the spine. Initially, it may be safer to abandon manual immobilisation and to remove the immobilisation devices, allowing the patient to move unhindered. If possible, the hard collar may be left in place to limit the extremes of movement. Reassurance and a diplomatic approach are essential, together with immediate therapy to correct hypoxia or hypotension. If it is clear that the patient cannot be settled rapidly with simple measures, it may be necessary to proceed to a rapid sequence induction of anaesthesia, followed by intubation and ventilation, to allow adequate diagnosis and therapy. In a risk–benefit analysis, such an intervention will often be safer than the alternative of providing sedation without definitive airway control, providing it is carried out by appropriately-trained personnel.

2.3.3. If the patient vomits

If the patient vomits before the airway has been secured, the firm surface on which the patient is lying should be tilted head-down rapidly and the airway aspirated using a large bore sucker. The alternative of turning the patient laterally requires the patient to be fully secured to a spinal board or vacuum mattress (including body and limb straps) or the immediate availability of a team to perform a log roll. In the Emergency Department, temporary head-down tilt is the preferred position for airway protection and suction, even in a head-injured patient.

2.3.4. If the patient needs to be intubated

Intubation of the trauma victim is generally best achieved using rapid sequence induction of anaesthesia and oro-tracheal intubation, though in specific situations in which the airway anatomy is distorted, alternative methods (e.g. fibreoptic intubation) may be safer. Anaesthesia and intubation of the trauma patient are often technically challenging and should be undertaken by an appropriately-trained practitioner. The collar should be removed and manual in-line immobilisation re-instituted for the manoeuvre. For oro-tracheal intubation, the routine use of a gum elastic boogie is recommended, allowing intubation to be achieved with minimal cervical movement and limited visualisation of the larynx.

2.3.5. If the patient needs secondary transfer to another hospital

If the spine has still not been cleared when the patient is to be transferred elsewhere, spinal immobilisation must be maintained throughout the journey on the ambulance trolley. The hard collar and side head supports can remain in place to provide stabilisation of the neck. While many ambulance trolleys have a firm, tiltable surface, they are not designed to maintain adequate spinal stabilisation of the trunk during transportation. Judiciously placing rolled-up towels or other side padding and straps to stabilise the trunk may provide a safe, if ad hoc, solution. A vacuum mattress is much better suited to the task and is recommended for secondary transfer. The use of a rigid spine board is discouraged, except for very short journey times if no suitable alternative is available.

3. Cervical spine clearance

Spinal immobilisation has a high priority in the severely injured patient and should be instituted and maintained by prehospital personnel. Spinal clearance is less urgent and should be completed in hospital during the secondary survey or beyond. The timing of this process depends on the overall pattern of injury and the patient's physiological state. Imaging the spine does not take precedence over life-saving interventions. Nevertheless, radiological clearance, using plain views supported by CT scans of poorly visualised or suspicious areas, should generally have been achieved in severely injured patients before admission to the ward area.

3.1. Clinical clearance

Numerous large prospective studies have described the high cost and low yield from the indiscriminate use of cervical spine imaging in trauma patients. Clinical assessment remains a simple and effective means of excluding spinal injury in patients who satisfy the following criteria:

- fully alert and orientated;
- no head injury;
- no drugs or alcohol;
- no neck pain;
- no abnormal neurology and
- no significant 'distracting' pain from an injury in a separate body region.

The neck may then be examined. If there is no bruising or deformity, no tenderness and a pain-free range of active movements, the cervical spine can be cleared by clinical means alone. Radiographic studies of the cervical spine are not indicated. Even though there may be evidence of high-energy transfer, the mechanism of injury alone does not determine the need for radiological investigation.

In order to clear the spine clinically, the assessment should be undertaken by trained personnel in a suitable environment to permit reliable evaluation. As yet, there is no conclusive evidence in the literature that supports clinical clearance of the spine in the prehospital environment. There is enough variation between prehospital and in-hospital assessments to advise against prehospital removal of spinal immobilisation.

In patients suffering serious blunt injuries who have a reduced conscious level or other painful injuries, both the clinical history and examination are unreliable. Radiological clearance using plain views, supported by CT imaging of poorly visualised or suspicious areas, is required. Subsequently, if the patient is awake and alert following such radiological studies, clinical assessment may be performed

to complete the spinal clearance. If the patient is still obtunded, clearance must be delayed or an alternative imaging strategy employed, as discussed below.

3.2. Plain film radiology

Radiological evaluation of the cervical spine is indicated for all patients who do not meet the criteria for clinical clearance as described above. Imaging studies should be technically adequate and interpreted by an experienced radiologist or other trained clinician.

The standard three-view plain film series comprises the lateral, the antero-posterior and the open-mouth peg views.

3.2.1. The lateral cervical view

Of the plain views, the lateral cervical spine view provides the most information, but on its own is inadequate and will miss up to 15% of cervical spine injuries. The lateral film should show the base of the occiput and all vertebrae down to the top of the first thoracic vertebra. As a routine, the arms should be gently but firmly pulled caudally to facilitate visualisation of the lower cervical spine. Repeated attempts to show the C7–T1 border should be avoided and oblique views or a CT scan arranged.

3.2.2. The antero-posterior view

The antero-posterior view should be carefully centred to avoid rotation arterfacts and should demonstrate the spinous processes of all the cervical vertebrae from C2 to T1.

3.2.3. The open-mouth peg view

The open-mouth view should allow visualisation of the lateral masses of C1 and C2, as well as the entire odontoid peg. In the unconscious, head-injured patient, missed fractures of C1 and C2 have been reported on open mouth views of adequate quality. In these patients, the open-mouth view should be replaced by a CT scan, extending from the occiput to the upper border of C3 with coronal and sagittal reconstruction. This is conveniently performed at the same time as the head CT scan that these patients will require.

3.2.4. Oblique views

Forty-five degrees trauma oblique views are valuable to indicate alignment at the C7–T1 level, if the lateral view fails to show the C7–T1 junction. These views allow good visualisation of the posterior elements of the cervical spine and reveal facet joint dislocations. If the lower cervical vertebrae are inadequately demonstrated on the lateral view, oblique views may not provide sufficient detail of the vertebral bodies to replace the lateral view.

3.2.5. Other views (swimmer's, coned penetrating lateral at the cervico-thoracic junction, submandibular basal peg view)

The swimmer's view and the coned penetrating lateral view have been used to visualise the lower cervical spine when it is not seen adequately on the lateral view, but oblique views are generally preferred. The swimmer's view requires one arm to be raised and the other pulled down, which tends to twist the spine, and it subjects the patient to nearly double the radiation dose of oblique views. The coned penetrating lateral view also requires more radiation, though less than the swimmer's. The submandibular basal peg view may show the odontoid process when it cannot be revealed on the standard open mouth view because of overlying bony structures. It does not provide adequate visualisation of the lateral masses of C1 and C2.

3.3. CT scanning

Thin-cut helical axial CT scanning on specific bone windows, with sagittal and coronal reconstruction should be used to evaluate abnormal, suspicious or poorly visualised areas on plain film radiology. For the odontoid process, the cuts should be at 2 mm intervals, with 3 mm cuts sufficing for other levels. CT scanning with reconstruction from the occiput to the upper border of C3 should replace the open-mouth radiograph in unconscious, intubated patients. The combination of plain film radiology and directed CT scanning, even with technically adequate studies and experienced interpretation, may still miss ligamentous injuries.

There is increasing evidence that primary helical CT scanning of the entire cervical spine (with sagittal and coronal reconstructions) is more sensitive than plain films, though it incurs a significantly higher radiation dose. The emerging technology of multislice CT scanning is likely to further improve sensitivity. It also requires less radiation than helical CT, though its versatility may lead to more CT-based investigations being performed in trauma patients. In the face of concerns about radiation dosage, there is as yet insufficient evidence to recommend that primary CT scanning of the entire cervical spine should replace the combination of plain films and targeted CT. Nevertheless, if carefully audited and reported, it may be regarded as a legitimate option.

When used as the primary imaging of the cervical spine, helical or multislice CT scanning should be performed at 2–3 mm collimation and 1.5 mm pitch from the occiput to T1. Sagittal and coronal reconstructions must be closely examined for indications of ligamentous instability, such as widening, slippage and rotational abnormalities. When whole cervical spine CT scanning is performed, the antero-posterior plain film becomes redundant.

3.4. Magnetic resonance imaging (MRI)

MRI is becoming more widely available and is being used more frequently in critically-ill patients. It is extremely sensitive at detecting soft tissue injury without applying any mechanical stress to the spine, though it can miss fractures. It will show cord, disc or ligamentous abnormalities that may not be evident on helical or multislice CT. Reported false negatives are very uncommon, so that ligamentous injury can be confidently excluded if the MRI scan is normal. However,

its specificity is relatively low and the significance of abnormal findings in terms of spinal stability is unclear. Ligaments not visualised in an area of oedema must be presumed ruptured, accepting that this will result in false positives.

MRI scanning of ventilated patients is a significant undertaking, requiring special non-ferromagnetic equipment in a challenging environment with limited access to the patient. When a surgical procedure is indicated on the basis of other investigations, an MRI scan is an invaluable adjunct to reveal any unsuspected neural tissue or disc injury.

Patients who have neurological symptoms or signs attributable to cord or nerve root injury should undergo an MRI scan of the spine. This includes those who report transient symptoms (e.g. 'stinging' or 'burning'), even if there are no abnormal signs.

3.5. Flexion-extension imaging

Active flexion-extension views are plain lateral radiographs performed with the neck actively flexed and extended by the patient. The patient must control the movements and stop if there are any neurological symptoms or significant increase in pain. They are intended to reveal pure ligamentous injury or disc disruption in alert patients with no demonstrable abnormality on the standard views, but who have persistent pain. Performing flexion-extension views in these patients is considered to be safe, provided that the procedure is directly supervised by an experienced clinician.

Passive dynamic flexion-extension fluoroscopy of the cervical spine, performed by an experienced radiologist, orthopaedic surgeon or neurosurgeon, has been used to reveal unstable ligamentous injuries in unconscious patients with no radiological abnormalities on plain films or CT scans. While several investigators have reported it to be safe, their studies are based on very small numbers of patients with demonstrated instability. The investigation is often technically inadequate and many cases were excluded from review in the reported series. Of 625 patients currently reported in the literature, dynamic fluoroscopy has a sensitivity of 92.3% and specificity of 98.8%. Two cases of neurological deterioration during the study have been reported, including one complete quadriplegia.

Given the inherent risks in passively flexing and extending the neck of an unconscious patient, this technique should not be undertaken, except as part of a controlled trial designed to investigate further its efficacy and safety.

3.6. Special circumstances

3.6.1. Assessment of the patient with persistent pain without neurological symptoms or signs

An alert patient with normal plain films (supplemented if necessary by CT scanning), but with persistent pain, should undergo flexion-extension imaging. It may be appropriate to delay this investigation for up to 10 days until any muscle spasm has resolved. Plain views should be taken at the extremes of comfortable flexion and extension during active movement by the patient, supervised by an experienced clinician. If pain increases or if neurological symptoms are reported, the procedure is abandoned and the patient is referred for specialist spinal injury advice.

3.6.2. Assessment of cervical spinal injury in the unconscious patient

Unconscious patients are unable to describe neck pain or other neurological symptoms. In this situation, clinical examination is unreliable. Even if the plain films and any supplementary CT scan are reported as normal, occult injuries to discs, ligaments, nerve roots or the spinal cord may be present. A careful strategy is required to manage safely the small number of patients with occult unstable injuries without subjecting the large number of unconscious patients who turn out not to have a spinal injury to the risks of prolonged spinal immobilisation. In critically-injured patients, spinal immobilisation leads to decubitus ulceration and deep venous thrombosis and may compromise nursing care, respiratory support and the management of traumatic brain injury.

Clearance of the cervical spine in unconscious patients is limited by the lack of clinical information. The incidence of unstable cervical spinal injury in adult, intubated, trauma patients is around 10%. The frequency of occult instability that is not evident on plain films or CT in unconscious trauma patients remains uncertain, as the reported studies vary in inclusion criteria, case mix and imaging strategy.

Four alternative strategies to complete spinal clearance in the unconscious trauma patient are considered:

- gentle in-line handling until the patient is awake and assessable clinically;
- MRI scanning;
- dynamic fluoroscopy and
- CT of the whole cervical spine.

In the first three strategies, it is assumed that plain films (supplemented by CT scanning if indicated) have been reported as normal by an experienced practitioner and that there is no other evidence of spinal injury at this time.

In the first approach, the hard collar is removed and gentle in-line handling is maintained in an adequately sedated, ventilated patient. A hard collar is not considered necessary in the adequately sedated, ventilated patient whose spine is radiologically normal on plain films supplemented by CT. It may increase intracranial pressure in patients with traumatic brain injury. A soft collar may be used to provide a visual clue to remind carers that the spine has not been cleared clinically. Full in-line turning is permitted for physiotherapy. When the patient is weaning from sedation, the hard collar is replaced to limit the extremes of movement. With the collar in place, the patient is managed without side supports and straps, in a similar way to that described above for the uncooperative or agitated patient. When the patient is sufficiently awake, alert and cooperative, a clinical examination is performed, including an assessment of active

neck movements. If these are normal, spinal clearance can be declared and the spinal precautions abandoned. If the patient fails to regain consciousness sufficiently to allow clinical evaluation, one of the alternative approaches should be adopted or a specialist in spinal injuries consulted.

Prolonged spinal immobilisation in critically ill patients has been associated with decubitus ulcers and deep venous thrombosis. It places a heavy burden on the nursing staff and, without attention to detail, it may interfere with respiratory support and the management of traumatic brain injury. It is recognised that with the first approach as described, the spine may remain uncleared for a longer period. It is essential to maintain careful nursing care and physiotherapy throughout.

In the second approach, MRI scanning is used to exclude spinal injury. If the MRI scan, interpreted by an experienced radiologist or specialist in spinal injury, is reported as normal, the spine can be declared clear and the spinal precautions abandoned. This strategy depends on the sensitivity of MRI to demonstrate soft tissue injury. Its drawbacks are the current relative lack of availability and cost of MRI scanners, the need for expert interpretation and the logistic difficulties in taking an unconscious, ventilated, critically-injured patient into the MRI scanner environment. In addition, the lack of specificity will often reveal abnormalities that are difficult to interpret in terms of spinal stability. Such findings should be referred to a specialist in spinal injury.

The third approach remains controversial, although it has been adopted in many centres in North America. This strategy involves supervised dynamic flexion-extension fluoroscopy, which may be supplemented by plain views at the extremes of flexion and extension. Until the safety of this procedure is better established, its use should be confined to centres undertaking it as part of a controlled study. To enhance the safety of this technique, it has been recommended that it should be performed in association with somatosensory evoked potential monitoring.

The fourth approach involves performing a plain lateral radiograph in conjunction with spiral or multislice CT of the entire cervical spine (with orthogonal reconstructions) instead of the conventional set of plain films with supplemental CT. There are still some concerns about high radiation dosage and missed ligamentous injuries with this approach.

There is currently insufficient evidence to support one strategy over the others in terms of the overall risk–benefit and cost-effectiveness. Ethical concerns hamper the design of randomised controlled trials to determine the best option. The first approach is currently regarded as a safe option, even if a prolonged period of unconsciousness is predicted, and is particularly recommended in patients who are expected to regain consciousness within 24–48 h.

3.6.3. Assessment of the patient with abnormal neurological symptoms or signs

All patients with abnormal neurological symptoms or signs attributable to spinal injury should be evaluated promptly in a specialist unit and have an MRI scan of the spine. Any abnormal findings on the MRI scan should prompt targeted CT of those areas (if not already imaged on CT scan) to identify occult fractures. Patients who report transient neurological symptoms should also undergo an MRI scan and should be referred for specialist advice if there are any abnormal findings.

For patients recognised to have a spinal cord injury, a clear policy should be in place to provide the indications and a dosage regime for high-dose steroid administration. In the absence of such a policy, immediate consultation with a specialist in spinal cord injury should take place.

3.6.4. Assessment of the child with a potential injury to the cervical spine

Spinal evaluation in children should follow the same principles as in adults, while recognising important differences. Clinical evaluation is inherently less reliable in young children and little is known about the validity of clinical clearance in this age group. Radiological evaluation requires particular care as the immature anatomy can be confusing. Growth plates and normal variants such as pseudo-subluxation are often difficult to distinguish from fractures or dislocations and pre-vertebral soft tissue swelling may be mimicked by crying or a flexed neck. In addition, spinal cord injury without radiographic plain film abnormality (SCIWORA) is more common in children and a thorough neurological examination is of paramount importance.

4. Thoracolumbar spine clearance

Similar considerations apply to the thoracolumbar spine, though it is less mobile and is better supported by the surrounding anatomical structures than the cervical spine. There is less evidence and no consensus on the indications for imaging in patients with no local symptoms or signs of a thoracolumbar injury but who have other painful injuries or who have a history of taking alcohol or other sedative drugs. This remains a matter of clinical judgement but must be considered seriously. Imaging is clearly indicated if there is pain, bruising, swelling, deformity or abnormal neurological findings attributable to a thoracic or lumbar spinal injury. Unconscious patients with a significant mechanism of injury who cannot be assessed clinically require radiological clearance of the whole spine.Patients with one fracture of the spine have a 5–15% chance of a second fracture, which may be non-contiguous. Detection of one injury should prompt a full spinal evaluation.

The basic investigations for potential thoracolumbar spinal injury are the antero-posterior and lateral thoracic and lumbar plain films. As in the cervical spine, plain films should be supplemented by CT scans of areas that are abnormal, suspicious or difficult to visualise. Active or

passive movements are not routinely examined, clinically or radiologically.

5. Consultation with referral to a specialist in spinal injuries

An acute spinal injury unit should be capable of providing emergency surgery to relieve spinal cord or nerve root compression. It should also be able to provide urgent operative stabilisation of unstable fractures when indicated. An important distinction should be made between acute spinal injury management and spinal cord injury rehabilitation. Acute spinal injury management should be available at a regional level, carried out by specialists in spinal injury within an acute major hospital. Spinal cord injury rehabilitation is carried out in a supra-regional spinal unit. While such a unit will often focus on continuing management and rehabilitation, it should also be capable of providing emergency operative intervention. Some supra-regional spinal units are physically isolated from other acute specialties. If a patient with a spinal injury has serious injuries in other body regions, he or she should be managed initially in a multi-disciplinary environment with other specialist surgical and critical care facilities on site.

For acute hospitals which receive trauma patients but which do not have specialists in spinal injury, an image transfer link with the regional or supra-regional spinal injury unit should be established to facilitate consultation and referral.

All patients with abnormal neurological findings following spinal injury should be evaluated promptly in a specialist spinal injury unit and have a good quality MRI scan of the spine. Consultation with a specialist in spinal injury is also indicated if:

- an injury to the spine or spinal cord is identified;
- there is uncertainty in interpreting the films and
- the appropriate imaging modality is not available

Patients may require transfer for urgent definitive care of other injuries, such as head or pelvic injuries. In a time-limited situation, there must be no unnecessary delays in transporting these patients. If completing spinal imaging will not alter immediate spinal management and the transfer is regarded as time-critical, completing radiological clearance may be deferred. The spine should be immobilised and protected for transfer as described above and the need to complete the spinal assessment at a later stage should be clearly documented in the clinical record.

6. Summary of recommendations for cervical spinal clearance

- For the patient at risk of cervical spinal injury, spinal precautions should be maintained until spinal clearance can be achieved. The techniques to be used in special circumstances (such as if the patient is uncooperative, vomiting or undergoing intubation) should be clearly understood.
- If there are no local signs of cervical spinal injury, no neurological deficit, no distracting pain and no significant recent intake of sedative drugs or alcohol, then an alert, orientated, asymptomatic patient may be allowed to move the neck actively. If the movements are normal, the cervical spine may be cleared clinically without any imaging.
- In all other circumstances, unless a formal policy of using whole cervical spine CT has been agreed, a patient at risk of cervical spinal injury should undergo plain radiographs of the cervical spine, supplemented by CT scanning of areas that are suspicious or poorly visualised. In a conscious patient, the recommended plain views are the lateral (with gentle caudal arm traction), the antero-posterior and the open-mouth odontoid peg films. If the cervico-thoracic junction is not adequately seen, oblique views or a coned penetrated view may be considered, before resorting to a CT scan of this area. In the unconscious trauma patient, lateral and antero-posterior views are required, but a CT from the occiput to the upper border of C3 should replace the open-mouth view.
- If plain views and any supplementary CT scans are normal and the patient is now awake, alert, has no neurological deficit and does not have persistent pain or tenderness, the patient may be allowed to move the neck actively. If the movements are normal, cervical spinal precautions may be relaxed.
- If plain views and any supplementary CT scans are normal and the patient is awake, alert and has no neurological deficit, but has persistent pain, flexion-extension views should be performed and reported as normal before cervical spinal clearance can be declared.
- If plain views and any supplementary CT scans are normal and the patient is unconscious, one of three strategies to achieve cervical spinal clearance should be undertaken:
  - Gentle in-line handling with the hard collar removed, but allowing full turning for nursing care and physiotherapy. A hard collar should be worn when weaning from sedation. When the patient is awake, a clinical assessment is undertaken, including active neck movements. If normal, cervical spinal precautions may be relaxed. If the patient's conscious level remains depressed after withdrawing sedation in the Intensive Care Unit, this planned management pathway cannot be completed. One of the other options for clearing the cervical spine must be used or other guidance sought from a specialist in spinal injury.
  - MRI scanning of the spine. If normal, cervical spinal precautions may be relaxed.
- Dynamic flexion-extension fluoroscopy, accompanied by somatosensory evoked potential monitoring, but only as part of a controlled study (until more evidence of its safety is available). If normal, cervical spinal precautions may be relaxed.

- A formal policy of using whole cervical spine CT scanning in unconscious patients may be agreed in preference to the set of plain views and targeted CT scanning. Until further evidence of its efficacy and radiation safety is obtained, a cautious approach should be adopted. The policy should be introduced with careful audit of its effectiveness. A CT of the whole cervical spine with sagittal and coronal reconstructions should be performed in conjunction with a plain lateral radiograph. If normal, cervical spinal precautions may be relaxed, accepting that in the absence of further research evidence, there may be a small residual risk of disc or ligamentous instability.
- A specialist in spinal injury should be consulted promptly if any of investigations show evidence of a spinal injury

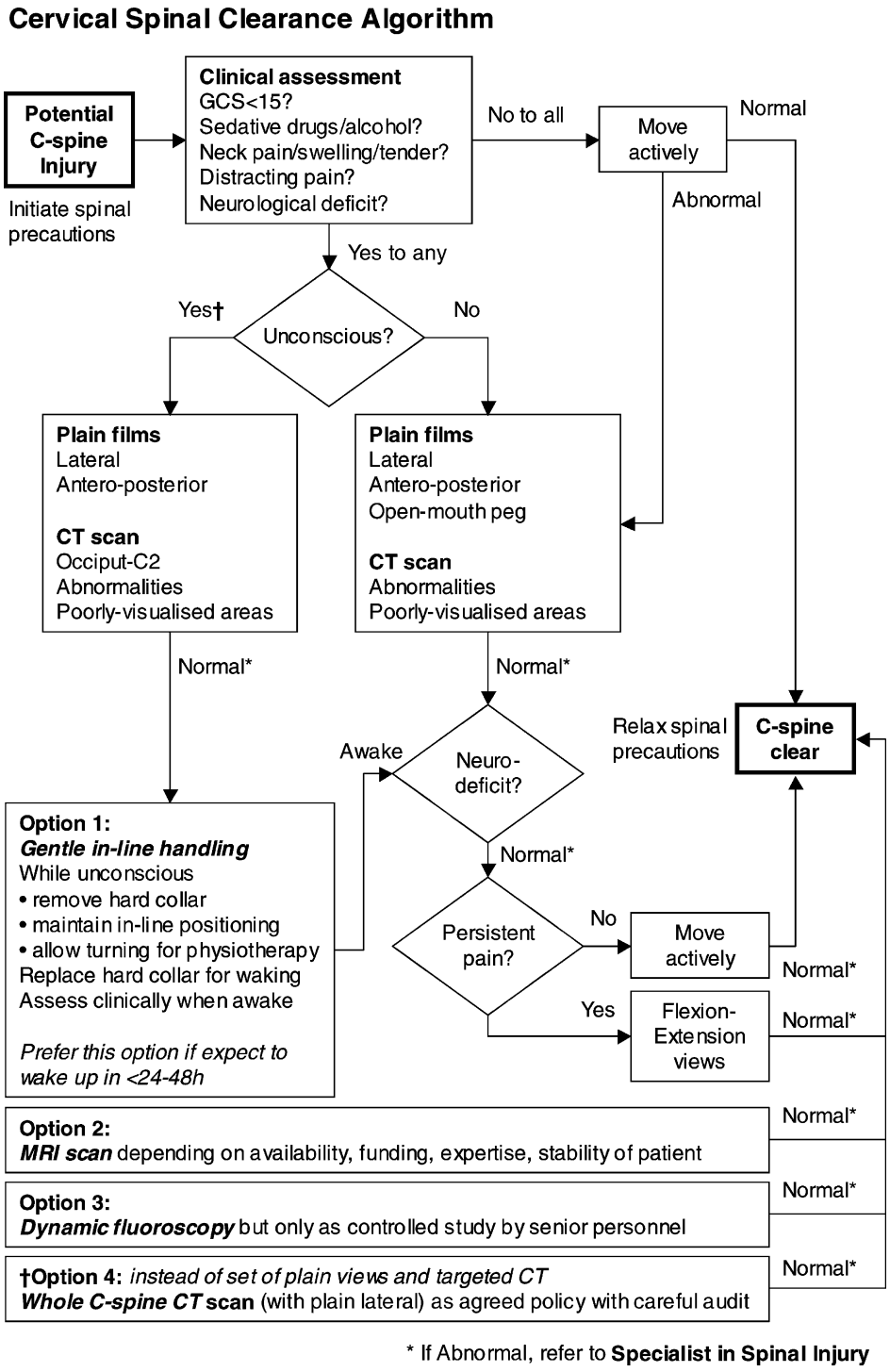

Fig. 1. Cervical spinal clearance algorithm.

or if the findings are uncertain. Any patient with evidence of a neurological deficit attributable to a spinal injury should be referred immediately.

These recommendations for cervical spine clearance are provided as an algorithm in diagrammatic form (Fig. 1).

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Incidence of cervical spine injury

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Evidence table

First author	Year	Title	*N*	Study design	Comment
Clinical clearance of spinal injury					
Bachulis	1987	Clinical indications for cervical spine radiographs in the traumatized patient	1823	Prospective observational	5% spinal injury rate; no injury was asymptomatic; no missed injury with three-view series
Cadoux	1987	High-yield roentgenographic criteria for cervical spine injuries	749	Retrospective series	2.4% spinal injury rate; no asymptomatic fractures
Ersoy	1995	Are cervical spine X-rays mandatory in all blunt trauma patients?	267	Retrospective series	5% blunt trauma had cervical injury, either symptomatic or tenderness had fractures
Gonzalez	1999	Role of clinical examination in screening for blunt cervical injury	2146	Prospective observational	33 (1.6%) cervical spine fractures; clinical exam 91% sensitivity; lateral C-spine 61% sensitivity
Hoffman (NEXUS)	2000	Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma; National Emergency X-Radiography Utilization Study Group	34,069	Prospective multicentre	818 (2.4%) cervical spine fractures; clinical criteria 99.6% sensitive; two patients with significant missed injury by clinical criteria
Kriepke	1989	Reliability of indications for cervical spine films in trauma patients	860	Prospective observational	2.8% spinal injury rate; no asymptomatic fractures
Lindsey	1993	Efficacy of radiographic evaluation of the cervical spine in emergency situations	1686, 597	Retrospective; prospective	Retrospectively cervical injuries were diagnosed in 1.9%; no false negatives in alert conscious asymptomatic patients
Mahadevan	1998	Interrater reliability of cervical spine injury criteria in patients with blunt trauma	122	Prospective	87.7% inter-rater concordance in findings on clinical examination
McNamara	1988	Post-traumatic neck pain: a prospective and follow-up study	186	Retrospective series	2% spinal injury rate; no asymptomatic fractures
McNamara	1990	Cervical spine injury and radiography in alert, high-risk patients	286	Retrospective series	1.7% injury rate; no asymptomatic fractures

Table (*Continued*)

First author	Year	Title	*N*	Study design	Comment
Meldon	1998	Out-of-hospital cervical spine clearance: agreement between emergency medical technicians and emergency physicians	190	Prospective observational	Significant disagreement between in-hospital and prehospital personnel; 27 of 44 (61%) initially cleared by prehospital staff were immobilised on admission to hospital; all 5 (2.6%) unstable injuries were immobilised on-scene
Mirvis	1989	Protocol-driven radiologic evaluation of suspected cervical spine injury: Efficacy study	408	Prospective	No unstable fracture detected in 138 asymptomatic patients
Ringenberg	1988	Rational ordering of cervical spine radiographs following trauma	312	Retrospective series	No asymptomatic fractures; diagnostic delay due to inadequate or misread radiology
Roberge	1992	Evaluation of neck discomfort, neck tenderness, and neurologic deficits as indicators for radiography in blunt trauma victims	480	Prospective observational	3.5% injury rate; 13 of 14 unstable injuries symptomatic; clinical evaluation 93% sensitive
Roberge	1988	Selective application of cervical spine radiography in alert victims of blunt trauma: a prospective study	467	Prospective observational	1.7% spinal injury rate; no asymptomatic fractures
Ross	1992	Clinical predictors of unstable cervical spinal injury in multiply injured patients	410	Prospective observational	6.1% injury rate; no asymptomatic injuries
Roth	1994	Roentgenographic evaluation of the cervical spine: a selective approach	290	Prospective cohort	2% cervical spine injury rate; no asymptomatic injuries
Saddison	1991	Clinical indications for cervical spine radiographs in alert trauma patients	47	Retrospective series	No true asymptomatic cases had cervical spine injuries
Velmahos	1996	Radiographic cervical spine evaluation in the alert asymptomatic blunt trauma victim: much ado about nothing	549	Prospective observational	No asymptomatic injuries
Zabell	1997	Adequacy and efficacy of lateral cervical spine radiography in alert, high-risk blunt trauma patients	223	Retrospective series	2.4% cervical fracture or dislocation; absence of clinical cervical symptoms sensitivity 89% specificity 81% and 0.32% negative predictive value, better than lateral spine radiography at 67, 58 and 1.4%, retrospectively
Prehospital clearance					
Domeier	1999	The reliability of prehospital clinical evaluation for potential spinal injury is not affected by the mechanism of injury	6500	Prospective observational	3.2% spinal injury rate, prehospital criteria missed 10 (4/9%) injuries; mechanism of injury was not an independent predictor
Meldon	1998	Out-of-hospital cervical spine clearance: agreement between emergency medical technicians and emergency physicians	190	Prospective observational	2.6% spinal injury rate; 23% disagreement between prehospital an din-hospital observers
Plain film radiology					
Fischer	1984	Cervical radiographic evaluation of alert patients following blunt trauma	333	Retrospective	All subjects fully alert; 1.5% injury rate; no asymptomatic injuries
Freemyer	1989	Comparison of five- and three-view cervical spine series in the evaluation of patients with cervical trauma	58	Prospective cohort	Addition of supine oblique views to the standard three-view series did not improve diagnostic sensitivity
Hoffman	1992	Low-risk criteria for cervical spine radiography in blunt trauma: a prospective study	1000	Prospective cohort	2.7% injury rate; all significant spinal injuries were symptomatic, had disordered sensorium or significant distracting injury

Table (*Continued*)

First author	Year	Title	*N*	Study design	Comment
Holliman	1991	Is the anteroposterior cervical spine radiograph necessary in initial trauma screening?		Retrospective	No significant cervical injury was visible only on the anteroposterior radiograph
Ireland	1998	Do supine oblique views provide better imaging of the cervicothoracic junction than swimmer's views?	122	Prospective cohort	Supine oblique views were better at showing posterior elements compared to the swimmer's view (70% vs. 37%), radiation dose also lower (1.6 mGy vs. 7.2 mGy)
Jacobs	1986	Prospective analysis of acute cervical spine injury: a methodology to predict injury	233	Prospective	10.3% injury rate; clinical examination alone would have missed five injuries
Lewis	1991	Flexion-extension views in the evaluation of cervical spine injuries	141	Retrospective	8% (11) injury rate; 2.8% (4) fractures only visible on flexion-extension views; 10 of 11 detected injuries had persistent neck pain
MacDonald	1990	Diagnosis of cervical spine injury in motor vehicle crash victims: how many X-rays are enough?	775	Retrospective	12% (92) injury rate in motor vehicle crash victims; 17.3% missed initially; lateral 83% sensitive; three-view series detected all but one unstable injury
Ross	1987	Clearing the cervical spine: initial radiologic evaluation	204	Prospective observational	6.4% injury rate; lateral radiograph 85% sensitive; maximal sensitivity and negative predictive value with three-view series combined with limited CT of poorly visualised regions
Shaffer	1981	Limitation of the cross table lateral view in detecting cervical spine injuries: a retrospective analysis		Retrospective	25.7% of unstable fractures difficult or impossible to view on lateral radiograph alone
Stiell	2001	The Canadian C-spine rule for radiography in alert and stable trauma patients	8924	Prospective cohort multicentre	1.7% important cervical spine injury; alert, stable patients actively rotate neck to 45° 100% sensitive for injury
Turetsky	1993	Technique and use of supine oblique views in acute cervical spine trauma	83	Retrospective	8 (9.6%) of 83 injuries demonstrated best on supine oblique views; 5 only visible on supine obliques
West	1997	Acute cervical spine trauma: diagnostic performance of single-view versus three-view radiographic screening	97	Observational study	Three-view series more sensitive than single cross-table lateral (83.3% vs. 81.8%); more significant different with more junior radiologists
Computed tomography					
Acheson	1987	High-resolution CT scanning in the evaluation of cervical spine fracture: comparison with plain film examinations	160	Retrospective	49 unstable cervical spines in 160 patients undergoing CT scan; CT scan detected 135 injuries, only 64 (47%) of which were seen on plain radiology; CT detected injuries mainly in suspicious areas on plain films or adjacent vertebra
Berne	1999	Value of complete cervical helical computed tomographic scanning in identifying cervical spine injury in the unevaluable blunt trauma patient with multiple injuries: a prospective study	58	Prospective, observational uncontrolled	ITU blunt trauma admissions requiring CT of another body area; 34.4% cervical injuries helical CT 3 mm slices 90% sensitivity, specificity 100% positive predictive value 100% negative predictive value 95%
Blacksin	1995	Frequency and significance of fractures of the upper cervical spine detected by CT in patients with severe neck trauma	100	Prospective series	7% fractures at craniocervical junction; CT of craniocervical junction replaced odontoid view; 8% fractures missed by lateral plain radiograph

Table (*Continued*)

First author	Year	Title	*N*	Study design	Comment
Borock	1991	A prospective analysis of a 2-year experience using computed tomography as an adjunct for cervical spine clearance	179	Prospective observational	CT plus three-views detected 98% of cervical spine injuries
Carvalho	1997	Diagnosis of root avulsions in traumatic brachial plexus injuries: value of computerized tomography myelography and magnetic resonance imaging	40	Retrospective	CT myelographs (1–3 mm) method of choice to diagnose complete or partial nerve root avulsions
Chiu	2001	Ligamentous injuries of the cervical spine in unreliable blunt trauma patients: incidence, evaluation, and outcome	14,577	Retrospective series	4.2% cervical spine injury; 0.6% (87) isolated ligamentous injury
Daffner	2001	Helical CT of the cervical spine for trauma patients	100	Prospective series	Helical spine 3 mm slices pitch of one reconstructed 2 mm; cervical spine CT at the time of cranial CT average of 12 min half plain radiographic time
Demetriades	2000	Non-skeletal cervical spine injuries: epidemiology and diagnostic pitfalls	14,755	Retrospective series	2% cervical spine injuries; cervical spine injury incidence inversely related to GCS; 0.2% (31) subluxation without fracture; 0.07% (11) isolated cord injury without fracture or subluxation
Hanson	2000	Cervical spine injury: accuracy of helical CT used as a screening technique	601	Retrospective series	Sensitivity 95%, specificity 93%, accuracy 93% of helical CT cervical spine injury; 4 false negatives (missed 3 ligamentous and 1 fracture); 36 false positive (6 possible facet fractures 8 possible ligament injury, 6 inadequate scan)
Jelly	2000	Radiography versus spiral CT in the evaluation of cervicothoracic junction injuries in polytrauma patients who have undergone intubation	73	Prospective	Intubated blunt polytrauma patients 20 cervical fractures 7/12 cervical dorsal injuries missed on plain films including oblilques
Lee	2001	The role of spiral CT vs. plain films in acute cervical spine trauma: a comparative study	604	Retrospective observational series	30 fractures (5.13%) seen on helical CT 1 mm from C0 to C3 and 3 mm C3 to T1 with coronal and sagittal reconstructions); two-thirds fractures missed on X-ray
Mower	2000	Odontoid fractures following blunt trauma	34,069	Prospective observational multicentre (NEXUS)	2.4% (818) cervical spine injury 94 odontoid fractures; prevalence of odontoid fractures 3% in the under 20's; 20% in the over 80's
Nunez	1996	How much more do we learn by routinely using helical CT?	88	Retrospective random sample	33% of missed fractures on lateral X-ray clinically significant or unstable (helical 5 mm pitch 1); most at C1–C2 (42%), 30% from C3 to C5 and 28% C6 and C7
Ptak	2001	Screening for cervical spine trauma with helical CT: experience with 676 cases	676	Retrospective observational series	Whole spine CT 3 mm slices post process to 1 mm, coronal and sagittal reconstructions 59 true positive, 1 false negative; no false positive; sensitivity 98.3%, specificity 100%, accuracy 99.9%
Schleehauf	1989	Computed tomography in the initial evaluation of the cervical spine	104	Prospective cohort	Sensitivity 78% overall; CT misses rotational atlanto-axial subluxation visible on plain films; combined with plain films—100% sensitivity

Table (*Continued*)

First author	Year	Title	*N*	Study design	Comment
Tehranzadeh	1994	Efficacy of limited CT for non-visualised lower cervical spine in patients with blunt trauma	100	Retrospective	Reviewed CT scans of patients whose plain films did not show C7–T1; 3% missed injury rate—none unstable
Woodring	1992	The role and limitations of computed tomographic scanning in the evaluation of cervical trauma	216	Retrospective series	Plain films diagnosed: 58% (262/453) fractures, 93% (97/104) subluxations or dislocations; CT 90% of fractures (406/453), 54% subluxations (46/104) plain films significantly better at detecting subluxation/dislocations
Magnetic resonance imaging					
Albrect	2001	Evaluation of cervical spine in intensive care patients following blunt trauma	1780	Retrospective observational	549 admitted to ICU 27/108 normal X-rays had ligamentous injury on MRI; 21 normal X-rays and MRI deemed clear and collar removed with no neurological deficit
D'Alise	1999	Magnetic resonance imaging evaluation of the cervical spine in the comatose or obtunded trauma patient	121	Prospective observational	All patients intubated, without fracture detected on plain films and no neurology 31 (25.6%) significant injury; 8 (6.6%) detected only on MRI; 90 (74.4%) normal on MRI had spinal clearance within 48 h
Benzel	1996	Magnetic resonance imaging for the evaluation of patients with occult cervical spine injury	174	Prospective observational	62 (36%) soft tissue injuries identified by MR alone: 27 disc disruption 35 isolated ligaments 0.064 T
Flanders	1996	Forecasting motor recovery after cervical spine or cord injury: value of MRI	104	Retrospective	328 cervical spinal cord injuries MRI data 104; MRI haemorrhage and oedema increase ability to predict clinical outcome 16–33% compared to clinical assessment alone
Geek	2001	Assessment of cervical ligamentous injury in trauma patients using MRI	89	Retrospective series	Major trauma cases with negative plain radiographs; 7 ligamentous injury 2 operations confirmed ligamentous injury; 22 spasm contra-indicated flexion/extention; 6 inadequate flexion/extension; 5/6 normal; MRI 1/6 MR ligamentous injury; 9 flexion/extension radiographs abnormal, 8/9 normal MRI 1/9 MR ligamentous injury; 9/10 reduced consciousness normal MRI, 1/10 MRI ligament injury confirmed at surgery
Giacobetti	1997	Vertebral artery occlusion associated with cervical spine trauma	61	Prospective series	MR angiography occluded vertebral arteries (all unilateral) 19.7%, usually from flexion injuries
Green	2000	MRI assessment of the whole spine in acute spinal injury patients	38	Prospective series	Fat suppressed T2 showed 29% cervical, 26% thoracic, 35% lumbar, 5% cervicothoracic and 5% thoracolumbar fractures
Green	2001	MRI assessment of cervical spine ligaments in a non-traumatic population	20		T1 ligaments not seen: AOL 21%, POL 25%, LF 37% and alar ligament 25% T2: 11, 7, 2%, respectively; Discontinuity of the black stripe unreliable sign of ligamentous disruption in isolation

Table (*Continued*)

First author	Year	Title	*N*	Study design	Comment
Katzberg	1999	Acute cervical spine injuries: prospective MRI assessment at a level I trauma centre	199	Retrospective observational	58 patients 172 cervical injuries 136/172 (79%) cord injuries associated with cervical spondylosis $P < 0.05$, acute fracture $P < 0.001$ and canal stenosis $P < 0.001$
Kihiczak	2001	Should an MR scan be performed routinely after a normal clearance CT scan in the trauma patient?	59	Retrospective series	Negative helical or multislice CT (3 mm, 1.5 pitch, reconstructed to 1 mm sagittal and coronal reconstructions); 10.2% injuries not seen on CT (6.8% ligamentous, 1.7% soft tissue and disc oedema, 1.7% nerve root avulsions)
Parbhoo	2001	Vertebral artery injury and cervical spine trauma	47	Prospective series	25 fracture dislocations had vertebral artery injury
Quayum	2001	MRI detection of unsuspected vertebral injury in acute spine trauma: incidence and significance	110	Retrospective	41.8% of tertiary referrals to a spine centre had trabecular microfractures
Varraro	1998	Usefulness of MRI in isolated upper cervical spine fractures in adults	55	Prospective	77 patients excluded MRI cost effective in neurological deficit, change treatment in 25%; MRI no effect without neurological deficit
Warner	1996	MRI of ligamentous injury of the cervical spine	420		43 acute cervical spine trauma; 97 ligamentous injuries; surgical corroboration 11 patients; 2 false positive posterior longtitudinal ligament rupture; no false negatives
Dynamic flexion-extension imaging					
Ajani	1998	Optimal assessment of cervical spine trauma in critically ill patients: a prospective evaluation	100	Prospective observational	6 unstable injuries; 9 fatalities before assessed 48 unconscious/uncooperative; 1 detected only on functional imaging; collar complications common after 72 h of immobilisation
Anglen	2002	Flexion and extension views are not cost effective in a cervical spine clearance protocol for obtunded trauma patients	837	Retrospective	Population screened 1484, 402 (27%) inadequate to rule out instability; 4 with increased GCS, 1 false positive
Cox	2001	Cervical spine instability: clearance using dynamic fluoroscopy	110	Prospective	110 normal 3 film series; 33% directed CT 4% MRI; all with normal radiograph disc abtunded under dynamic fluoroscopy; no diagnosed unstable by radiologists; 5 of these thought insignificant by neurosurgeon/orthopaedist; 1 death before assessment; 3 unstable, 2 treated operatively
Brooks	2001	Evaluation of the Oxford protocol for total spinal clearance in the unconscious trauma patient	210	Retrospective series	86 (41%) cleared clinically before (30.5%) or after (10.5%) unconsciousness; 15 (7.1%) died; 78 (37.1%) fluoscopy; 5 unstable or cervical fracture; 1 isolated ligamentous injury was surgically fussed
Davis	1995	Clearing the cervical spine in obtunded patients: the use of dynamic fluoroscopy	116	Prospective cohort	113 negative studies in obtunded patients; one unstable fracture identified
Davis	2001	Routine evaluation of the cervical spine in head-injured patients with dynamic fluoroscopy: a reappraisal	301	Retrospective series; (includes 116 cases from 1995)	GSC <13 normal cervical radiographs 297 true negative; 2 true positive; 1 false negative; ligamentous injury 2/301 0.7%; 1 quadraplegic patient produced by flouoscopy

Table (*Continued*)

First author	Year	Title	*N*	Study design	Comment
Hino	1999	Dynamic motion analysis of normal and unstable cervical spines using cini radiography	22	Prospective controlled	10 healthy volunteers, step wise motion initiated at C1/2, transmitted to the lower segments with a time lag; 12 rheumatoid (unstable C1/2); in C1/2 instability motion started significantly earlier that successive segments; segmental instability below C2, started with the motion at the level of instability before the upper segments
Thoracolumbar spine					
Durham	1995	Evaluation of the thoracic and lumbar spine after blunt trauma	344	Retrospective series	19 (5.5%) unstable injury; awake, alert patients without clinical evidence of injury did not have unstable thoracolumbar spine injuries
Frankel	1994	Indications for obtaining surveillance thoracic and lumbar spine radiographs	233, 167	Retrospective, prospective	15.7% injury rate; Indications for thoracolumbar radiography: back pain or tenderness, GCS $\leq$ 8, neurological deficit, fall >10 feet or ejection from crash
Meldon	1995	Thoracolumbar spine fractures: clinical presentation and the effect of altered sensorium and major injury	145	Retrospective series	No asymptomatic thoracic or lumbar spine fractures in neurologically intact patients with clear sensoriums and no concomitant major injuries