Assessment of possible cervical spine injury in children suffering blunt trauma

Queensland Paediatric Trauma Service

Purpose

This document provides clinical practice guidelines to aid clinicians involved in the emergency management of children with possible cervical spine injury (CSI) following blunt trauma.

Scope

This document relates to emergency staff involved in the care and management of children with possible cervical spine injury.

INTRODUCTION

Serious paediatric cervical spine injury following blunt trauma is uncommon, occurring in approximately 1% of all paediatric blunt trauma cases, with incidence ranging from 0.4% in the preschool population to 2.5% in the adolescent age group (Mohseni 2011). Of these injuries, the majority are stable injuries, with approximately 20% requiring bracing or operative fixation (Leonard 2011, Vicellio 2001).

At the Mater Children's Hospital (MCH) Brisbane, during the five year period 2007-2012, there were 75 patients admitted for possible spinal injury, of whom 37 had resolving sprain/strain injuries, and 38 patients had significant spinal injury (fractures, dislocations, spinal cord injury, or some combination thereof). Fourteen children required operative stabilisation (internal fixation or halo), one was transferred to an adult spinal rehabilitation centre for spinal cord injury, and 2 children died. This is on a background of 40,000 annual ED presentations, of which an estimated 6%, or 2,400 (12,000 over 5 years) have had blunt trauma injury (1), and after correction for external transfers yields an incidence in our population of approximately 0.6% admission and 0.1% operative cases of CSI per paediatric blunt trauma presentation to the emergency department.
Identification of this small group of patients with clinically significant CSI is challenging, but especially important in light of the functional sequelae these injuries may cause. Radiological imaging plays a crucial role in defining injuries incurred, but comes with a poorly-defined increase in lifetime risk of malignancy (2, 3).

Risk stratification to determine which patients warrant radiological investigation minimises such risk. Despite good quality clinical rules for identifying adult blunt trauma patients at low risk for C-spine injury (National Emergency X-radiography Utilisation Study (NEXUS), Canadian C-spine Rules (CCR) (4, 5), there remained until recently a paucity of evidence relating to children. Clinical practice guidelines based on the NEXUS and CCR criteria are routinely used in paediatric patients, however there is little or no evidence of their applicability in this population. The paediatric NEXUS subgroup only included 13 children under 16 years of age with true cervical spine injury (6). It is necessary to obtain specific paediatric criteria for identification of the low risk patient because the paediatric C-spine is anatomically different to that of an adult, and the mechanisms of injury, and triggers for emergency department presentation, are quite different between these populations (7).

The Paediatric Emergency Care Applied Research Network (PECARN) recently published results of a retrospective study to identify risk factors for cervical spine injuries in children after blunt trauma. In this study, the records of 540 children with true CSI, as well as those of nearly 3000 controls were interrogated. The authors identified eight factors associated with C-spine injury (8), at least one of which was present in 98% of the 540 children with CSI.

These eight factors (some of which are present in the NEXUS and CCR models) are the basis of the clinical practice algorithm and user notes in Appendix A. The next section will detail the clinical assessment of patients according to these eight risk factors.

ASSESSMENT

The clinical history is critical in the risk assessment of paediatric patients with suspected cervical spine injury. Features of the clinical history that carry particular significance include mechanism of injury (MOI), history of neurological symptoms or neck pain or ambulation subsequent to the traumatic incident, and history of medical conditions that may predispose to CSI.

MOI associated with paediatric CSI:

- **High risk motor vehicle accident (MVA)** – head-on collision, rollover, ejected from vehicle, death in same crash, or speed >88kph
- **Axial load to any part of the head or neck**, e.g. diving or falling from a height
- **Rugby forced hyperflexion** as can occur in scrum collapse predisposes the player to a particular type of injury (facet joint dislocation +/- spinal cord injury) which may require urgent reduction and is specifically flagged (9)
- **Medical conditions that may predispose to CSI** include Down syndrome, Klippel-Feil syndrome, achondroplasia, mucopolysaccharidosis, Ehlers-Danlos syndrome, Marfan syndrome, osteogenesis imperfecta, Larsen syndrome, juvenile rheumatoid arthritis, juvenile ankylosing spondylitis, renal osteodystrophy, rickets, history of CSI or cervical spine surgery.
- **Pain vs tenderness**: A traumatic cervical spine injury like any other traumatic deformation causes the conscious infant, child or adolescent to be acutely aware of pain and dysfunction, and to protect the area with muscle spasm. The PECARN study found a **complaint of posterior neck pain to be a significant risk factor for true PSCI**, rather than “midline tenderness” which was not a good
discriminator between true PSCI and controls without PSCI. Asking the conscious, verbal injured child where they are sore, and assessing mobility and tenderness in pre-verbal children with this in mind, can help discernment.

- Physical examination of the child with a suspected CSI should commence with the primary survey (airway, breathing, circulation (ABC), with specific attention paid to the maintenance of C-spine precautions (see Appendix C). Patients who are stable from an ABC point of view should be examined from head to toe (secondary survey), with particular attention to the risk factor flagged by the PECARN study as concerning for CSI: torticollis, substantial thoracic injury, focal neurological deficit, or other specific features of spinal cord injury such as unexplained hypotension or priapism. It is important to note that assessment of active range of motion should only be undertaken if the patient has no other physical symptom risk factor (pain, abnormal neurology, or altered conscious state) as an indication for imaging. Active neck rotation to 45 degrees bilaterally is considered adequate evidence of appropriate range of motion, although most children have a greater normal range than this.

- Unstable patients, patients with altered conscious state, and patients with specific focal neurological deficits suspicious of spinal cord injury are straightforward in their ED management: they require spinal immobilisation and spinal precautions until their situation changes to enable interactive assessment of function. Patients being admitted to PICU are dealt with in Appendix B. Patients with persistent focal neurological abnormality or persistent pain/limitation of movement, particularly in the setting of high risk mechanism, will require consultant review and/or orthopaedic or spinal involvement, regardless of their radiological findings.

- Special groups:

  **Inter-hospital transfers:** Patients with suspected CSI transferred from other hospitals should have a full C-spine assessment undertaken on arrival in DEM or PICU.

  The **adolescent with a clinical picture consistent with acute cervical facet joint dislocation** (low velocity injury with hyperflexion or axial loading, abnormal focal neurology suggestive of cord injury, and normal conscious state, e.g. rugby scrum collapse) **must be immediately assessed and referred to the Spinal service**, as time to reduction is critical (9, 10). These children have readily apparent abnormal plain films.

  The **pre-verbal child with suspected CSI** presents a particular challenge for the clinician. While relevant history may be obtained from parents of other witnesses, subjective symptomatology is very difficult to elicit. History and objective examination findings must be synthesised to determine the need for investigations and/or observation. While the incidence of CSI in this group is lower, the sensitivity of plain films for injury or instability is also lower. It is critical that the clinician pays attention to subtle signs of neck pain, torticollis, and the combination of irritability and reluctance to move the head after trauma. Assessment of the young child and interpretation of the young child’s radiology may require a high degree of sophistication and experience.

  **Children with pre-existing disorders that predispose them to CSI** (see above) should be assessed with a high suspicion of injury and a low threshold for imaging, and may require specialist input. However, a predisposing risk factor alone does not mandate imaging in the absence of other concerns.
MANAGEMENT

Clinical clearance – Children with none of the eight risk factors identified by Leonard et al are considered to have had their C-spine clinically cleared. No imaging or immobilisation is required.

If any of the eight risk factors outlined above is found on history or examination, C-spine immobilisation and spinal precautions during transfer and handling should commence or continue.

Immobilisation and spinal precautions: The MOR approach (See Appendix C)

- In contrast to the popular use of hard C-spine immobilisation collars, the recommendation of the Princess Alexandra Hospital (PAH) Spinal Injuries Unit and of the senior surgeons at Children’s Health Queensland is for careful attention to neutral handling and positioning, with soft or two-piece neck collars, thoracic elevation devices in patients under 8 years, and lateral sandbags in unconscious patients.

- Soft collars are recommended in preference to hard collars because of the lack of evidence of hard collar efficacy (11), and increasing concerns about hard collar related morbidity. Cervical spine immobilisation by hard collars contributes to raised intracranial pressure, respiratory disturbance, patient agitation, and soft tissue ulceration (12). Patients admitted for possible or definite spinal injury should be changed from hard to soft or two piece collars within 4 hours of arrival in the emergency department, to minimise the likelihood of pressure ulceration.

- As with all mechanical trauma to the skeleton, deformations causing spinal cord injury or ischemia occur at the time of the initial massive angulating/displacing forces and are unlikely to be reproduced during normal handling. No orthopaedic immobilisation device can prevent angulation during transfers when high level instability is present, and the differences in angulation between one-piece, two-piece and soft devices with cervical spine precautions during handling is small (11). Standard cervical collars cannot prevent anteropulsion of horizontally unstable injuries, or the risks associated with atlanto-occipital instability.

- Patients who become physically agitated with external devices may be at increased risk of instability due to non-anatomical mechanical fixation points. Clinical assessment must consider the risks of alternative management, such as sedation or removal of immobilisation.

- Because of their short submental distance and poor tolerance for immobilisation, children have a tendency to slip their chins under the collars, causing hyperflexion and poor airway positioning. In practice, with young children this is aggravated by reluctance of attendant staff to keep a hard collar snug, and by children’s natural desire to flex their heads to see more than the ceiling. These factors place children at even great risk of malpositioning and unintended negative consequences of immobilisation devices.

- The MOR approach to immobilisation and spinal precautions involves LESS discomfort and risk of pressure complications (the change from stiff to soft collars) but MORE attention to addressing Moments of Risk (MOR) in the smaller number of higher risk patients identified by the PECARN risk factors. These strategies are outlined below and summarised in Appendix C:

MOR: Strategies to Address Moments of Risk for Cervical Spine Malpositioning:

Agitation: early pain relief, change to soft or two-piece collar, prop upright if conscious, stable, and at low risk for thoraco-lumbar spine injury, special handling for high-risk infants and toddlers

Trolley Transfers and Log Roll: Pat slide and dedicated Head/spine nurse or doctor, place directly on TED (Thoracic Elevation Device) on arrival if under 10
**Vomiting:** early prophylactic anti-emetic for head injuries or nausea, nasogastric insertion where required, “specialling” of uncleared patients at risk of vomiting

**Imaging:** TED for under 10, dedicated attendant to insist on appropriate neutral positioning for head/neck CTs (no pillows; if head rest is used spine must be suitably elevated)

**Intubation:** Dedicated attendant to hold head inline during intubation, consider fibreoptic laryngoscope.

During these Moments of Risk, inadvertent angulation or distraction may occur with or without fixation devices, and a medical or nursing staff member must pay particular care to neutral positioning during these times.

Children under age ten who are kept on a flat trolley or mattress will tend to have a Cobb angle (the difference in inclination of lines drawn parallel to inferior endplates of C2 and C6) in the flexed range. A TED (thoracic elevation device) should be used to improve neutral positioning for spine and airway (13).

Allowing a cooperative conscious patient to find his/her position of comfort may be appropriate, as realignment of the C-spine from torticollis to normal anatomical position may cause distress or discomfort. This is particularly true if immobilisation is causing distress or agitation. The muscle spasm resulting in torticollis may confer some protection of an underlying CSI. While active movements may be elicited to optimise imaging, an assessing doctor should not force passive realignment of torticollis in a conscious patient who has suffer significant blunt trauma: rather, a senior review should be sought (14).

**Thoracolumbar spinal injury**

Risk factors for thoracolumbar spinal injury include the following:

- High velocity MVA particularly if sash or harness restraint devices have not been worn
- Ejection from MVA
- High speed motor bike or bicycle collisions in which the patient has gone over his head prior to impact
- Multi-trauma victims with un-clear mechanism of injury and altered conscious state
- Abnormal focal neurology
- Localised thoracolumbar pain
- Patients with spinal injury at other levels.

These patients should be kept flat, with neutral positioning of the entire spine and log-rolling. Urinary catheterisation should be considered.

**Imaging: Plain films**

Recommended initial imaging comprises the standard three plain film views (antero-posterior, lateral and odontoid peg) where possible, due to the increased sensitivity of the three-series for detection of clinically-significant CSI, compared to fewer projections (15) (16). If the odontoid view is difficult to achieve, a focussed CT may be required in certain high risk patients after senior discussion. The high proportion (75%) of upper injuries in the younger age group, makes it worth obtaining where possible (15).

Since the collar must be removed for an open mouthed view, a high risk patient who cannot be relied upon to independently maintain safe positioning throughout imaging must have an attendant escort for this.
Imaging: CT/MRI

As described above, patients who sustained an injury via a high-risk mechanism, and those with persistent focal neurological abnormality or persistent pain or limitation of movement require review by an emergency physician and/or orthopaedic or spinal team involvement prior to cessation of immobilisation, even if initial imaging is unremarkable. Consideration must be given to the need for further imaging in this cohort as the sensitivity of the plain film series for the detection of CSI is only about 90% (16) and may be as low as 75% in younger children (17). Despite the limitation of plain x-rays, risk profiling by careful examination and eye-witness historical analysis of mechanism is essential prior to further radiation in order to avoid over-investigation and attendant radiation exposure.

If plain films are not normal, or are inadequate, immobilisation and attendant neutral positioning must continue. The combination of plain x-ray series and selective CT imaging with reconstructions increases identification of CSI to 94%. CT imaging is better for identifying bony injury, and MRI for identifying ligamentous and soft tissue injury, although subtle signs of injury may be present with both modalities (18, 19).

A targeted ‘fine cut’ cervical CT scan with reconstructed views is the investigation of choice for clarification of most concerns. MRI is preferred when there is consideration of SCIWORA (spinal cord injury without radiological abnormality), to provide further information about ligamentous structures in patients with possible unstable injuries, and to augment understanding of CSI risk in patients requiring prolonged (>48h) immobilisation in PICU.

Clearance:

The patient with normal imaging, without a high-risk mechanism of injury, and without any persistent altered mental status or focal neurological deficit or neck pain or torticollis, can be considered to have a clinically cleared cervical spine.

DISPOSITION

Unstable patients, patients with altered conscious state, and patients with specific focal neurological deficits suspicious of spinal cord injury are straight-forward in their ED management. They require admission with spinal immobilisation and spinal precautions and neutral handling until their situation changes to enable interactive assessment of function.

Patients who have been clinically cleared, with or without C-spine imaging, are considered at low risk of CSI and may be discharged with appropriate advice regarding analgesia and expected recovery. Practically speaking however, many children are slow to mobilise following blunt trauma, particularly if they have been transported with spinal injury precautions. In this group, removal of splinting, adoption of sitting posture where appropriate, simple analgesia, and gradual mobilisation is recommended, with repeat medical review including active range of motion prior to discharge.

Patients who have been assessed by the orthopaedic or spinal team may be discharged home for early outpatient review, with or without ongoing immobilisation, at the subspecialty team’s discretion.

Related documents

Policy and standard(s)

- NSQHS 8.5 Preventing Pressure Injuries
Definition of terms

<table>
<thead>
<tr>
<th>Term</th>
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<tbody>
<tr>
<td>C-spine</td>
<td>Cervical spine</td>
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<td>CSI</td>
<td>Cervical spine injury</td>
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<td>CCR</td>
<td>Canadian C-spine rules</td>
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<td>NEXUS</td>
<td>National emergency x-ray utilisation study</td>
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<td>MVA</td>
<td>Motor vehicle accident</td>
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<td>MOI</td>
<td>Mechanism of injury</td>
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<td>MOR</td>
<td>Moments of risk</td>
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<td>CT</td>
<td>Computerised tomography</td>
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<td>MRI</td>
<td>Magnetic resonance imaging</td>
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<tr>
<td>TED</td>
<td>Thoracic Elevation Device</td>
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Consultation

Key stakeholders who reviewed this version:

**PCSI Working Group:** Dr Robyn Brady, PEM Specialist MCH; Dr Natalie Phillips, PEM specialist RCH; Dr Geoff Askin, MCH Spinal Surgeon; Dr John Tuffley, Spinal Surgeon RCH; Dr Mark Walsh, Paediatric Radiologist MCH; Dr Umesh Shetty, Paediatric Radiologist RCH; Dr Jennifer Williams, PEM Fellow; Dr Katie Rasmussen, PEM Fellow; Dr Roy Kimble, Director, Paediatric Trauma Service, Queensland Health, Tona Gillen, Paediatric Trauma Coordinator; Gerard Duckworth, Chief Paediatric Radiographer, MCH; Tim Flanagan, Nurse Practitioner MCH; Lorelle Malyon, Nurse Educator RCH; Dr Jason Acworth, Director PEM Services QCH.

References and suggested reading

1. Brady RM. A 5 Year audit of cervical spine injuries admitted to Mater Children’s Hospital Qld. 2012.

Guideline revision and approval history

<table>
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<tr>
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Keywords
Cervical Spine Injury

Accreditation references
EQuiP National Standards: 8.5; 12

Appendix A – QPTS Cervical Spine Clearance Algorithm

Appendix B – MCH PICU Cervical Spine Clearance Protocol

Appendix C – Immobilisation and neutral positioning: The MOR strategy
Appendix A – Cervical Spine Clearance Algorithm

**STABLE PRIMARY SURVEY**

Any of:
1. High-risk MVA
2. Diving or other axial load
3. Conditions predisposing to CSI
4. Substantial torso injury
5. Altered mental status
6. Focal neurological deficit
7. Neck pain
8. Torticollis

**C-spine cleared**

- Continue immobilisation
- ED consultant +/- orthopaedic review (& discuss with spinal fellow)
- Consider further imaging (CT/MRI)
- Facet joint dislocation with abnormal neurological findings is a time-critical injury — urgent reduction for best neurological outcomes

**UNSTABLE PRIMARY SURVEY**

- Manage ABCD as per APLS
- IMMOBILISE (collar +/- sandbags) and
- THORACIC ELEVATION DEVICE (<10 years)
- C-Spine imaging

Any persistent:
1. Altered mental status
2. Focal neurological deficit
3. Neck pain
4. Torticollis

**NOT NORMAL**

- Continue immobilisation
- ED consultant +/- orthopaedic review (& discuss with spinal fellow)
- Consider further imaging (CT/MRI)
- Facet joint dislocation with abnormal neurological findings is a time-critical injury — urgent reduction for best neurological outcomes
Notes to accompany Paediatric Cervical Spine Clearance Algorithm

Definitions for risk factors for C-spine injury (CSI):

- **High-risk MVA** = head-on collision, rollover, ejected from vehicle, death in same crash, or speed >88kph
- **Diving or other axial load** = falling and landing head first from a height
- **Conditions predisposing to CSI** include Down syndrome, Klippel-Feil syndrome, achondrodysplasia, mucopolysaccharidosis, Ehlers-Danlos syndrome, Marfan syndrome, osteogenesis imperfecta, Larsen syndrome, juvenile rheumatoid arthritis, juvenile ankylosing spondylitis, renal osteodystrophy, rickets, history of CSI or cervical spine surgery
- **Substantial torso injury** = observable injuries that are life threatening, warrant surgical intervention, or warrant inpatient observation
- **Altered mental status** = GCS < 15 or AVPU < A or evidence of intoxication or other ALOC (e.g. disorientation, persistent anterograde amnesia, delayed or inappropriate response to external stimuli)
- **Focal neurological deficit** = paraesthesia, loss of sensation, motor weakness, or other neurologic finding consistent with spine injury (e.g. priapism)
- **Neck pain** = child >2 years complains of neck pain
- **Torticollis** = torticollis, or difficulty moving the neck noted in history or physical examination; if no other indications for imaging test rotation of neck, and proceed to immobilisation and imaging if unable to rotate to 45 degrees bilaterally

**Immobilisation:**

- Cervical collar (hard or soft) +/- sandbags
- Allow conscious patient to find position of comfort if torticollis occurs – do not attempt to realign C-spine to normal anatomical position if this causes increased distress or discomfort

**C-spine imaging:**

- X-ray series - lateral, AP and peg views (where possible) as initial screen
- If pre-existing condition the only trigger for imaging, senior review is mandated prior to imaging

**Patients not requiring imaging should have a period of observation:**

- Explain to patient and guardian that patient is very low risk for clinically significant C-spine injury
- Administer ibuprofen 10mg/kg + paracetamol 15mg/kg if no contraindications
- Prop patient up
- Soft collar optional
- Reassess pain and mobility 30-60 minutes later

**Continued immobilisation (>4h):**

- Soft or 2-piece collar for age >4months
- Cut-to-size soft collar for age <4months

**Urgent reduction:**

- Focal neurological deficit plus acute low velocity mechanism and facet joint dislocation requires urgent reduction (<4h) – contact spinal service immediately

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Mater PICU – Cervical Spine Clearance & Assessment

Any concern should necessitate early referral to specialist spinal team via MCH switchboard

Option 1: Clearance performed prior to PICU admission

Clear written documentation by DEM / Peripheral hospital detailing mechanism of injury, radiological and clinical findings with appropriate conclusion. In a patient who is not intubated, If inadequate replace collar

Option 2: Clearance performed by PICU medical staff

- Age >8
- Not intubated
- Normal plain films and CT if indicated
- Normal clinical examination
- Documented in PICIS by treating intensivist

Option 3: Clearance performed by Spinal team (all intubated patients)

- If age >8
  - Plain films – AP and lateral
  - PEG view if age >10
  - CT-C-spine if indicated
  - Dynamic views if 5-Byrs (performed by spinal fellow or consultant ONLY)
  - Documented Spinal Plan in PICIS

- If age ≤8
  - Plain films – AP and lateral
  - CT-C-spine
  - MRI if indicated

Developed by Dr Mark Hayden & Dr Geoff Askin: Date 01/01/2013
Appendix 3 - The MOR strategy for neutral positioning in possible cervical spine injury

MOR: Moments of Risk and Strategies for Neutral Positioning

**Transfers and log rolls:**
- PAT slide between same-level surfaces
- Attendant maintains neutral head/neck/spine positioning
- Slide onto TED if under 10 years

**Pain/agitation:**
- Provide early clinical “low risk” clearance in those without PECARN risk factors
- Replace stiff with appropriately fitting two-piece or soft collars
- Give early pain relief
- Position parent at head
- Consider propping up if conscious, normal neurology and low thoracolumbar risk
- Attendant to reassure and advise family re process

**Vomiting:**
- Prophylactic ondansetron where necessary
- Attendant or parent present and “nurse call” for log roll if required

**Imaging:**
- Attendant to accompany to xray if manual positioning required
- Attendant to ensure TED used appropriately
- Attendant to ensure CT head neck positioning maintains neutrality

**Intubation:**
- Specific attendant assigned to neck positioning during intubation

Unconscious/ Multi-trauma patients require MOR attention
- Soft or two piece collar or manual inline immobilisation AND lateral sandbags
- These children are higher risk and require a dedicated attendant and MOR attention to handling
- Document limb movements and sensory responses on arrival and prior to paralysis
- There is no such thing as radiological clearance: interactive assessment is required to confirm mobility and lack of pain. Specify in trauma chart that spine has NOT been cleared, and maintain neutral positioning.

Thoracic Elevation Device (TED): Recommended for neutral positioning under 10
- 33 cm W x 14cm L x 2.5cm H foam, wrapped in plastic to allow clean/re-use.
- Keep on or by resus trauma trolleys. Position the high end under neck as in picture
- Also may aid in positioning for intubation of infants.
MOR Immobilisation Strategies
Stiff neck collars should be replaced by soft or two-piece devices for immobilisation in hospital.

3yo in 2-piece “infant” Philadelphia collar:
• Measure around neck and from chin to sternal angle, and identify appropriate collar
• While attendant maintains neutral positioning, remove existing collar and slip back form in place between occiput and upper back
• Slip front component under chin and attach to back with velcro
Support can be obtained from Orthotics during hours

Alternative 1: Soft collar cut to size
Cut along the lower edge of a small soft collar at base of velcro pad matching the chin scallop and fit snugly under chin as in this child with stable AARS being discharged for spinal clinic review.

Alternative 2: Unconscious or severely injured young children may be maintained and imaged in a vacuum splint with careful head neck positioning.

If an immobilisation device is not tolerated and is leading to agitation, a conscious infant can be left to find their own best neck position, for example, in a parent’s arms.