

Technical Report Chapter 1: Diagnosis

**Australian Clinical Guidelines for
Health Professionals Managing
People with Whiplash-Associated
Disorders, Fourth Edition**

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2. Abbreviations

CCR = Canadian C-spine Rule

CT = Computed Tomography

ED = Emergency Department

GRADE = Grading of Recommendations, Assessment, Development, and Evaluations

HCP = healthcare professional

MRI = Magnetic Resonance Imaging

MVC = motor vehicle collision

NEXUS = National Emergency X-Radiography Utilization Study

NHMRC = National Health and Medical Research Council

NRS = Numeric Rating Scale

PHCP = Primary Healthcare Professionals

QUADAS = Quality Assessment of Diagnostic Accuracy Studies

ROM = Range of Motion

WAD = whiplash-associated disorders

3. Abstract

Background: Whiplash-associated-disorders (WAD) are the most common outcome for Australians involved in non-catastrophic motor vehicle collisions (MVC), where half have persisting problems. Despite three iterations of Australian acute whiplash guidelines, implementation of evidence-based care can be inconsistent and little guidance has been provided on managing people with chronic WAD.

Objective: The objective of these evidence reviews, and recommendation development procedures was to develop new multidisciplinary guidelines for the management of people with acute and chronic WAD.

Methods: A multidisciplinary panel (n=18) was convened comprising key stakeholders. Diagnostic studies involving screening for cervical fracture (WAD grade IV) and cervical radiculopathy (WAD grade III) were searched for by systematic review and those included in the previous Australian guidelines. The panel prioritised three clinical questions related to screening for WAD IV and WAD III (cervical radiculopathy) based on the literature and current practice. The Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) Evidence to Decision Framework was used to develop recommendations. Where there was no evidence for people with whiplash injury for a given clinical question, relevant literature for similar conditions was evaluated (e.g., systematic reviews). Implementation considerations for each treatment were developed in accordance with the included studies (e.g., screening method) and input from the guideline panel (e.g., subject matter experts, healthcare professionals, consumers).

Results: No diagnostic studies were identified by systematic review that were specific to a population with WAD. The panel decided to use two relevant systematic reviews and one observational study following a general literature search and consultation with researchers to inform these recommendations. A strong recommendation was made for the Canadian C-spine to screen for cervical fracture (WAD IV) in people with acute WAD. A conditional recommendation was made for performing a neurological examination involving several assessments to screen for cervical radiculopathy (WAD grade III): interview (arm pain>neck pain, paraesthesia/numbness),

assessment of neurological signs (sensory deficit – dermatomal abnormality, muscle weakness, reduced reflexes), and relief signs (hand in pocket, shoulder abduction relief test). A panel consensus recommendation was made for when to refer those with suspected cervical persistent radiculopathy for magnetic resonance imaging (MRI) which included fulfillment of the following criteria: presence of subjective signs, two or more neurological abnormalities present, and no improvement following a period of conservative treatment.

Conclusions: The use of Canadian C-spine rule to screen for cervical fracture (WAD IV) is strongly recommended as a clinical tool, is consistent with current practice in Australia, and can reduce unnecessary imaging compared with another assessment (NEXUS). If clinically indicated, healthcare professionals should undertake a neurological examination comprising the recommended assessments to screen for cervical radiculopathy and, if positive, reassess the signs after a period of conservative treatment. Guidance on indication for imaging referral to determine probable diagnosis of cervical radiculopathy is also detailed in this report.

4. Suggested citation

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5. Introduction

Whiplash-associated-disorders are the most common injury for the ~2.6 million Australians involved in a non-catastrophic MVC and are characterised by symptoms following whiplash trauma to the neck (MAA, 2009). Whilst half of those Australians injured should see rapid recovery following a MVC, the clinical course is not so clear for the remaining 50% who may develop chronic pain, disability, psychological disorders (e.g., posttraumatic stress, depression, and anxiety) and continue to report long-term interference in daily life (Campbell et al., 2018; Sterling et al., 2010).

The 2014 NSW SIRA “Guidelines for the Management of Acute Whiplash Associated Disorders for Health Professionals” (SIRA, 2014) covers management of people with WAD in the first 12 weeks following an MVC. The 2008 Trauma and Injury Recovery “Clinical Guidelines for Best Practice Management of Acute and Chronic Whiplash-Associated Disorders” (TRACsa, 2008) provides some guidance on management of people with chronic WAD. However, a considerable number of studies have been published since these two guidelines, and at present, the acute guidelines are mostly used across Australia. As per the Australian National Health and Medical Research Council (NHMRC) Standards for Guidelines, recommendations within clinical guidelines need to be based on current evidence to ensure ongoing relevance and reliability. There is a need for systematic review and collation of current evidence to update the existing Australian WAD guidelines and bridge the gap between research and clinical practice. Since the previous guidelines the GRADE process for evaluating certainty of evidence and developing recommendations is being increasingly used and is now a requirement of new Australian guidelines. The overall aim of developing these guidelines is to improve health and social outcomes of people with acute and chronic WAD by providing best practice recommendations for health professionals managing these people. This technical report details the evidence review and guideline recommendation procedures for the screening of cervical fracture and radiculopathy in people acute and chronic WAD.

6. Contents

1.	Authors	2
2.	Abbreviations	2
3.	Abstract.....	2
4.	Suggested citation.....	3
5.	Introduction	3
6.	Contents	4
7.	Technical Report Chapter 1: Diagnosis of acute and chronic whiplash-associated disorders.....	5
7.1.	Review of evidence.....	5
7.1.1.	Objectives.....	5
7.1.2.	Systematic review	5
7.1.3.	Search strategy	5
7.1.4.	Absence of evidence procedures.....	6
7.1.5.	Inclusion criteria.....	6
7.1.6.	Selection of clinical questions.....	7
7.1.7.	Risk of bias.....	7
7.1.8.	Data extraction and evidence synthesis	7
7.1.9.	Certainty of evidence	8
7.2.	Recommendation development	8
7.3.	Method limitations	9
8.	Diagnosis.....	11
D.1.	Clinical examination rule to screen for whiplash cervical fracture	11
D.1.1.	Executive summary	11
D.1.2.	GRADE certainty of evidence summary	16
D.1.3.	Conclusions (clinical rule to screen for whiplash cervical fracture).....	23
D.2.	Diagnosis: Neurological examination to screen for cervical radiculopathy (WAD III).....	26
D.2.1.	Executive summary	26
D.2.2.	GRADE certainty of evidence summary	29
D.2.3.	Conclusions (neurological examination assessments to screen for cervical radiculopathy).....	38
D.2.4.	Conclusions (when to refer people with suspected radiculopathy for imaging).....	40
9.	References.....	43
10.	List of tables.....	46

7. Technical Report Chapter 1: Diagnosis of acute and chronic whiplash-associated disorders

7.1. Review of evidence

7.1.1. Objectives

Objectives of this systematic review and recommendation development procedures were to identify clinical examination rules to assist primary health care professionals (HCPs) in diagnosing WAD grade IV (fracture) or WAD grade III (neurological injury/cervical radiculopathy). The following clinical questions were addressed: i) What clinical examination rule is most accurate to screen for whiplash cervical fracture (WAD IV) in people with acute WAD? ii) What neurological examination assessments should healthcare professionals use to screen for cervical radiculopathy (WAD III) in people with acute WAD? iii) When should healthcare professionals refer people with acute WAD and evidence of cervical radiculopathy from neurological examination for imaging?

7.1.2. Systematic review

Systematic review methods used in the 2014 NSW SIRA “Guidelines for the Management of Acute Whiplash Associated Disorders for Health Professionals” (SIRA, 2014) and 2008 Trauma and Injury Recovery “Clinical Guidelines for Best Practice Management of Acute and Chronic Whiplash-Associated Disorders” (TRACsa, 2008) were adapted for this review to ensure a consistent methodological approach and synthesis of current evidence with that of the existing guidelines.

7.1.3. Search strategy

Database searches were performed specific to the population group (whiplash injury) and study design criterion (observational studies), as per the Assessment systematic review procedures (see Assessment chapter). A single search strategy was used to capture original research articles pertaining to assessment and or diagnostic section for acute or chronic WAD. The search strategy was developed in the Ovid Medline database (Table 1) and adapted for database specific medical subject headings.

Table 1: Management of whiplash associated disorders database search strategy

Characteristics	Search strategy
Whiplash injury	<ol style="list-style-type: none"> 1. whiplash* 2. whiplash injuries/ 3. neck pain* adj4 whiplash 4. neck injur* adj4 whiplash 5. traumatic neck injur* 6. traumatic neck pain*
Assessment	<ol style="list-style-type: none"> 7. diagnosis/ 8. diagnosis*. mp. 9. assessment*.mp. 10. evaluation study/ 11. evaluat*.mp. 12. analy*.mp.
Whiplash injury And Assessment	1 OR 2 OR 3 OR 4 OR 5 OR 6 AND 7 OR 8 OR 9 OR 10 OR 11 OR 12
Subclassification	Sub?classif* Sub?group*
Filters	Publication date: 2007-current

/ = medical subject heading; * = truncation of keyword; adj4 = adjunct within 4 words keyword; mp. = multi-purpose

Searches were performed using eight electronic databases covering the period of 2007 to 1 June 2022: Allied and Complementary Medicine Database (Amed), CINAHL, Cochrane (Systematic Reviews Database), Embase, Medline, PsycINFO, and Web of Science Core Collection. Articles were screened for eligibility using the online software Covidence (Covidence.org: Melbourne, Australia). Diagnostic studies included in the previous Australian guidelines were identified. Reference lists of review articles that were specific to whiplash injury were screened.

7.1.4. Absence of evidence procedures

Our search strategy did not identify studies evaluating the diagnostic accuracy of clinical examination tools available for primary HCPs to screen for possible cervical fracture. To our knowledge no studies of this type have focussed specifically on whiplash injury. Studies that have evaluated the accuracy of clinical examination tools for cervical fractures are based on mixed injury mechanisms to the cervical spine such as MVC or blunt trauma. As a result, a general literature search for appropriate systematic reviews was performed and a Cochrane systematic review comparing the Canadian C-spine rule and NEXUS was identified (Nitzsche et al., 2020). The abstract stated that an additional 9 studies had been identified since the 2012 review on the same topic (Michaleff et al., 2012). The research team contacted the authors of the Cochrane review who noted that the review is ongoing. From the preliminary results (N=15 studies) the authors concluded that the diagnostic accuracy of Canadian C-spine rule appears to be greater compared to NEXUS. However, these results were consistent with the studies included in the 2012 review and therefore the panel agreed to use the 2012 review (Michaleff et al., 2012) to inform our recommendation. The review evaluated the accuracy of the Canadian C-spine rule and NEXUS to screen for clinically important cervical spine injury (fracture).

To our knowledge there are no studies that have focussed on evaluating the accuracy of neurological examination assessments for detecting cervical radiculopathy in people with WAD. A general literature search for appropriate systematic reviews identified a systematic review that evaluated the diagnostic value of a person’s history and physical tests in diagnosing cervical radiculopathy (Thoomes et al., 2018). Further, the research team identified a cross-sectional study that evaluated the diagnostic accuracy of peoples interview items and other assessments for diagnosis of cervical radiculopathy published after the systematic review (Sleijser-Koehorst et al., 2021). The guideline panel agreed to use these studies to inform the recommendation for these clinical questions. It is to be noted that there is no gold standard for diagnosing cervical radiculopathy and caution is advised when interpreting diagnostic accuracy values of physical assessments (Sleijser-Koehorst et al., 2021). A combination of results from several assessments and consistency with the person’s history is likely to be the most effective method when screening for cervical radiculopathy (Sleijser-Koehorst et al., 2021; Thoomes et al., 2018). In conjunction with positive neurological signs and a person’s history, imaging (MRI) of the cervical region can be used to diagnose probable cervical radiculopathy (e.g., evidence of foraminal stenosis matching the person’s clinical presentation).

7.1.5. Inclusion criteria

Table 2 details the inclusion criteria for diagnosis studies related to clinical assessment techniques and/or examination rules to screen for WAD grade IV (cervical fracture) and WAD grade III (cervical radiculopathy).

Table 2: Inclusion criteria for whiplash associated disorders (grade III or IV) diagnosis studies

Characteristics	Inclusion criteria
Population	<ul style="list-style-type: none"> Human study Participants were of driving age ≥ 16 years. Motor vehicle accident resulting in WAD grade I-III (Spitzer, 1995). Study includes an identifiable and separately analysed subgroup of people suffering from whiplash, that comprise $\geq 50\%$ of the total sample size.
Study design	<ul style="list-style-type: none"> Observational studies. Participants with acute WAD.

	<ul style="list-style-type: none"> • Study includes an identifiable and separately analysed subgroup of participants suffering from whiplash. • Available in English.
Index test	<ul style="list-style-type: none"> • Clinical assessment techniques and/or examination rules that were used to screen for: <ul style="list-style-type: none"> ○ Cervical fracture (WAD grade IV). OR ○ Cervical radiculopathy (WAD grade III).
Reference standard	<ul style="list-style-type: none"> • Imaging techniques (e.g., MRI or CT) that were used to diagnose: <ul style="list-style-type: none"> ○ Cervical fracture (WAD grade IV). OR ○ Probable cervical radiculopathy (WAD grade III).
Outcomes	<ul style="list-style-type: none"> • Diagnostic accuracy statistics (e.g., sensitivity and specificity outcomes).

7.1.6. Selection of clinical questions

Diagnosis clinical questions were developed in accordance with recommendations presented in the previous Australian whiplash guidelines and for consistency with clinical practice. The research team developed questions that may be relevant to an Australian context, which were agreed upon by the guideline panel (Table 3). These questions were underpinned by the aim of reducing unnecessary imaging and the possible adverse effects and costs associated with imaging when the condition is not present.

Table 3: Clinical questions related to the diagnosis of whiplash-associated disorders

Diagnosis (Whiplash grade)	Clinical question
Fracture (IV)	What clinical examination rule (Canadian C-spine rule vs NEXUS) is most accurate to screen for whiplash cervical fracture (WAD IV) in people with acute WAD?
Cervical radiculopathy (III)	What neurological examination assessments should healthcare professionals use to screen for cervical radiculopathy (WAD III) in people with acute WAD?
Cervical radiculopathy (III)	When should health care professionals refer people with acute WAD and evidence of cervical radiculopathy from neurological examination for imaging?

7.1.7. Risk of bias

The 11-item Quality Assessment of Diagnostic Accuracy Studies (QUADAS) criteria (Whiting et al., 2003) was used by Michaleff et al. (2012) to evaluate risk of bias in the included studies for cervical fracture. The revised version, QUADAS-2 (Whiting et al., 2011) was used by Thoomes et al. (2018) to evaluate risk of bias in the included neurological examination studies for cervical radiculopathy. These scores were used for our assessment of risk of bias when determining the certainty of diagnostic accuracy.

7.1.8. Data extraction and evidence synthesis

Data was extracted in the same table layouts as those presented in Michaleff et al. (2012) for WAD IV and (Thoomes et al., 2018) and the inclusion of (Sleijser-Koehorst et al., 2021) for WAD IV (radiculopathy) by two members of the research team. The following study information was extracted from those studies tables: first-author, year of publication, number of participants,

%male (for Michaleff et al. 2012), index test(s) and reference standard, true positive, false positive, true negative, sensitivity, and specificity outcomes.

7.1.9. Certainty of evidence

The GRADE method (Guyatt et al., 2008) was used to evaluate the certainty of evidence for the diagnostic accuracy of the Canadian C-spine rule and NEXUS for WAD IV, and the Spurling test and upper limb neural tension test for WAD III. The certainty rating (very low, low, moderate, high) provided an indication of the likelihood that the estimated accuracy was close to that of the true accuracy and was used to inform recommendations.

Evidence certainty was evaluated against each of the four primary GRADE domains:

1. Risk of bias: based on the risk of bias evaluation using the QUADAS/QUADAS-2 scales for included studies and considering the weighting of each study (sample size) to the summarised diagnostic accuracy.
2. Inconsistency: extent of heterogeneity in the study findings as evaluated by visual inspection of the treatment effects and confidence intervals for narrative summaries, and/or heterogeneity statistics for meta-analyses.
3. Indirectness: extent to which the included studies were applicable to the clinical question (e.g., population characteristics and index test) and an Australian healthcare context.
4. Imprecision: i) whether there was optimal information size (>300 events for dichotomous outcomes; presence of the condition); ii) by considering the position of the estimated effect and width of confidence intervals with respect to the clinical decision threshold. Diagnostic accuracies of 0.5 - <0.70, 0.70 - <0.90, and ≥ 0.90 were indicative of low, moderate, and high predictive ability (Fischer et al., 2003). A clinical decision threshold of 0.9 (high predictive ability) was set for detecting cervical fracture and 0.70 (moderate predictive ability) for detecting cervical radiculopathy. A higher threshold is required for cervical fracture compared with radiculopathy due to the possible significant adverse effects if not managed.

7.2. Recommendation development

For the first two clinical questions, an evidence summary and draft GRADE Evidence to Decision Framework (Alonso-Coello et al., 2016) was provided to the guideline panel for review prior to meeting, consistent with the format detailed in this technical report. A recommendation development meeting for this section was held during a face-to-face workshop and simultaneously in Microsoft Teams for those who could not attend physically. A short verbal summary explaining findings from the evidence synthesis was provided in a language appropriate for all panel members. The GRADE Evidence to Decision Framework was used to discuss and develop diagnosis recommendations. Diagnostic accuracy (sensitivity and specificity), possible adverse effects, and certainty of this evidence were considered as critical outcomes when developing these recommendations. Resources, equity, acceptability, and feasibility framework elements received input from healthcare professionals, consumers, and insurers on the guideline panel. There were limited cost-effectiveness evaluations for these clinical examination rules. However, sensitivity outcomes can be used to inform cost-effectiveness, as false positives lead to unnecessary imaging and significant costs associated with it. For when HCP should refer a person for imaging (reference standard), the clinical question was informed by evidence presented in the framework for WAD III. A panel consensus recommendation was developed by considering the evidence presented, prevalence of cervical radiculopathy in people with WAD, possible adverse effects associated with imaging, and input from experts and consumers on the panel.

Following review and panel agreement on content presented in the framework (the panel was asked to comment on each item in the framework) an anonymous online voting system (Menti.com) was used by the panel to reach consensus on a recommendation classification. Recommendation classifications and their interpretations are outlined in 4.

More than 50% of votes were required to reach consensus, with a quorum of eight panel members. However, 50% was not considered sufficient to be a consensus if there is strong opposition to the result. If there is no clear consensus after the first vote, the working group would critically discuss the outcome and rationale before proceeding to a second vote. Where a consensus cannot be reached, the Chair could choose to have the casting vote.

Table 4: Diagnosis recommendation classifications and their interpretation

Recommendation classification	Interpretation
Strong for	<p>Healthcare professionals should use the (rule or assessment) in all or almost all people, in all or almost all circumstances to screen for (cervical fracture/radiculopathy), in accordance with the implementation considerations.</p> <p>“The guideline panel strongly recommend that healthcare professionals use (rule or assessment) to screen for (cervical fracture/radiculopathy) in people with acute WAD”</p>
Conditional for	<p>Healthcare professionals should use the (rule or assessment) in most people, but not all, to screen for (cervical fracture/radiculopathy) in accordance with the implementation considerations.</p> <p>“The guideline panel suggests that healthcare professionals use (rule or assessment) to screen for (cervical fracture/radiculopathy) in people with acute WAD”</p>
Neutral	<p>Neither for nor against using the (rule or assessment). Healthcare professionals could use (rule or assessment) to screen for (cervical fracture/radiculopathy) in some instances, in accordance with the implementation considerations.</p> <p>“The guideline panel cannot recommend for or against the (rule or assessment) to screen for (cervical fracture/radiculopathy) in people with acute WAD”</p>
Conditional against	<p>Healthcare professionals should <u>not</u> use the (rule or assessment) to screen for (cervical fracture/radiculopathy) in most people.</p> <p>“The guideline panel suggest that healthcare professionals do not use (rule or assessment) to screen for (cervical fracture/radiculopathy) in people with acute WAD”</p>
Strong against	<p>Healthcare professionals should <u>not</u> use the (rule or assessment) to screen for (cervical fracture/radiculopathy) in all or almost all people in all or almost all circumstances.</p> <p>“The guideline panel strongly recommend that healthcare professionals do not use (rule or assessment) to screen for (cervical fracture/radiculopathy) in people with acute WAD”</p>

Clinical implementation considerations were developed for all recommendations. These considerations were informed by the literature presented in the evidence summary (e.g., index test, clinical presentation features of the participants) and from input by the guideline panel (e.g., subject matter experts, healthcare professionals, consumers).

7.3. Method limitations

The evidence synthesis and recommendation development procedures are potentially limited by the following factors:

- Our systematic review was not sensitive for identifying clinical examination rules and assessments to screen for cervical fracture or radiculopathy. Systematic reviews were used as evidence to inform our recommendations. However, the recommended Canadian C-Spine rule is

consistent with the previous guidelines and current practice in Australia, and there is high certainty in the evidence for near perfect sensitivity.

- There is an ongoing Cochrane systematic review which identified 9 additional studies comparing the Canadian C-spine rule and NEXUS to screen for cervical fracture. However, their current results are identical to the systematic review we have included in this guideline, as they have not yet analysed the additional studies. As noted above, the C-spine rule is highly sensitive and consistent with Australian practice.
- There is no gold reference standard for diagnosing cervical radiculopathy and caution is advised when interpreting diagnostic accuracy values of physical assessments (Sleijser-Koehorst et al., 2021). We have taken a pragmatic approach to recommending a combination of neurological examinations that are unlikely to exacerbate symptoms and have provided a criterion for detecting possible cervical radiculopathy.
- Risk of bias outcomes were extracted from the systematic reviews and not conducted by the research team. Based on these outcomes, risk of bias was rated as serious for all GRADE certainty ratings.

8. Diagnosis

D.1. Clinical examination rule to screen for whiplash cervical fracture

What clinical examination rule (Canadian C-spine rule vs NEXUS) is most accurate to screen for whiplash cervical fracture (WAD IV) in people with acute WAD?

D.1.1. Executive summary

Two clinical examination rules are available to primary healthcare professionals (PHCPs) when screening for possible cervical fracture following whiplash injury: i) Canadian C-spine rule; ii) National Emergency X-Radiography Utilization Study (NEXUS) criteria. The gold standard for diagnosing cervical fracture following injury is by imaging methods (e.g., radiography or computed tomography). However, clinical examination rules can minimise unnecessary medical assessment and potential negative effects associated with imaging and reduce overall economic burden related to managing people with WAD. A systematic review (Michaleff et al., 2012) compared accuracy of the Canadian C-spine rule and NEXUS (N=15 studies) to screen for cervical fracture following injury (mechanism of injury varied across studies; 9 studies included a proportion of participants who has sustained a motor vehicle collision), which was used to inform the recommendation for this clinical question.

It is to be noted that an updated Cochrane systematic review comparing the Canadian C-spine rule and NEXUS is currently being performed by Nitzsche et al. (2020), which has identified an additional 9 studies since the 2012 review. From the preliminary results (N=15 studies) the authors conclude that the diagnostic accuracy of Canadian C-spine rule appears to be greater compared to NEXUS. However, these results are consistent with the studies included in the 2012 review and therefore the panel agreed to use the 2012 review to inform our recommendation. The research team have contacted the authors of the Cochrane review (Nitzsche et al., 2020) who have noted that the review is ongoing.

Table 5: Summary of included studies (as reported in the study by Michaleff et al., 2012)

First Author, Year	Number of participants	% Male	Index test	Reference standard (% of people who received it)
(Hoffman et al., 2000)	34 069	64.8	Index: NEXUS • Assessors: emergency physician • Training: yes	Radiography: minimum 3 views; additional views/investigations ordered at the discretion of treating physician (100)
(Stiell et al., 2001)	8 924	51.5	• Index: Canadian C-spine rule • Assessors: emergency physicians, supervised residents • Training: yes	Radiography ordered at the discretion of the treating physician (68.9) 14-day proxy (31.1)
(Stiell et al., 2003)	8 283	52.3	• Index: Canadian C-spine rule and NEXUS • Assessors: resident emergency medicine physicians • Training: yes	Radiography ordered at the discretion of the treating physician (71.7) 14-day proxy (28.2)
(Dickinson et al., 2004)	8 924	51.5	Index: 5 NEXUS items approximated from 20-items collected prospectively • Assessors: emergency physicians, supervised residents • Training: yes	Radiography and computed tomography ordered at the discretion of the treating physician (68.9) 14-day proxy (31.1)
(Miller et al., 2006)	460	NR	• Index: Canadian C-spine rule for immobilization • Assessors: nursing staff all grades • Training: yes	Radiography ordered at the discretion of the treating physician (45) 14-day proxy, no. not reported 21-day surveillance, no. not reported
(Rethnam et al., 2008)	114	NR	• Index: Canadian C-spine rule • Assessors: retrospective application of Canadian C-spine rule • Training: NR	Only people who had cervical spine radiographs were included.
(Mahler et al., 2009)	202	NR	• Index: 4 NEXUS items and clinical sobriety assessment tool (7 questions) • Assessors: emergency physicians • Training: NR	All people underwent computed tomography (100)
(Stiell et al., 2009)	3 628	3 628	• Index: Canadian C-spine rule • Assessors: emergency physicians. • Training: yes	Radiography ordered at the discretion of the treating physician (53.3) 30-day surveillance of ED and neurosurgical centres

(Vaillancourt et al., 2009)	2 393	2 393	<ul style="list-style-type: none"> • Index: Canadian C-spine rule revised for paramedics† • Assessors: paramedics • Training: yes 	Radiography ordered at the discretion of the treating physician (52.9) 14-day proxy (28.5)
(Coffey et al., 2011)	1 420	1 420	<ul style="list-style-type: none"> • Index: Canadian C-spine rule • Assessor: emergency physicians of all grades • Training: yes 	Radiography ordered at the discretion of the treating physician (69.5) 14-day proxy (18)
(Stiell et al., 2010)	3 633	3 633	<ul style="list-style-type: none"> • Index: Canadian C-spine rule for immobilization • Assessors: experienced nurses in emergency department • Training: yes 	Radiography ordered at the discretion of the treating physician (47.2) 30-day surveillance of ED and neurosurgical centres
(Duane, Wilson, et al., 2011)	3 201	3 201	<ul style="list-style-type: none"> • Index: approximation of Canadian C-spine rule (minus rotation) • Assessors: residents • Training: yes‡ 	All people underwent computed tomography (100)
(Duane, Mayglothling, et al., 2011)	2 606	2 606	<ul style="list-style-type: none"> • Index: NEXUS • Assessors: residents • Training: yes‡ 	All people underwent computed tomography (100)
(Griffith et al., 2011)	1 589	1 589	<ul style="list-style-type: none"> • Index: NEXUS • Assessors: 2nd and 3rd year radiology students • Training: evaluation of clinical records 	Only people who underwent cervical spine computed tomography were included
(Migliore et al., 2011)	80	NR	<ul style="list-style-type: none"> • Index: NEXUS • Assessors: physicians, residents • Training: NR 	Radiography or computed tomography (75)

Table 6: Sensitivity and specificity of the Canadian C-spine rule (CCR) and National Emergency X-radiography Utilization Study (NEXUS) criteria (as reported in the study by Michaleff et al., 2012)

Index test / author year	true positive	false positive	false negative	true negative	Sensitivity	Specificity
Canadian C-spine rule						
Stiell 2001	151	5041	0	3732	1 (0.98–1.00)	0.43 (0.42–0.44)
Stiell 2003	161	3995	1	3281	0.99 (0.97–1.00)	0.45 (0.44–0.46)
Miller 2006	3	214	0	227	1 (0.29–1.00)	0.51 (0.47–0.56)
Rethnam 2008	2	26	0	86	1 (0.16–1.00)	0.77 (0.68–0.84)
Stiell 2009	23	0	0	0	1 (0.85–1.00)	Not estimable
Vaillancourt 2009	12	1204	0	731	1 (0.74–1.00)	0.38 (0.36–0.40)
Coffey 2010	8	701	0	509	1 (0.63–1.00)	0.42 (0.39–0.45)
Stiell 2010	37	1958	4	1535	0.9 (0.77–0.97)	0.44 (0.42–0.46)
Duane 2011	192	2991	0	18	1 (0.98–1.00)	0.01 (0.00–0.01)
NEXUS						
Hoffman 2000	576	29184	2	4307	1 (0.99–1.00)	0.13 (0.13–0.13)
Stiell 2003	147	4599	15	2677	0.91(0.85–0.95)	0.37 (0.36–0.38)
Dickinson 2004	140	5461	11	3312	0.93 (0.87–0.96)	0.38 (0.37–0.39)
Mahler 2009	3	115	0	84	1 (0.29–1.00)	0.42 (0.35–0.49)
Duane 2011	130	1331	27	1118	0.83 (0.76–0.88)	0.46 (0.44–0.48)
Griffith 2011	37	1160	4	364	0.9 (0.77–0.97)	0.24 (0.22–0.26)
Migliore 2011	1	46	0	14	1 (0.03–1.00)	0.23 (0.13–0.36)
Direct comparison						
Stiell 2003 (C-spine)	161	3995	1	3281	0.99 (0.97–1.00)	0.45 (0.44–0.46)
Stiell 2003 (NEXUS)	147	4599	15	2677	0.91 (0.85–0.95)	0.37 (0.36–0.38)

Summary: For the Canadian C-spine rule, sensitivity ranged from 0.90 to 1.00 and specificity ranged from 0.01 to 0.77. For NEXUS, sensitivity ranged from 0.83 to 1.00 and specificity ranged from 0.02 to 0.46.

Table 7: Additional studies identified from the Assessment section systematic review

First Author, Year	Aim	Study Population	Results	Comments
(Athinartrattanapong et al., 2021)* (Derivation study) Prediction Score for Cervical Spine Fracture in people with Traumatic Neck Injury	Develop a clinical tool to identify people who must undergo a computed tomography scan to evaluate cervical spine fracture in a noncomputed tomography scan available hospital	375 people with suspected C-spine injury underwent CT scan in the ED	Clinical prediction score in identifying positive results (C-spine fracture) based on the CT scan The AUROC curve (82.52% (95% CI: 74.02–91.01)) The clinical prediction scores for C-spine fracture are divided into three categories: scores of 0, low probability; scores of 1–5, moderate probability; and scores of 6–11, high probability. The LRs for a positive C-spine fracture on CT scan was 0.18 (95% CI: 0.05–0.56) in the low probability category, 1.46 (95% CI: 1.09–1.96) in the moderate probability category, and 7.16 (95% CI: 2.82–18.19) in the high probability category.	A clinical prediction score ≥ 1 was associated with a spine fracture. People under the moderate and high probability categories in non-CT scan available hospitals should be sent for a CT scan to evaluate C-spine fracture.
(Bandiera et al., 2003) The Canadian C-spine rule performs better than unstructured healthcare professional judgement	Compare Canadian C-spine rule with healthcare professional judgement	6265 people reporting to ED with neck pain or trauma above the clavicle.	C-spine rule was 100% sensitive (95%CI 98%-100%) vs 92.2% (95%CI 82%-96%) for unstructured physician judgement ($p<0.001$) and 44% specific vs 54% ($p<0.001$) in detecting 64 people with significant neck injury (clinically important fracture)	Highly sensitive clinical decision rule for X-ray of cervical spine.

*Not considered in the evidence to decision framework for this PICO as the clinical tool is based on a derivation study only and requires further validation.

D.1.2. GRADE certainty of evidence summary

Canadian C-spine rule

Table 8: GRADE certainty of evidence summary (Canadian C-spine rule)

Outcome	N° of studies (N° of people)	Study design	Factors that may decrease certainty of evidence					Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Additional	
True positives (people with cervical fracture = 589)	9 studies 594 people	cohort & case-control type studies	serious ^a	not serious	not serious	not serious	very strong association ^b	Sensitivity ⊕⊕⊕⊕ High
False negatives (people incorrectly classified as not having cervical fracture = 5)								
True negatives (people without cervical fracture = 16130)	9 studies 26249 people	cohort & case-control type studies	serious ^a	not serious	not serious	not serious ^c	n/a	Specificity ⊕⊕⊕⊕ High
False positives (people incorrectly classified as having cervical fracture = 10119)								

^aPrevalent selection and clinical review bias across included studies.

^bVery-large magnitude of association (near perfect sensitivity).

^cSpecificity was not rated down from high certainty due to risk of bias being considered serious, as precision was high: overall number of participants was large and confidence intervals for specificity were narrow.

NEXUS

Table 9: GRADE certainty of evidence summary (NEXUS)

Outcome	N° of studies (N° of people)	Study design	Factors that may decrease certainty of evidence					Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Additional	
True positives (people with cervical fracture = 1034)	7 studies 1093 people	cohort & case-control type studies	serious ^a	not serious	not serious	not serious	strong association ^b	Sensitivity ⊕⊕⊕⊕ High
False negatives (people incorrectly classified as not having cervical fracture = 59)								
True negatives (people without cervical fracture = 41896)	7 studies 1093 people	cohort & case-control type studies	serious ^a	not serious	not serious	not serious ^c	n/a	Specificity ⊕⊕⊕⊕ High
False positives (people incorrectly classified as having cervical fracture = 11876)								

^aPrevalent selection and clinical review bias across included studies.

^bLarge magnitude of association (near perfect sensitivity).

^cSpecificity was not rated down from high certainty due to risk of bias being considered serious, as precision was high: overall number of participants was large and confidence intervals for specificity were narrow.

Table 10: Evidence to decision framework for clinical examination rules to screen for cervical fracture (acute WAD)

Test accuracy How accurate is the test?		
Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Very inaccurate ○ Inaccurate ○ Accurate ● Very accurate ○ Varies ○ Don't know 	<ul style="list-style-type: none"> ○ Canadian C spine rule (N=9 studies): highly sensitive (range 0.90 to 1.00), specificity ranged from 0.01 to 0.77. ○ NEXUS criteria (N=7 studies): highly sensitive (range 0.83 to 1.00), specificity ranged from 0.02 to 0.46. <p>Sensitivity analysis of four included studies in the systematic review found that the Canadian C-spine rule is highly sensitive (range 0.99–1.00) and significantly reduced the specificity range (range 0.42–0.45) when compared with NEXUS (Michaleff 2012).</p> <p>A single study (Stiell 2003) performed a direct comparison between the two rules and found significantly greater diagnostic accuracy in the Canadian C-spine rule compared with NEXUS.</p> <p>The Canadian C-spine rule was 100% sensitive (95%CI 98%–100%) vs 92.2% (95%CI 82%–96%) for unstructured physician judgement ($p < 0.001$) and 44% specific vs 54% ($p < 0.001$), respectively (Bandiera 2003).</p>	<p>The Canadian C-spine rule is currently recommended in the previous Australian guidelines over NEXUS based on these data.</p> <p>The lower bound for the specificity range for the Canadian C-spine rule was based on a single study (Duane 2012), while the remaining 8 studies showed a consistent trend for higher specificity than NEXUS.</p>
Desirable Effects How substantial are the desirable anticipated effects?		
Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Trivial ○ Small ○ Moderate ● Large ○ Varies ○ Don't know 	<p>Sensitivity analysis of four included studies in the systematic review found that the Canadian C-spine rule is highly sensitive (range 0.99–1.00) for determining cervical fracture and avoids a greater proportion of unnecessary imaging compared with NEXUS.</p>	<p>Large significant undesirable effects can occur if cervical fracture is not detected.</p>
Undesirable Effects How substantial are the undesirable anticipated effects?		

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Large ○ Moderate ○ Small ● Trivial ○ Varies ○ Don't know 	No undesirable effects are reported from administering the clinical examination rules.	Both rules are highly sensitive and result in referral for imaging for diagnosis of fracture. However, a significant proportion of people are still having unnecessary imaging without the presence of a cervical fracture. The Canadian C-spine rule reduces the amount of unnecessary imaging compared with NEXUS.
Certainty of the evidence of test accuracy What is the overall certainty of the evidence of test accuracy?		
Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Very low ○ Low ○ Moderate ● High ○ No included studies 	<p>Canadian C-spine rule (Table 5): High certainty in the evidence for near perfect sensitivity and low specificity.</p> <p>NEXUS (Table 6): High certainty in the evidence for high sensitivity and low specificity.</p> <p>For both clinical rules, risk of bias was deemed serious for sensitivity and specificity given the prevalent selection and clinical review bias across the studies (as reported in the study by Michaleff 2012). However, sensitivity was elevated to high certainty due to the large magnitude of association (high sensitivity) with both rules. Specificity was not rated down for either test from high certainty, as precision was high: overall number of participants was large and confidence intervals for specificity were narrow (Michaleff et al., 2012)</p>	
Certainty of the evidence of management's effects What is the overall certainty of the evidence of effects of the management that is guided by the test results?		
Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Very low ○ Low ○ Moderate ○ High 	No included studies.	A positive result on either rule is an indication for imaging. Management of people with acute WAD is then guided by the imaging result, i.e., for cervical fracture (WAD IV) or WAD 0-III. Recommendations for the management of WAD 0-III are

<ul style="list-style-type: none"> ● No included studies 		<p>addressed in these guidelines (see Assessment, Prognosis, and Treatment recommendations). Management of cervical fracture is not within scope of these guidelines. Follow local guidelines for management of cervical fracture.</p>
<p>Certainty of the evidence of test result/management How certain is the link between test results and management decisions?</p>		
<p>Judgement</p>	<p>Research evidence</p>	<p>Additional considerations</p>
<ul style="list-style-type: none"> ○ Very low ○ Low ○ Moderate ● High ○ No included studies 	<p>Grade certainty not evaluated, however, all participants in the 15 studies included in the systematic review (Michaleff 2012) who were positive on the C-spine or NEXUS rule underwent imaging (radiography and/or computed tomography) to confirm or rule out cervical fracture.</p>	<p>Positive Canadian C-spine rule is an indication for imaging, which is consistent with clinical practice in an Australian context.</p>
<p>Values Is there important uncertainty about or variability in how much people value the main outcomes?</p>		
<p>Judgement</p>	<p>Research evidence</p>	<p>Additional considerations</p>
<ul style="list-style-type: none"> ○ Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ● No important uncertainty or variability 	<p>Not included studies.</p>	<p>People and their treating PHCP(s) want to know if there is structural damage (fracture) to the cervical region following whiplash injury.</p>
<p>Balance of effects Does the balance between desirable and undesirable effects favour the intervention or the comparison?</p>		

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Favours the comparison ○ Probably favours the comparison ○ Does not favour either the intervention or the comparison ○ Probably favours the intervention ● Favours the intervention ○ Varies ○ Don't know 	<p>Sensitivity analysis of four included studies in the systematic review found that the Canadian C-spine rule is highly sensitive (range 0.99–1.00) and significantly reduced the specificity range (range 0.42–0.45) when compared with NEXUS (Michaleff 2012).</p> <p>A single study (Stiell 2003) performed a direct comparison between the two rules and found significantly greater diagnostic accuracy in the Canadian C-spine rule compared with NEXUS.</p>	<p>The Canadian C-spine rule is currently recommended in the previous Australian guidelines over NEXUS based on these data.</p> <p>The Canadian C-spine rule was derived and validated in ED settings. If first contact is in primary care settings, then healthcare professionals should apply the C-spine rule. Diagnostic accuracy is unlikely to be influenced negatively in primary care settings and may have higher specificity than in ED settings (mechanism of injury and symptoms associated with greater risk of fracture are more likely to result in admission of the person to ED following a motor vehicle collision).</p>
Resources required How large are the resource requirements (costs)?		
Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Large costs ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know 	<p>Not included studies.</p>	<p>Canadian C-spine rule is widely available (e.g., available on the NSW SIRA website: https://www.sira.nsw.gov.au/resources-library/motor-accident-resources/publications/for-professionals/whiplash-resources/SIRA08109-Canadian-C-spine-Rule1117-396476.pdf)</p> <p>The rule will be included as part of these updated guidelines.</p>
Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)?		
Judgement	Research evidence	Additional considerations

<ul style="list-style-type: none"> ○ Very low ○ Low ○ Moderate ○ High ● No included studies 	No included studies.	
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Cost effectiveness
Does the cost-effectiveness of the intervention favour the intervention or the comparison?

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Favours the comparison ○ Probably favours the comparison ○ Does not favour either the intervention or the comparison ● Probably favours the intervention ○ Favours the intervention ○ Varies ○ No included studies 	No included studies on cost-effectiveness.	<ul style="list-style-type: none"> ● Implementation of the Canadian C-spine rule reduces cervical spine x-ray rates (Kerr 2005, https://doi.org/10.1016/j.jemermed.2004.08.016). ● From direct comparison of the two clinical rules (Stiell 2003), the Canadian C-spine rule would have reduced imaging rates by 44%, while NEXUS would have reduced the rates by 36%. ● The Canadian C-spine rule was 100% sensitive (95%CI 98%-100%) vs 92.2% (95%CI 82%-96%) for unstructured physician judgement (p<0.001) and 44% specific vs 54% (p<0.001), respectively (Bandiera 2003). <p>Based on these findings, the Canadian C-spine rule is likely to be associated with greater cost effectiveness than NEXUS or physician judgement, due to the costs associated with imaging.</p>

Equity
What would be the impact on health equity?

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Reduced ○ Probably reduced ● Probably no 	No included studies.	Can be administered by health professionals in ED or primary care settings.

impact <input type="radio"/> Probably increased <input type="radio"/> Increased <input type="radio"/> Varies <input type="radio"/> Don't know		
Acceptability Is the intervention acceptable to key stakeholders?		
Judgement	Research evidence	Additional considerations
<input type="radio"/> No <input type="radio"/> Probably no <input type="radio"/> Probably yes <input checked="" type="radio"/> Yes <input type="radio"/> Varies <input type="radio"/> Don't know	No included studies.	People and their treating PHCP(s) want to know if there is structural damage (fracture) to the cervical region following whiplash injury.
Feasibility Is the intervention feasible to implement?		
Judgement	Research evidence	Additional considerations
<input type="radio"/> No <input type="radio"/> Probably no <input type="radio"/> Probably yes <input checked="" type="radio"/> Yes <input type="radio"/> Varies <input type="radio"/> Don't know		Part of routine consultation. PHCP are qualified to administer the rule. Minimal costs associated with application of the rule. Canadian C-spine rule is widely available (available on the NSW SIRA website: https://www.sira.nsw.gov.au/resources-library/motor-accident-resources/publications/for-professionals/whiplash-resources/SIRA08109-Canadian-C-spine-Rule1117-396476.pdf)

D.1.3. Conclusions (clinical rule to screen for whiplash cervical fracture)

Type of recommendation

Strong recommendation against use (tool) <input type="radio"/>	Conditional recommendation against use (tool) <input type="radio"/>	Conditional recommendation for either use or not (tool) <input type="radio"/>	Conditional recommendation for use (tool) <input type="radio"/>	Strong recommendation for use (tool) <input checked="" type="radio"/>
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Recommendations

The guideline panel strongly recommend that primary healthcare professionals use the Canadian C-spine rule to screen for cervical fracture (WAD IV) in people with acute WAD.

(Panel vote summary: 9/9 (100%) strong for)

Justification

Evidence summary:

- The Canadian C-spine rule is highly sensitive (range 0.90-1.00) for screening for cervical fracture. High certainty in the evidence for near perfect sensitivity and low specificity.
- Specificity is low for both clinical examination rules, however, the Canadian C-spine rule reduces unnecessary imaging by 44% compared with 36% by NEXUS.
- In a single comparison between the two rules, the Canadian C-spine rule has significantly greater diagnostic accuracy than NEXUS (Stiell et al., 2003).
- The Canadian C-spine rule has significantly greater diagnostic accuracy than healthcare professional judgement (Bandiera et al., 2003).

Consistency:

- The recommendation is consistent with previous guidelines and current practice in an Australian context.

Acceptability and feasibility:

- The Canadian C-spine rule was derived and validated in emergency department (ED) settings. If first contact is in primary care settings, then HCP should apply the C-spine rule. Diagnostic accuracy is unlikely to be influenced negatively in primary care settings and may have higher specificity than in ED settings (mechanism of injury and symptoms associated with greater risk of fracture are more likely to result in admission of the person to ED following a motor vehicle collision).

Subgroups considerations

Outcome of the rule (positive) determines the subgroup of WAD once confirmed by imaging (WAD IV – cervical fracture).

Implementation considerations

Indications:

- The rule should be applied upon first contact (ED or primary care) with a person following a MVC who is alert (GCS score = 15) and medically stable, and when cervical spine injury is a concern.

How to apply the rule

- Healthcare professionals should ask questions around the dangerous mechanism related to the crash and/or paraesthesia in the extremities to determine if positive/negative on the rule.
- Apply the rule as outlined in Figure 1 in the main guideline document.

Result

- A positive result is an indication for imaging to determine possible cervical fracture.
- Management of people with acute WAD is then guided by the imaging result, i.e., for cervical fracture (WAD IV) or WAD 0-III. Recommendations for the management of WAD 0-III are addressed in these guidelines (see Assessment, Prognosis, and Treatment recommendations).
- If a cervical fracture is detected there should be urgent referral to a Hospital Emergency Department or immediate consultation. Management is according to cervical fracture guidelines.

Additional considerations

- The Canadian C-spine rule relates to mechanism of injury and includes the nature of the MVC (dangerous mechanism). While we have not recommended for asking questions relating to the nature of the MVC for determining prognosis, it is required for application of the Canadian C-spine rule.

D.2. Diagnosis: Neurological examination to screen for cervical radiculopathy (WAD III)

Question 1: What neurological examination assessments should healthcare professionals use to screen for cervical radiculopathy (WAD III) in people with acute WAD?

Question 2: When should healthcare professionals refer for imaging to determine probable diagnosis of cervical radiculopathy (WAD III) in people with acute WAD and evidence of cervical radiculopathy from neurological examination?

D.2.1. Executive summary

From previous data collected in NSW, prevalence of cervical radiculopathy is <5% in people with acute WAD. A neurological examination consisting of physical assessments can be performed by PHCPs to screen for possible cervical radiculopathy which can result in referral for MRI and surgical opinion. To our knowledge there are no studies evaluating the accuracy of neurological examination assessments for detecting cervical radiculopathy in people with acute WAD. A general literature search for appropriate systematic reviews identified a systematic review that evaluated the diagnostic value of a person's history and physical tests in diagnosing cervical radiculopathy (Thoomes et al., 2018). Further, the research team identified a cross-sectional study that evaluated the diagnostic accuracy of a person's interview items and other assessments for diagnosis of cervical radiculopathy published after the systematic review (Sleijser-Koehorst et al., 2021). The guideline panel agreed to use these studies to inform the recommendations for these questions. It is to be noted that there is no gold standard for diagnosing cervical radiculopathy and caution is advised when interpreting diagnostic accuracy values of physical assessments (Sleijser-Koehorst et al., 2021). A combination of results from several assessments and consistency with the person's history is likely to be the most effective method when screening for cervical radiculopathy (Sleijser-Koehorst et al., 2021; Thoomes et al., 2018). In conjunction with positive neurological signs and a person's history, MRI of the cervical region can be used to diagnose probable cervical radiculopathy (e.g., evidence of foraminal stenosis).

Table 11: Summary of sensitivity and specificity of neurological examination assessments for diagnosing cervical radiculopathy (studies reported in Thoomes et al., 2018 and inclusion of Sleijser-Koehorst et al., 2021)

Index test / Author year - type	Reference standard	true positive	false positive	false negative	true negative	Sensitivity	Specificity
Spurling test (Shabat et al., 2012) (ext+rot: radicular pain)*	MRI/CT	115	6	3	49	0.98 (0.92–0.99)	0.89 (0.77–0.96)
(Shah & Rajshekhar, 2004) (ext+LF)	MRI/operation	28	0	15	7	0.65 (0.49–0.79)	1.00 (0.56–1.00)
(Sleijser-Koehorst et al., 2021) (ext+rot+LF)	MRI	38	11	27	57	0.59 (0.46-0.70)	0.84 (0.72-0.91)
(Viikari-Juntura et al., 1989) (LF+rot)	Myelogram	12	3	20	51	0.38 (0.22–0.56)	0.94 (0.83–0.99)
					Crude pooled accuracy	0.75	0.89
Upper limb neural tension test (Apelby-Albrecht et al., 2013)	MRI	34	5	1	11	0.97 (0.83–1.00)	0.69 (0.41–0.88)
(Sleijser-Koehorst et al., 2021)	MRI	43	22	21	44	0.67 (0.54-0.78)	0.67 (0.54-0.78)
					Crude pooled accuracy	0.78	0.67
Arm Squeeze test** (Gumina et al., 2013)	MRI	295	43	10	1219	0.97 (0.93–0.98)	0.97 (0.95–0.98)
Shoulder abduction relief test (Sleijser-Koehorst et al., 2021)	MRI	32	17	32	50	0.50 (0.37–0.63)	0.75 (0.62–0.84)
Hand in pocket reduction							

(Sleijser-Koehorst et al., 2021)	MRI	9	10	57	58	0.14 0.07–0.25	0.85 0.74–0.92
Cervical distraction test							
(Sleijser-Koehorst et al., 2021)	MRI	29	20	37	48	0.50 (0.37–0.63)	0.75 (0.62–0.84)
Reduced reflexes							
(Sleijser-Koehorst et al., 2021)	MRI	18	13	47	55	0.28 (0.18–0.40)	0.81 (0.69–0.89)
Muscle weakness							
(Sleijser-Koehorst et al., 2021)	MRI	20	19	46	49	0.30 (0.20–0.43)	0.72 (0.60–0.82)
Sensory changes							
(Sleijser-Koehorst et al., 2021) (soft cotton ball)	MRI	28	18	36	46	0.44 (0.32–0.57)	0.72 (0.59–0.82)
Interview							
(Sleijser-Koehorst et al., 2021) (arm pain>neck pain)	MRI	38	13	28	55	0.58 0.45–0.70	0.81 0.69–0.89
(Sleijser-Koehorst et al., 2021) (paraesthesia and/or numbness)	MRI	58	43	8	25	0.88 0.77–0.94	0.37 0.26–0.49

*Single Spurling test outcome extracted to ensure consistency with other included studies.

**The examiner squeezed the person's middle third of the upper arm with his own hand [with simultaneous thumb and fingers compression]; the thumb from posterior on the triceps muscle and the fingers from anterior on the biceps muscle. The test was considered as positive when the score was 3 points or higher on pressure on the middle third of the upper arm compared with the other two areas (difference between results in middle third of the upper arm area and in the acromioclavicular joint and subacromial area).

D.2.2. GRADE certainty of evidence summary

Table 12: GRADE certainty of evidence summary (Spurling test)

Outcome	N° of studies (N° of people)	Study design	Factors that may decrease certainty of evidence					Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Additional	
True positives (people with cervical radiculopathy = 193)	4 studies 258 people	cohort & case-control type studies	serious ^a	not serious	serious ^b	serious ^c	n/a	Sensitivity ⊕○○○ Very low
False negatives (people incorrectly classified as not having cervical radiculopathy = 65)								
True negatives (people without cervical radiculopathy = 164)	4 studies 184 people	cohort & case-control type studies	serious ^a	not serious	not serious	serious ^c	strong association ^d	Specificity ⊕⊕⊕○ Moderate
False positives (people incorrectly classified as having cervical radiculopathy = 20)								

^aall studies had a “high” or “unclear” risk of bias in at least one category (poor-moderate overall quality) (Thoomes et al., 2018)

^bSensitivity varied significantly across all 4 studies.

^cTotal pooled sample size below the optimal threshold.

^dStrong magnitude of association (highly specific).

Table 13: GRADE certainty of evidence summary (upper limb neural tension test)

Outcome	N° of studies (N° of people)	Study design	Factors that may decrease certainty of evidence					Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Additional	
True positives (people with cervical radiculopathy = 77)	2 studies 99 people	cohort & case-control type studies	not serious ^a	not serious	serious ^b	very serious ^c	n/a	Sensitivity ⊕○○○ Very low
False negatives (people incorrectly classified as not having cervical radiculopathy = 22)								
True negatives (people without cervical radiculopathy = 55)	2 studies 82 people	cohort & case-control type studies	not serious ^a	not serious	not serious	very serious ^d	n/a	Specificity ⊕⊕○○ Low
False positives (people incorrectly classified as having cervical radiculopathy = 27)								

^aUnclear risk of selection bias across the two studies but were moderate quality overall.

^bSensitivity varied significantly across the 2 studies (point estimate and confidence intervals).

^cTotal pooled sample size below the optimal threshold and confidence intervals across the two studies ranged from moderate to perfect specificity.

^dTotal pooled sample size below the optimal threshold confidence intervals across the two studies ranged from low to high specificity.

Table 14: Evidence to decision framework for clinical examination rules to screen for cervical fracture (acute WAD)

Test accuracy How accurate is the test?		
Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Very inaccurate ○ Inaccurate ○ Accurate ○ Very accurate ● Varies ○ Don't know 	<p>No research evaluating the accuracy of neurological examination assessments for diagnosing cervical radiculopathy in people with acute WAD. Overall, there was variable diagnostic accuracy for a person's interview and neurological examination assessments for detecting cervical radiculopathy.</p> <p>Interview (history):</p> <ul style="list-style-type: none"> ● Paraesthesia and/or numbness had high sensitivity (N=1) ● Arm pain > neck pain had high specificity (N=1) <p>Summary of key provocative tests:</p> <ul style="list-style-type: none"> ● Spurling test (N=4) (crude pooled sen/spec): 0.75/0.89 (moderate/high) ● Upper limb neural tension test (N=2) (crude pooled sen/spec): 0.78/0.67 (moderate) ● Arm squeeze test (N=1): high diagnostic accuracy (sen/spec) 0.97 (0.93–0.98)/0.97 (0.95–0.98) <p>Summary of key relief tests (antalgic postures):</p> <ul style="list-style-type: none"> ● Shoulder abduction relief test (N=1): low-moderate sensitivity, moderate specificity ● Hand in pocket (N=1): very low sensitivity, high specificity <p>Summary of key neurological signs:</p> <ul style="list-style-type: none"> ● Assessed muscle weakness, sensory changes, and reduced reflexes (N=1) had low-moderate sensitivity overall, but moderate-high specificity. 	<p>It is to be noted that there is no gold standard for diagnosing cervical radiculopathy and caution is advised when interpreting diagnostic accuracy values of physical assessments (Sleijser-Koehorst et al., 2021).</p> <p>A combination of results from several assessments and consistency with the person's history is likely to be the most effective method when screening for cervical radiculopathy (Sleijser-Koehorst 2021; Thoomes 2018).</p> <p>Specificity overall was greater using these assessments than sensitivity and it is therefore more likely to rule out than detect cervical radiculopathy in people with acute WAD.</p>
Desirable Effects How substantial are the desirable anticipated effects?		
Judgement	Research evidence	Additional considerations

<ul style="list-style-type: none"> ○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know 	<p>No included studies.</p>	<p>It is important to know that neurological abnormalities are present as this guides treatment direction. As these assessments are more likely to rule out cervical radiculopathy in people with acute WAD, than this may reduce unnecessary imaging.</p> <p>In a cohort of people with acute WAD who claimed compensation (N=186), a large proportion of people with WAD grade II were still receiving an MRI (37.6%) (Bandong 2018). Bandong, A.N., Leaver, A., Mackey, M. et al. Adoption and use of guidelines for whiplash: an audit of insurer and health professional practice in New South Wales, Australia. BMC Health Serv Res 18, 622 (2018). https://doi.org/10.1186/s12913-018-3439-5</p>
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Undesirable Effects
How substantial are the undesirable anticipated effects?

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Large ○ Moderate ○ Small ○ Trivial ● Varies ○ Don't know 	<p>No adverse events occurred from performing the clinical tests (Sleijser-Koehorst 2021). This study included provocative, relief, evaluation of neurological signs, and interview assessments.</p>	<p>Clinical examination using provocative tests (e.g., neural tension test or Spurling test) can provoke pain and may exacerbate radiculopathy-related symptoms.</p> <p>Other aspects of the neurological examination are unlikely to be provocative when done carefully (e.g., reflexes, sensation, strength).</p> <p>PHCP should inform the person with acute WAD of the purpose of the assessment.</p> <p>High specificity in these assessments can rule out unnecessary imaging and possible negative effects associated with imaging. However, using single assessments may lead to higher rates of false positives and possible incorrect management of these people.</p>

Certainty of the evidence of test accuracy
What is the overall certainty of the evidence of test accuracy?

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Very low ● Low 	<p>Spurling test (N=4):</p>	<p>While the GRADE process was not performed for the other outcomes, it is likely that there is very-low certainty in the</p>

<ul style="list-style-type: none"> ○ Moderate ○ High ○ No included studies 	<ul style="list-style-type: none"> ● Very low certainty in the evidence for moderate sensitivity. ● Moderate certainty in the evidence for high specificity. <p>Upper limb neural tension test (N=2):</p> <ul style="list-style-type: none"> ● Very low certainty in the evidence for moderate sensitivity. ● Low certainty in the evidence for moderate specificity. 	<p>evidence for these assessments/outcomes due to findings being reported from a single study.</p>
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Certainty of the evidence of management's effects
 What is the overall certainty of the evidence of effects of the management that is guided by the test results?

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Very low ○ Low ○ Moderate ○ High ● No included studies 	<p>No included studies.</p>	<p>Please refer to the consensus recommendation on when to refer for MRI and surgeon's opinion. Management of people with acute WAD and possible cervical radiculopathy is then guided by the imaging result, i.e., for probable cervical radiculopathy (WAD III) or WAD I-II. Recommendations for the management of WAD 0-III are addressed in these guidelines (see Assessment, Prognosis, and Treatment recommendations).</p>

Certainty of the evidence of test result/management
 How certain is the link between test results and management decisions?

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Very low ○ Low ○ Moderate ○ High ● No included studies 	<p>All participants in the included studies for this clinical question (N=6) who were positive on a neurological examination underwent imaging (MRI) to confirm probable diagnosis of cervical radiculopathy.</p>	<p>A positive result on these assessments could be an indication for imaging. However, given that the certainty in the evidence is low, and sensitivity of the assessments are moderate, avoiding unnecessary imaging for those who are false positive is critical. A combination of results from several assessments and consistency with the person's history is likely to be the most effective method when screening for cervical radiculopathy (Sleijser-Koehorst 2021; Thoomes 2018).</p>

Values
 Is there important uncertainty about or variability in how much people value the main outcomes?

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ● No important uncertainty or variability 	Not included studies.	People and their treating PHCP(s) want to know whether they have radiculopathy as the treatment/management direction is different compared to WAD grade I-II.

Balance of effects
Does the balance between desirable and undesirable effects favour the intervention or the comparison?

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Favours the comparison ○ Probably favours the comparison ○ Does not favour either the intervention or the comparison ● Probably favours the intervention ○ Favours the intervention ● Varies (provocative tests) ○ Don't know 	<p>No research evaluating the accuracy of neurological examination assessments for diagnosing cervical radiculopathy in people with acute WAD. Overall, variable diagnostic accuracy for a person's interview and neurological examination assessments for detecting cervical radiculopathy.</p> <p>Specificity overall was greater using these assessments than sensitivity. More likely to rule out cervical radiculopathy in people with acute WAD.</p> <p>A combination of results from several assessments and consistency with the person's history is likely to be the most effective method when screening for cervical radiculopathy (Sleijser-Koehorst 2021; Thoomes 2018).</p> <p>No adverse events occurred from performing the clinical tests (Sleijser-Koehorst 2021). This study included provocative, relief, evaluation of neurological signs, and interview assessments.</p>	<p>Combination of assessments could include:</p> <ul style="list-style-type: none"> ● Interview (history): arm pain > neck pain (NRS), presence of paraesthesia/numbness. ● Relief signs (shoulder abduction relief test, hand in pocket) – unloading of arm. ● Neurological signs: sensory deficit (dermatomal abnormalities), muscles weakness (myotomal abnormalities), reduced reflexes. ● Provocative testing only in some cases as it can result in exacerbation of radiculopathy-related symptoms (Spurling test and upper limb neural tension test). More useful for ruling out radiculopathy.

Resources required How large are the resource requirements (costs)?		
Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Large costs ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know 	Not included studies.	PHCP: Completed as part of an initial consultation / clinical examination. Resources on how to perform these assessments are available online on Whiplash Navigator.
Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)?		
Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Very low ○ Low ○ Moderate ○ High ● No included studies 	No included studies.	
Cost effectiveness Does the cost-effectiveness of the intervention favour the intervention or the comparison?		
Judgement	Research evidence	Additional considerations

<ul style="list-style-type: none"> ○ Favours the comparison ○ Probably favours the comparison ○ Does not favour either the intervention or the comparison ○ Probably favours the intervention ○ Favours the intervention ○ Varies ● No included studies 	<p>No included studies on cost-effectiveness.</p>	<p>In a cohort of people with acute WAD who claimed compensation (N=186), a large proportion of people with WAD grade II were still receiving an MRI (37.6%) (Bandong 2018). Bandong (2018) noted that alternate implementation strategies may need to be considered to reduce unnecessary imaging. Given that specificity overall was greater using these assessments than sensitivity, a combination of assessments is likely to rule out cervical radiculopathy in people with acute WAD (confirming WAD grade I-II) and may reduce unnecessary imaging and the costs associated with imaging.</p>
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Equity
What would be the impact on health equity?

Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> ○ Reduced ○ Probably reduced ● Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know 	<p>No included studies.</p>	<p>PHCP (e.g., physiotherapists) can carry out neurological examination assessments as part of routine consultation.</p>

Acceptability
Is the intervention acceptable to key stakeholders?

Judgement	Research evidence	Additional considerations
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<ul style="list-style-type: none"> <input type="radio"/> No <input type="radio"/> Probably no <input checked="" type="radio"/> Probably yes <input type="radio"/> Yes <input type="radio"/> Varies <input type="radio"/> Don't know 	No included studies.	People expect interview questions and clinical examination by PHCP to determine the likelihood of a certain diagnoses (e.g., cervical radiculopathy). PHCP should inform the person with acute WAD of the purpose of the assessment, especially for those that are provocative.
Feasibility Is the intervention feasible to implement?		
Judgement	Research evidence	Additional considerations
<ul style="list-style-type: none"> <input type="radio"/> No <input type="radio"/> Probably no <input type="radio"/> Probably yes <input checked="" type="radio"/> Yes <input type="radio"/> Varies <input type="radio"/> Don't know 	No included studies.	PHCP (e.g., physiotherapists) can carry out neurological examination assessments as part of routine consultation and these assessments are taught in tertiary settings.

D.2.3. Conclusions (neurological examination assessments to screen for cervical radiculopathy)

Type of recommendation

Strong recommendation against use (assessments)	Conditional recommendation against use (assessments)	Conditional recommendation for either use or not (assessments)	Conditional recommendation for use (assessments)	Strong recommendation for use (assessments)
○	○	○	●	○

Recommendations
<p>The guideline panel suggest that primary healthcare professionals perform the following neurological examination assessments to screen for cervical radiculopathy (WAD grade III):</p> <p>Interview (arm pain>neck pain, paraesthesia/numbness), assessment of neurological signs (sensory deficit – dermatomal abnormality, muscle weakness – myotomal abnormality, reduced reflexes), and relief signs (hand in pocket, shoulder abduction relief test).</p> <p><i>(Panel vote summary: 8/11 (73%) conditional for; 3/11 917%) strong for</i></p> <p>Justification</p> <p><i>Evidence summary:</i></p> <ul style="list-style-type: none"> • No research evaluating the accuracy of neurological examination assessments for diagnosing cervical radiculopathy in people with acute WAD. • Overall, variable diagnostic accuracy for a person’s interview and neurological examination assessments for detecting cervical radiculopathy. • Spurling test (N=4): Very low certainty in the evidence for moderate sensitivity and moderate certainty in the evidence for high specificity. • Upper limb neural tension test (N=2): Very low certainty in the evidence for moderate sensitivity and low certainty in the evidence for moderate specificity. • Specificity overall was greater using these assessments than sensitivity. More likely to rule out cervical radiculopathy in people with acute WAD. • No adverse events occurred from performing the clinical tests (Sleijser-Koehorst 2021). This study included provocative, relief, evaluation of neurological signs, and interview assessments. However, provocative tests could exacerbate pain and symptoms associated with radiculopathy. • A combination of results from several neurological assessments and consistency with the person’s history is likely to be the most effective method when screening for cervical radiculopathy (Sleijser-Koehorst 2021; Thoomes 2018). <p><i>Undesirable effects:</i></p> <ul style="list-style-type: none"> • Large proportion of people with WAD grade II were still receiving an MRI (Bandong 2018) in an Australian context. Use of these assessments may reduce unnecessary imaging, possible negative consequences associated with imaging, and economic burden.

- *Feasibility:*
- PHCPs (e.g., physiotherapists) can carry out neurological examination assessments as part of routine consultation and these assessments are taught in tertiary settings.

Subgroups considerations

- Cervical radiculopathy is present in <5% of people with acute WAD.
- Management of people with acute WAD and possible cervical radiculopathy is then guided by the imaging result, i.e., for probable cervical radiculopathy (WAD III) or WAD I-II.

Implementation considerations

It is to be noted that there is no gold standard for diagnosing cervical radiculopathy and caution is advised when interpreting diagnostic accuracy values of physical assessments.

Indications (history):

- PHCPs should quantify arm and neck pain using a NRS and evaluate whether arm pain is greater.
- PHCPs should consider whether the person has signs of paraesthesia / numbness by asking questions during their initial interview with the person.
- A pattern of radiculopathy is present during ROM assessment (when determining WAD grade).
- PHCPs should undertake these the assessments below if clinically indicated (arm pain > neck pain and neurological symptoms identified from the interview with the person).

How to conduct a neurological examination:

- A combination of results from several assessments and consistency with the person's history is likely to be the most effective method when screening for cervical radiculopathy.
- Healthcare professionals should ensure that they have adequate training to determine this / carry out these assessments.
- Note that cervical radiculopathy is not radicular pain, and radiculopathy is where there is objective neurological abnormality.
- *Consumer comment (panel member) "de-implementation of provocative tests is important".*
- PHCPs should assess for neurological signs and relief signs (antalgic postures) that may be indicative of cervical radiculopathy:

Neurological signs: sensory deficit (dermatomal abnormalities), muscles weakness (myotomal abnormalities,) reduced reflexes. Guidance on how to perform these assessments is available on Whiplash Navigator.

Relief signs (antalgic postures): shoulder abduction relief test, hand in pocket (unloading of arm) – relief in pain with antalgic posture(s).

Interpretation and actions:

1. Presence of radiculopathy indications from interview and relief signs

AND

2. **Two or more** neurological abnormalities present (Section 5.8 in version 9.1 of the Motor Accident Guidelines, available at <https://www.sira.nsw.gov.au/resources-library/motor-accident-resources/publications/for-professionals/motor-accident-guidelines>)

- Conservative treatments should be considered before referral, as per the acute WAD treatment guidelines for medium-high risk subgroups.
- Healthcare professionals should reassess the neurological examination to evaluate whether there has been any meaningful change over time.
- **Please refer to the panel consensus recommendation on when to refer for MRI (see D.2.4).**
- If imaging occurs, healthcare professionals should consider the person’s history (subjective information), neurological examination, and imaging findings to determine the probable diagnosis of radiculopathy (WAD III).
- In some circumstances, injection / spinal surgery may be considered (see spinal surgery recommendation in Treatment section T.25).
- In other circumstances, conservative treatment guidelines / recommendations for managing cervical radiculopathy should be followed.

D.2.4. Conclusions (when to refer people with suspected radiculopathy for imaging)

Panel consensus recommendation classification

Strong consensus recommendation against ○	Conditional consensus recommendation against ○	Neutral consensus recommendation ○	Conditional consensus recommendation for ●	Strong consensus recommendation for ○
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Recommendations

There was guideline panel consensus that primary healthcare professionals refer people with acute WAD and suspected cervical radiculopathy, as assessed from a neurological examination, for imaging (MRI).

(Panel vote summary: 11/12 (92%) conditional for, 1/12 (8%) strong for)

Justification

Evidence summary:

- No research evaluating the appropriate length of time for when MRI referral should occur in people with acute WAD and signs of cervical radiculopathy.

- A combination of neurological examination assessments is likely to have high specificity and rule out cervical radiculopathy in a considerable portion of people with acute WAD. Very-low certainty in the evidence for moderate sensitivity (Spurling test, upper limb neural tension test).
- In clinical trials that evaluated the effect of surgical intervention on people with cervical radiculopathy, these people had to have had high pain intensity, evidence of radiculopathy, and ineffective conservative care to be considered for surgery. As a result, conservative care should be considered prior to MRI referral and surgical opinion.

Adverse effects:

- Structural abnormalities in the cervical spine are prevalent even in asymptomatic control populations. Referral for MRI for people with WAD grade II is unlikely to provide important information for management of WAD and can have negative consequences associated with imaging.
- Large proportion of people with WAD grade II were still receiving an MRI (Bandong 2018) in an Australian context. It is to be noted that these people had compensation scheme claims at the time which could influence rates of imaging compared to those without compensation scheme claims. Use of neurological examination assessments may reduce unnecessary imaging, possible negative consequences associated with imaging, and economic burden.

Subgroups considerations

- Possible referral: People with acute WAD and evidence of radiculopathy (WAD grade III) present – from a neurological examination (see D.2.3).
- MRIs for people with acute WAD grade II are unlikely to provide important information for management of WAD and can have negative consequences associated with imaging.

Implementation considerations

Indication (when to refer):

- See neurological examination recommendation (D.2.3) for cervical radiculopathy neurological examination.
- Referral for MRI could be considered necessary if there is:
 - Subjective history of neurological signs (e.g., arm pain>neck pain, paraesthesia/numbness)

AND

- **Two or more** neurological abnormalities present.
- Conservative treatments should be considered before referral, as per the acute WAD treatment guidelines for medium-high risk subgroups.
- Healthcare professionals should reassess the neurological examination to evaluate whether there has been any meaningful change over time.
- Evidence of cervical radiculopathy present.

Considerations:

- If referral for MRI has been requested based on the above criteria, the insurer should prioritise approval (consumer input).

When not to refer:

- People with WAD grade II (no neurological signs).
- Presence of radicular pain but absence of neurological signs.

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10. List of tables

Table 1: Management of whiplash associated disorders database search strategy	5
Table 2: Inclusion criteria for whiplash associated disorders (grade III or IV) diagnosis studies	6
Table 3: Clinical questions related to the diagnosis of whiplash-associated disorders	7
Table 4: Diagnosis recommendation classifications and their interpretation.....	9
Table 5: Summary of included studies (as reported in the study by Michaleff et al., 2012).....	12
Table 6: Sensitivity and specificity of the Canadian C-spine rule (CCR) and National Emergency X-radiography Utilization Study (NEXUS) criteria (as reported in the study by Michaleff et al., 2012)	14
Table 7: Additional studies identified from the Assessment section systematic review	15
Table 8: GRADE certainty of evidence summary (Canadian C-spine rule)	16
Table 9: GRADE certainty of evidence summary (NEXUS)	17
Table 10: Evidence to decision framework for clinical examination rules to screen for cervical fracture (acute WAD).....	18
Table 11: Summary of sensitivity and specificity of neurological examination assessments for diagnosing cervical radiculopathy (studies reported in Thoomes et al., 2018 and inclusion of Sleijser-Koehorst et al., 2021)	27
Table 12: GRADE certainty of evidence summary (Spurling test).....	29
Table 13: GRADE certainty of evidence summary (upper limb neural tension test)	30
Table 14: Evidence to decision framework for clinical examination rules to screen for cervical fracture (acute WAD).....	31

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