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A Review of the Clinical Application of Skull Traction in Cervical Spine Injury

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Abstract: *Cervical spine injury often results in spinal instability and neural compression, and early restoration of alignment and stability is essential for improving prognosis. Skull traction is a commonly used method for closed reduction and temporary stabilization in acute cervical spine injury, helping restore alignment and facilitate subsequent surgical treatment. This review summarizes the indications, device selection, technical considerations, complications, and clinical efficacy of skull traction. Current evidence suggests that, with appropriate patient selection and standardized monitoring, skull traction has important clinical value, although its traction parameters and application strategies still require further standardization.*

Keywords: *skull traction; cervical spine injury; closed reduction; Gardner–Wells tongs; temporary stabilization*

1. Introduction

The cervical spine is an essential structure connecting the skull and trunk, playing a key role in maintaining head and neck stability, protecting the spinal cord, and enabling movement. Traumatic cervical fracture-dislocation or facet dislocation can rapidly compromise spinal stability and compress the spinal cord or nerve roots, making early restoration of cervical alignment and biomechanical stability clinically important. By directly transmitting external force to the skull, skull traction enables axial traction, closed reduction, and temporary fixation of the cervical spine, and has long been used as an important adjunct in the management of acute cervical spine injury. However, its indications, procedural protocols, and risk control strategies have not yet been fully standardized. Therefore, this review summarizes the clinical progress of skull traction in cervical spine injury in order to provide a reference for related clinical practice and future research.

In this review, the level of evidence was classified using a four-tier framework similar to GRADE (high, moderate, low, and very low), primarily based on study design (guidelines/systematic reviews, randomized trials, prospective cohorts, retrospective cohorts, or case series), risk of bias, and consistency. The terms “recommend” and “suggest” were used, as far as possible, in accordance with the wording adopted in the original guidelines[1].

2. Definition and Purpose

In clinical practice, cranioskeletal traction, also referred to as skull traction, generally denotes the direct application of traction force to the outer table of the skull through skull pins or tongs (e.g., Gardner–Wells or Crutchfield devices) or a halo ring/crown. Through axial traction, this technique is used to achieve cervical realignment, indirect decompression, and temporary stabilization. It is commonly employed for closed reduction in acute cervical spine trauma and may also serve as an adjunct for surgical positioning and fixation[2].

Its principal objectives may be summarized into three categories, each corresponding to a different balance of evidence strength and risk-benefit profile:

- Emergency reduction and realignment: to restore the sagittal diameter of the spinal canal and the mechanical environment of the spinal cord/nerve roots as early as possible, thereby reducing the risk of secondary injury (level of evidence: low to moderate, mainly derived from observational cohorts and time-to-treatment studies) [3].

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- Temporary stabilization during transport or while awaiting surgery: when definitive surgical fixation is planned, traction can maintain alignment and facilitate subsequent decompression and fixation (level of evidence: low) [4].
- A component of conservative management in selected populations or resource-limited settings: a small number of studies and regional practices have used prolonged skull traction for several weeks, particularly in resource-constrained settings or in patients unable to undergo timely surgery (level of evidence: low) [2].

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3. Indications and Contraindications

3.1. Indications: Categorized by Disease Type and Clinical Condition

3.1.1. Traumatic subaxial cervical instability/dislocation

Skull traction is applicable to patients with subaxial cervical fracture-dislocation, unilateral or bilateral facet dislocation, cervical spondyloptosis, and similar injuries requiring rapid reduction and realignment[5].

In cohorts of single-level facet dislocation, the success rate of closed reduction with skull traction has been reported to be approximately 70%–90% (level of evidence: low to moderate, depending on cohort characteristics and protocol differences)[6][3].

3.1.2. Traction-assisted management of the upper cervical spine/craniocervical junction

In the perioperative management of deformity or instability at the craniocervical junction, halo traction is occasionally used for gradual reduction or pre-realignment preparation. In this context, the technique usually refers to halo-gravity traction or halo-based external immobilization rather than rapid short-term reduction using skull tongs (level of evidence: low).

3.1.3. Adjunctive traction for spinal deformity surgery or operative positioning

Systematic reviews have shown that Gardner–Wells tongs may also be used for intraoperative traction in spinal deformity surgery, for example, to reduce facial pressure or assist correction. However, this application falls within a different risk spectrum and monitoring framework from that of acute cervical dislocation reduction (level of evidence: low) [7].

3.2. Contraindications/Relative Contraindications: Categorized by Source of Risk

3.2.1. Skull/scalp-related factors

Common contraindications include skull fracture, localized scalp infection or septic foci, severe soft tissue injury, or conditions in which safe pin placement cannot be achieved[8].

3.2.2. Unavailable or unreliable neurological monitoring

In patients who cannot communicate reliably or undergo dependable neurological examination, closed reduction with traction is generally considered unsuitable or requires more stringent conditions, such as intraoperative monitoring, specific anesthetic strategies, or prompt conversion to open reduction, because signs of neurological deterioration may be masked[9].

3.2.3. Factors related to chronicity and anatomical characteristics

Delayed or chronic dislocations beyond a certain time window (e.g., >2 weeks) are often regarded as contraindications or are associated with markedly reduced success rates. Concomitant traumatic intervertebral disc herniation is considered by some authors to be a relative contraindication, with the main controversy centering on whether MRI evaluation is required before traction and whether reduction may aggravate spinal cord compression [5].

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3.2.4. Injury mechanisms potentially exacerbated by traction

Certain distraction/distraction-flexion injuries, as well as stable fractures that clearly do not require reduction and can be managed with a cervical collar or brace alone, may not be appropriate for skull traction.

4. Types of Traction and Comparison of Devices

Skull traction devices may be broadly classified according to two principal purposes: short-term rapid reduction (skull tongs/pins) and long-term external immobilization or gravity-assisted traction (halo systems). In the setting of acute cervical facet dislocation, Gardner–Wells tongs (GWT) have been among the most commonly used short-term traction devices in recent multicenter studies and reviews [7], as shown in Table 1.

Table 1 Comparison of Commonly Used Devices

Device/Method	Main Advantages	Main Limitations	Typical Indications	Typical Traction Force/Parameters	Major Complication Profile	Level of Evidence
Gardner-Wells tongs(GWT)	Easy to apply; strong axial traction; low overall complication rate	Needs aseptic technique and close monitoring; difficult for long-term bed rest; protocols vary	Emergency closed reduction and temporary stabilization for subaxial cervical fracture-dislocation, facet dislocation, spondyloptosis	Initial 2.5–5 kg, gradual increase; maintenance usually 5–10 kg after reduction[4]	Pin loosening, pin-site infection, bleeding; rare skull penetration, abscess, vascular/neural injury[7]	Systematic review and cohort studies: mostly minor complications; success about 70%–90%[7]
Crutchfield tongs	Available and inexpensive in some regions	Lower stability; higher complication rate than GWT	Resource-limited settings for traction reduction and maintenance	Approx. 2.3 kg per injured level, +5 kg increments; up to 40 kg, not beyond 60% body weight	More complications than GWT	Multicenter retrospective study: more complications, but no clear difference in AIS outcome or mortality
Halo crown/ring with traction	Allows controlled postural adjustment	More complex system; still needs pin care	Acute closed reduction of cervical dislocation	Initial 10 kg, then +5 kg up to 30 kg[7]	Pin-site infection/loosening; rare skull penetration[7]	Case series: 36/40 reduced successfully; no permanent neurological worsening[7]
Halo-vest	Strong external immobilization; allows early mobilization; useful as preoperative stabilization in selected patients	Complications not uncommon; less suitable for emergency reduction	Preoperative stabilization, severe deformity, craniocervical deformity, selected ankylosing spondylitis cases	Mainly fixation rather than progressive traction; pin torque commonly 6–8 in-lb or lower[10]	Pin-site infection/loosening; rare skull penetration[10]	Retrospective evidence suggests benefit in selected groups, but evidence level is low[10]
Halo-gravity traction (HGT)	Gradual long-term awake traction; useful for severe deformity optimization	High nursing burden; increased risk in elderly or osteoporotic patients	Upper cervical instability, selected cervical fractures, preoperative stabilization in special populations	Progressive loading based on body weight; varies by center[10]	Pin-site problems; cranial nerve palsy may occur[10]	A Pediatric review: pin-site problems up to one-third; cranial nerve palsy up to 10%[10]

5. Procedural Steps and Technical Considerations

Although considerable inter-center variation exists in operative practice, recent technical reviews and cohort studies have shown substantial agreement regarding the core elements of safe closed reduction

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with traction, including an appropriate clinical setting (ICU or operating room), repeatable imaging confirmation, stepwise loading, continuous neurological assessment, and clearly defined thresholds for traction reduction or termination [4][11][12].

5.1. Pre-reduction Assessment and Environmental Preparation

Assessment of monitorability: At a minimum, the patient should be able to report new pain, numbness, or weakness, or the clinical team should have access to alternative monitoring strategies, such as monitored reduction under anesthesia. In resource-limited settings, some studies have explicitly used a Glasgow Coma Scale (GCS) score >14 as a prerequisite for traction reduction so that deterioration can be recognized promptly and the procedure discontinued in a timely manner.

Imaging strategy: CT is widely accepted as the primary modality for evaluating bony injury patterns and dislocation morphology. Whether MRI should be performed before or after reduction remains controversial[4][13].

Location and monitoring requirements: The procedure should be performed in an ICU or operating room equipped for continuous vital sign monitoring and resuscitation, with access to bedside radiography, fluoroscopy, or equivalent repeat imaging modalities [4].

5.2. Pin Placement and Control of Traction Direction

Using Gardner–Wells tongs (GWT) as an example, recent technical reviews have provided practical guidance for pin placement: at the level of the external auditory canal and approximately 1 cm above the superior margin of the auricle, with symmetrical bilateral insertion[14]. These reviews also emphasize that the traction rope should remain unobstructed throughout the procedure, the traction apparatus should be kept level, and anteroposterior/lateral skull radiographs or CT should be obtained when necessary to confirm that the pins have not penetrated the inner table [5].

5.3. Stepwise Loading, Imaging, and Neurological Monitoring

One technical review proposed clinically applicable criteria for immediate traction reduction or termination: traction should be reduced or stopped without delay if abnormal vital signs develop (e.g., bradycardia, hypotension, or arrhythmia), neurological deterioration occurs, or imaging demonstrates intervertebral overdistraction of >5 mm [15].

In addition, adjunctive head-positioning maneuvers, which should be performed only under appropriate conditions and by experienced clinicians, include rotation of approximately 30°–40° toward the dislocated side in unilateral dislocation while maintaining traction. In bilateral dislocation, alternating left-right rotation of 30°–45° may be performed on the basis of axial traction combined with flexion, with the strict principle that the maneuver should be stopped immediately if resistance is encountered [5].

5.4. Recommended Traction Force and Duration

Traction parameters remain among the most experience-dependent aspects of skull traction. Even for the same indication of closed reduction, the literature shows substantial variability in initial load, increment frequency, maximum load, and maintenance load, and there is a lack of high-quality randomized controlled trials to define an optimal strategy [5].

Based on currently available technical reviews and cohort evidence, the following clinically applicable, safety-oriented parameter ranges may be suggested for adults:

Initial load: A commonly used starting load is approximately 5–10 kg. One technical review described an initial load of 5 kg with increments according to injury level, whereas another halo crown protocol used a uniform starting load of 10 kg.

- Increment size and interval: Reported protocols range from +2.5 kg every 20 minutes to more rapid regimens of +5 kg with reassessment every 2–3 minutes. The key requirement is that each increment should be accompanied by repeat neurological assessment and imaging confirmation.
- Maximum load (upper limit): The literature commonly defines upper limits either as a proportion of body weight or as an absolute value, for example, up to 50% of body weight maintained for 1 hour to attempt reduction, or not exceeding 60% of body weight with an

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absolute maximum of 40 kg. These thresholds should not be interpreted as proven safety standards, but rather as empirically derived institutional limits (level of evidence: low) [5] [16].

- Maintenance load and duration: After successful emergency reduction, most protocols recommend reducing the load to a low maintenance level (e.g., approximately 5 kg or 7.5–10 kg), often combined with a cervical collar or external immobilization, followed by early transition to definitive fixation. Prolonged traction over several weeks as a final treatment strategy is mainly reported in selected regions or resource-limited settings, where special attention must be given to complications of prolonged bed rest and pin-site care [4].

6. Complications, Prevention, and Management

Classifying complications as local versus systemic and early versus late is helpful for identifying risk-control points throughout the entire process of pin placement, traction, maintenance, and device removal. Systematic reviews indicate that GWT-related complications are predominantly minor and manageable; however, although serious complications such as skull perforation and brain abscess are rare, their consequences can be severe and therefore require proactive prevention [7].

6.1. Early Local Complications

Bleeding, pain, and pin malposition: These may result from pins being inserted too shallowly or too deeply, placed outside the safe zone, or positioned asymmetrically. Prevention relies on aseptic technique, symmetric tightening, and timely imaging-based correction when needed [5].

Inner table violation/early skull penetration: Technical reviews emphasize that anteroposterior/lateral skull radiographs or CT can be used to detect inner table breach and that pin position should be adjusted immediately when necessary. Some cases may be managed conservatively, but only with close follow-up [5].

Neurological fluctuation during reduction: Case series have shown that transient pain and neurological worsening may occur during traction or flexion-assisted reduction; these changes are often reversible with prompt adjustment of head position or reduction of traction load. This observation also underpins the safety rationale of awake reduction [7]

6.2. Late Local Complications

Pin-site infection, scalp cellulitis, and pin loosening: Systematic reviews indicate that the most common complications are minor events such as pin loosening, asymmetric pin placement, and superficial infection. Technical reviews have also reported pin loosening rates reaching the double-digit percentage range [7]

Brain abscess and other central infections (rare but high-risk): Reviews and case reports suggest that brain abscess is usually associated with superficial infection tracking inward along the pin tract. Once suspected, neurosurgical evaluation is required, and management often involves surgical drainage/debridement together with prolonged antimicrobial therapy [7].

Specific concern regarding halo-related skull penetration: An adult retrospective study found that halo pin penetration was associated with thinning of the outer and inner cranial tables, with cases clustering in elderly women. The authors recommended assessment of skull thickness, when feasible, and consideration of lower torque thresholds[17].

6.3. Systemic Complications

Early complications: Cardiovascular reactions and abnormal vital signs. Technical reviews identify bradycardia, hypotension, and arrhythmia as monitoring triggers requiring immediate traction reduction or termination; pin insertion itself may also provoke stress-related physiological responses.

Late complications: Complications related to prolonged bed rest, particularly respiratory complications. Multicenter studies of conservative traction have shown that deaths are predominantly associated with respiratory complications, and studies in special populations have similarly linked prolonged recumbent traction with an increased risk of pneumonia [2].

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6.4. Key Preventive Measures

Preventive strategies should be integrated into the procedural workflow and include aseptic pin placement and standardized pin-site care; neurological examination and imaging confirmation after each traction increment; clearly defined stopping criteria (neurological deterioration, intervertebral overdistraction, or abnormal vital signs); and minimizing the duration of the maintenance-traction/bed-rest phase by transitioning as early as possible to definitive fixation and rehabilitation pathways [5].

7. Evidence on Efficacy and Clinical Outcomes

The overall success rate of closed reduction with traction is moderate to high, although substantial heterogeneity exists. A systematic review including 631 patients reported an overall success rate of approximately 73.3%, with a range of about 56%–92%, suggesting that the key determinant is not merely whether traction is attempted, but rather appropriate patient selection and protocol design. Level of evidence: low to moderate, given that most included studies were retrospective and methodologically heterogeneous[18].

The risk of reduction failure appears to be predictable. Factors associated with failure include involvement of the C7–T1 segment, complete paralysis, absence of a contralateral perched facet, and the use of awake reduction protocols. The same systematic review identified several relatively consistent predictors of failure; among patients in whom closed reduction failed, posterior rescue procedures appeared to have a higher success rate than anterior approaches in comparable datasets. Level of evidence: low to moderate, as observational consistency was relatively good but residual confounding cannot be excluded[19].

A single-center cohort of 70 patients reported an 88% success rate for closed reduction with traction, with failures of anterior ACDF concentrated at the C7–T1 level. This study did not routinely perform MRI before reduction and emphasized prompt reduction followed by early surgery. Level of evidence: low, owing to its retrospective single-center design.

Device and workflow optimization may substantially shorten the delay to reduction and potentially improve neurological outcomes. In a prospective/historical control cohort, the median time from initial orthopedic assessment to initiation of reduction was reduced from approximately 9 hours to 1 hour, accompanied by a higher proportion of neurological improvement. Level of evidence: low, because the findings may have been influenced by environmental and population-related confounding [3].

The optimal imaging strategy, particularly whether MRI should be performed before or after reduction, remains unresolved. Some authors advocate pre-reduction MRI to minimize the catastrophic risk of worsening spinal cord compression during traction reduction, whereas multiple cohort studies have favored post-reduction MRI out of concern for treatment delay. Level of evidence: low, due to conflicting evidence and the absence of randomized trials[12].

Skull traction should be considered within the broader treatment pathway for acute spinal cord injury, particularly in relation to early decompression and perfusion management. The 2024 guideline, developed using a GRADE-based process, upgraded surgery within 24 hours from a prior “suggestion” to a formal “recommendation,” and also suggested maintaining a target mean arterial pressure (MAP) range for 3–7 days. Although this is not a traction-specific guideline, it directly informs the role of traction in the acute phase: traction should serve as a means of achieving more rapid and safer realignment and facilitating definitive decompression/fixation, rather than prolonging the waiting period indefinitely[1][20].

8. Recommendations for Follow-up and Rehabilitation

After successful reduction, the key goals of follow-up and rehabilitation are to prevent redislocation, identify residual compression, manage pin-related complications, and reduce the complications associated with prolonged immobilization [4].

- Imaging follow-up: Cervical alignment should be reassessed after reduction, and MRI should be performed when necessary to evaluate residual compression and guide surgical planning. In many studies, MRI was obtained as soon as possible after reduction.
- Pin-site and pin-position care: A pediatric review of halo use proposed practical pin-site care

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measures, including cleaning several times daily and escalating management in the presence of erythema or drainage, with oral antibiotics and pin adjustment when necessary. Although these recommendations were primarily developed for halo systems, they are broadly applicable to all skull pin-based devices [10].

- Early transition to definitive fixation and rehabilitation: When surgery is feasible, traction should be regarded as a bridging strategy rather than a long-term endpoint. Studies of prolonged traction have shown a substantial burden of respiratory complications and mortality, which should be minimized through early fixation, respiratory training, and mobilization out of bed whenever possible [1].

9. Special Populations, Ongoing Controversies, and Future Research Directions

9.1. Key Considerations in Special Populations

9.1.1. Children

Halo systems, whether for traction or external immobilization, are more commonly used in children to allow long-term adjustment. However, pin loosening and infection may occur in up to approximately one-third of cases, and cranial nerve palsy has been reported in up to about 10% of patients undergoing halo-gravity traction (HGT). When neurological changes occur, the usual strategy is to reduce the load to below the symptomatic threshold and, if necessary, completely remove the traction load and perform further evaluation. Level of evidence: low[17].

9.1.2. Older adults and patients with osteoporosis

Halo pin-related skull penetration warrants particular caution in elderly women. Studies have shown that thinning of the cranial outer and inner tables is significantly associated with perforation risk, and have proposed CT-based adjustment of pin torque when feasible. Level of evidence: low[21].

9.1.3. Patients with ankylosing spondylitis or a rigid spine

This population is at higher risk during traction reduction and positional change, and studies suggest that reduction using skull traction alone may be insufficient. One comparative study found that the halo-vest group was more likely to achieve satisfactory preoperative reduction and had shorter operative time and less blood loss. The same study also cautioned that excessive traction may aggravate neurological injury and vertebral artery compromise. Level of evidence: low [22].

9.1.4. Patients with concomitant traumatic brain injury or unreliable neurological monitoring

Technical reviews indicate that insertion of skull pins may induce hemodynamic responses, and some literature, mainly from the context of cranial pin fixation in intracranial surgery, has suggested an association between pin stimulation and changes in intracranial pressure. More importantly, the inability to obtain awake neurological feedback weakens the recognition of safety thresholds during traction; consequently, these patients often require more conservative traction strategies or earlier conversion to open reduction. Level of evidence: low [5].

9.2. Major Controversies

Is MRI before reduction mandatory? Proponents emphasize the value of identifying disc herniation and potential spinal cord compression before reduction, whereas opponents argue that MRI-related delays may increase secondary injury risk and note that awake reduction may allow earlier recognition of neurological deterioration. Existing evidence is derived mainly from cohort studies and narrative reviews, with no randomized data sufficient to resolve the controversy. [7][23]

Awake traction versus traction under anesthesia/sedation: Awake traction emphasizes "monitorability," but systematic reviews have also suggested that some awake protocols are associated with failure, which may reflect case selection, muscle spasm, or pain-related limitations. How best to integrate anesthesia, muscle relaxation, neurophysiological monitoring, and traction algorithms remains an important issue requiring standardization [24][25].

Lack of uniform standards for maximum traction load and increment frequency: Recent studies have proposed various upper limits based on body weight proportion or absolute load; however, most of these thresholds are institution-specific empirical standards with limited cross-center comparability[5][26].

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9.3. Future Research Directions

Engineering optimization of workflow and equipment: Prospective/historical control evidence suggests that a standardized protocol combined with a dedicated reduction table can significantly shorten the time to reduction and may confer neurological benefit. Such systems-level modifications may be more widely generalizable than simply fine-tuning traction load.

Automated or robotic traction with a closed-loop safety system: Biomechanical proof-of-concept studies suggest that robotic traction may maintain target traction forces more precisely and reduce the risk of inadvertent overdistraction; however, clinical validation of both efficacy and safety is still required[27].

Need for high-quality comparative studies: The most pressing research priorities include multicenter prospective studies comparing MRI strategies (before vs after reduction), awake versus anesthetized/muscle-relaxed protocols, and different loading algorithms (rapid vs gradual; absolute load vs body weight-based load), with outcomes focused on neurological recovery, complications, and treatment timing.

10. Conclusion

Skull traction is used for closed reduction, temporary stabilization, and preoperative realignment in patients with cervical fractures/dislocations. Evidence-based studies indicate that, under conditions of strict indication selection, stepwise loading, and continuous neurological monitoring, awake traction is generally safe, with reported reduction success rates ranging from 50% to 90%. Failure is more likely in cases involving the C7–T1 segment, complete paralysis, and the absence of a contralateral perched facet; in such patients, early open reduction and fixation should be considered. Gardner–Wells tongs (GWT) are the most commonly used device. The main complications are pin loosening and pin-site infection, whereas serious adverse events such as skull perforation and brain abscess are rare.

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