

Skin Traction In Pediatric Orthopaedics: Principles, Techniques, and Clinical Monitoring

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Abstract

Skin traction is a non-operative orthopaedic technique that applies controlled pulling force to an extremity through the skin and underlying soft tissues. In pediatric orthopaedics, its primary use is in selected femoral shaft fractures in infants and young children, either as definitive conservative treatment or as an initial method before cast immobilization. This narrative review summarizes the principles, techniques, indications, patient selection, advantages, limitations, equipment, clinical monitoring, complications, and contemporary alternatives of skin traction. Literature was identified through PubMed/MEDLINE and Google Scholar, with the final search on September 1, 2026. Current evidence indicates that the use of skin traction has become more selective with the increasing use of early spica casting, functional bracing, and operative fixation. Nevertheless, carefully supervised skin traction may provide acceptable fracture healing and alignment in appropriately selected young children. Its main limitations include restricted traction force, prolonged hospitalization in some protocols, and potential skin and neurovascular complications. Safe application requires individualized traction loading, appropriate limb positioning and countertraction, protection of pressure-sensitive areas, unobstructed ropes and weights, and regular skin and neurovascular assessment. Skin traction therefore remains a treatment option for selected patients, particularly young children with femoral shaft fractures, when incorporated into an individualized treatment plan.

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1. INTRODUCTION

Femoral shaft fractures are relatively uncommon compared with fractures of the distal radius and other peripheral bones, but they represent an important cause of hospitalization in children. Their incidence and mechanisms vary with age. Infants and toddlers may sustain femoral fractures following relatively low-energy events, whereas older children more commonly present after falls, sports-related injuries, or road traffic trauma. This age-related variation is clinically relevant because the mechanism of injury influences both the diagnostic assessment and selection of treatment [1,2,3].

Treatment of femoral shaft fractures in children differs from that in adults because the growing skeleton has considerable potential for remodeling and post-fracture femoral overgrowth. Younger children can therefore tolerate a certain degree of shortening or angular deformity without substantial long-term functional impairment. However,

remodeling is not unlimited, and its extent depends on age, fracture location, deformity, and remaining growth. Rotational deformity is also less reliably corrected through growth [4,5]. Consequently, treatment should balance the biological capacity of the growing femur with the need to maintain acceptable alignment throughout healing [6].

Historically, traction followed by cast immobilization was an established method for managing pediatric femoral shaft fractures, particularly in infants and young children. Bryant or Gallows traction was traditionally used in very young children, whereas balanced traction systems such as Hamilton-Russell traction were applied in older children [7,8]. The increasing use of flexible intramedullary nails and other operative techniques has subsequently reduced reliance on prolonged traction and casting, particularly among school-aged children [9]. Nevertheless, traction remains relevant in selected patients because it can provide fracture stabilization without skeletal pins or internal implants [10].

Current treatment recommendations emphasize individualized selection rather than routine use of a single technique. The American Academy of Orthopaedic Surgeons supports early spica casting or traction followed by delayed spica casting as options for selected children aged 6 months to 5 years with diaphyseal femoral fractures and less than 2 cm of shortening [11]. Similarly, the National Institute for Health and Care Excellence includes age- and weight-related traction options, including Gallows traction in selected infants and young children and straight-leg skin traction before conversion to hip spica casting in appropriate patients [12]. These recommendations indicate that traction remains an accepted part of pediatric fracture management, although its use depends on patient characteristics, fracture stability, and the intended treatment pathway.

The evidence concerning skin traction itself is more limited than the broader literature on pediatric femoral fracture treatment. A systematic review comparing traction followed by casting, spica casting, and intramedullary nailing found differences in hospital stay, malunion, and functional outcomes, although the available studies were heterogeneous and generally limited in quality [13]. More recent pediatric data have provided additional information on the use of vertical skin traction in children younger than four years, demonstrating fracture consolidation with generally acceptable clinical outcomes but also highlighting the potential for prolonged traction and superficial soft-tissue complications. These findings suggest that the role of skin traction should be considered within the broader balance between fracture control, treatment duration, complications, and family burden [14].

Skin traction is mechanically distinct from skeletal traction because the applied force is transmitted through the skin and underlying soft tissues rather than directly through a pin or wire anchored to bone. This limits the amount of force that can be safely transferred and makes the condition of the skin an important determinant of treatment safety [15]. Excessive loading, constrictive bandaging, pressure over bony prominences, or migration of the traction device may result in skin injury or compromise the intended traction force. These considerations are particularly important in infants and young children because of their small body size and relatively delicate skin [16].

Despite the changing treatment landscape, skin traction remains a useful option in selected pediatric patients, either as definitive conservative management or as an initial or temporizing treatment before casting or another form of stabilization. Its appropriate use requires an understanding of the mechanical principles of traction, patient selection, equipment, application technique, and continuous clinical monitoring. Therefore, this narrative review discusses the principles and clinical application of skin traction in pediatric orthopaedics, with particular emphasis on femoral shaft fractures in infants and young

children, including indications, techniques, monitoring, complications, outcomes, and its role relative to casting, bracing, and operative fixation.

2. METHODS

This article was prepared as a narrative literature review focusing on the use of skin traction in pediatric orthopaedics, particularly in the management of femoral shaft fractures in infants and young children. The literature search was conducted through PubMed/MEDLINE and Google Scholar for publications from January 2015 to September 1, 2026. Earlier landmark studies, clinical guidelines, and foundational publications were also considered when they provided important information on established traction techniques, pediatric fracture management, or the historical development of treatment strategies.

The search strategy combined terms related to skin traction, pediatric femoral shaft fractures, and commonly used traction techniques. The main search terms included “skin traction,” “pediatric femoral shaft fracture,” “paediatric femoral shaft fracture,” “Gallows traction,” “Bryant traction,” “Hamilton-Russell traction,” “Buck’s traction,” “traction followed by spica casting,” “pediatric femur fracture,” “traction complications,” and “neurovascular monitoring.” The terms were combined using the Boolean operators AND and OR. Reference lists of relevant guidelines, reviews, and primary studies were also screened to identify additional publications considered relevant to the objectives of this review.

Eligible publications included clinical practice guidelines, systematic reviews and meta-analyses, comparative studies, prospective or retrospective pediatric studies, narrative reviews, and relevant clinical guidance addressing traction principles, pediatric femoral shaft fractures, fracture alignment, traction application, monitoring, complications, or treatment outcomes. Adult studies were considered only when they provided information directly relevant to the general principles or limitations of skin traction, and findings from adult populations were not extrapolated to pediatric fracture treatment. Publications unrelated to pediatric orthopaedics or skin traction, non-clinical engineering studies without clinical relevance, and articles that did not provide information relevant to the review objectives were excluded or not prioritized.

Titles and abstracts were screened for relevance, followed by full-text assessment of potentially eligible publications. Data were extracted narratively according to patient age and body size, fracture characteristics, traction technique, treatment sequence, prescribed loading, duration of traction, reported complications, hospitalization, radiographic alignment, and functional outcomes. The findings were synthesized descriptively to summarize the principles, techniques, indications, monitoring requirements, limitations, and contemporary role of skin traction in pediatric orthopaedic practice. As a narrative review, no formal meta-analysis or quantitative risk-of-bias assessment was performed. The final literature search was conducted on September 1, 2026.

3. RESULTS AND DISCUSSION

The reviewed literature identified several major themes concerning the use of skin traction in pediatric orthopaedics: its changing role in femoral shaft fracture management, biomechanical principles and traction techniques, patient selection, application and monitoring, complications, treatment outcomes, and its position relative to casting, bracing, and operative fixation. The available evidence consists largely of clinical guidelines, retrospective pediatric series, comparative studies, systematic reviews, and historical

reports. Contemporary literature generally supports a selective role for skin traction rather than routine use in all pediatric femoral shaft fractures.

3.1. Changing Role of Skin Traction in Pediatric Femoral Fractures

Skin traction was historically an important component of conservative treatment for pediatric femoral shaft fractures, particularly in infants and young children. Traction was commonly used to restore or maintain length and alignment before definitive cast immobilization, while some protocols used traction as the primary conservative treatment for selected fractures [1,7,8]. Over time, the increasing use of early spica casting and flexible intramedullary nails has reduced the routine use of prolonged traction [9,10].

This change reflects differences in treatment priorities rather than a complete loss of clinical value for traction. Contemporary management increasingly considers hospital stay, early mobilization, family burden, fracture stability, and the availability of operative resources when selecting treatment. National treatment data have demonstrated increasing use of surgical fixation among younger children, particularly those aged four to five years, while other studies have documented changes in treatment patterns following the development of major trauma networks [10]. These findings illustrate the broader shift toward individualized treatment pathways [17].

The evidence specifically evaluating skin traction remains relatively limited. Dietzel et al. reported the outcomes of 36 children younger than four years treated with vertical skin traction and found fracture consolidation in all patients. Five children developed superficial soft-tissue complications that resolved spontaneously, while the mean duration of traction was 18.5 days. The study also reported no significant worsening of shortening or axial deviation during treatment. These findings support the feasibility of skin traction in selected young children but also demonstrate that successful fracture healing may require a prolonged period of inpatient treatment [14].

Comparative evidence provides additional context. A systematic review of pediatric femoral shaft fracture treatment found that intramedullary nailing was associated with shorter hospital stay and lower malunion rates than traction followed by casting in children aged 2–10 years, although the authors emphasized the heterogeneity and limited quality of the available evidence [13]. Earlier comparative studies similarly demonstrated that both operative and non-operative strategies can achieve satisfactory fracture healing, with differences primarily involving treatment duration, complications, mobilization, and hospitalization [18]. Therefore, the current literature supports viewing skin traction as one option within a broader treatment spectrum rather than as a universally preferred method [19].

3.2. Biomechanical Principles and Types of Skin Traction

Skin traction applies a longitudinal or combined directional force to an extremity through the skin and underlying soft tissues. The force is generated through a traction weight and transmitted by an extension device, rope, pulley, and supporting structure. The intended effects include reducing fracture movement, controlling muscle spasm, maintaining limb length, and assisting fracture alignment [15,16].

The effective traction force is determined by the entire mechanical system rather than by the weight alone. Pulley friction, the position of the patient, the direction of the ropes, the supporting surface, and countertraction all influence the resulting force vector. A weight that rests against the bed or frame cannot provide the intended continuous traction force. Similarly, incorrect pulley alignment may alter the direction of pull and reduce the effectiveness of the system [15,16].

Countertraction is necessary to prevent the patient's body from moving in the direction of traction. Depending on the technique, it may be provided by body weight, bed

positioning, or the configuration of an overhead frame. Maintaining the intended relationship between traction and countertraction is particularly important in children because small changes in position can substantially alter the mechanical effect of the system [15].

A major limitation of skin traction is the amount of force that can safely be transmitted through the skin. Unlike skeletal traction, in which force is transferred directly to bone through a pin or wire, skin traction depends on the tolerance of the skin and subcutaneous tissues. Increasing the load may improve longitudinal force but simultaneously increase pressure, shear, and the risk of skin injury [15]. The appropriate load should therefore be individualized according to body size, skin condition, fracture characteristics, and the specific traction system rather than determined by a universal formula [16].

Several configurations have been described. Gallows or Bryant traction uses vertical traction of both lower limbs and has traditionally been associated with infants and small children [7,12]. Hamilton-Russell traction combines horizontal and vertical components using a knee sling and pulley system and was historically used for older children [20]. Buck's traction provides a simpler longitudinal pull and may be used for temporary immobilization in selected patients [15]. These techniques differ in mechanical configuration and patient suitability, and they should not be considered interchangeable [21].

3.3. Patient Selection and Indications

The principal contemporary indication for skin traction is a selected young child with a femoral shaft fracture that can reasonably be managed non-operatively. Age remains an important factor because younger children have greater remodeling potential and are more likely to tolerate a degree of residual shortening or angulation [1,2,3]. However, treatment selection should also consider fracture pattern, displacement, shortening, body weight, soft-tissue condition, associated injuries, and the ability to maintain acceptable alignment during treatment [4,5,6].

Current guidelines support this individualized approach. The AAOS guideline recognizes early spica casting or traction followed by delayed spica casting for selected children aged 6 months to 5 years with diaphyseal femoral fractures and less than 2 cm of shortening [11]. NICE similarly provides age- and weight-related recommendations for traction and subsequent casting. These recommendations indicate that traction is an accepted treatment option in specific circumstances rather than a mandatory component of care [12].

Traction may be particularly useful when muscle spasm and shortening make immediate immobilization difficult, when gradual reduction is required, or when a staged pathway toward spica casting is planned. It may also provide temporary stabilization while the child's overall condition is assessed or while definitive treatment is arranged. Conversely, unstable fracture patterns, major soft-tissue injury, vascular compromise, open fractures, or failure to maintain acceptable alignment may require another form of stabilization [2,13].

Skin integrity is another important consideration. Adhesive traction should not be applied over damaged skin, significant dermatitis, or areas with suspected adhesive sensitivity. Edema may also alter the fit of the traction device and increase pressure at the skin interface [15]. A baseline skin examination is therefore an integral part of patient selection and not merely a component of subsequent nursing surveillance [16].

The mechanism of injury should also be considered in infants and non-ambulatory children. Femoral fractures in this population may require assessment for nonaccidental

trauma when the reported mechanism is inconsistent with the child's developmental stage or injury pattern. This consideration affects the overall diagnostic and safeguarding process but does not independently determine whether traction should be used [22].

3.4. Application and Technical Considerations

Safe application begins with confirmation of the indication, prescribed traction method, and intended load. Before application, the child's skin and distal neurovascular status should be assessed and documented. Pain or behavioral indicators of discomfort should also be recorded. The parent or caregiver should be informed about the purpose of traction, expected treatment course, and warning signs requiring immediate clinical attention [15,16].

The traction attachment should be applied symmetrically and smoothly, with appropriate padding over pressure-sensitive areas. Bandaging should provide sufficient fixation without circumferential constriction. The heel, malleoli, fibular head, and other bony prominences require particular attention because prolonged pressure may result in skin injury. The toes should remain visible whenever possible to facilitate repeated assessment of distal perfusion [15,16].

In Gallows or Bryant traction, the lower limbs are elevated using an overhead apparatus. The child's body acts as countertraction when the system is correctly positioned. Because infants have a small body mass and relatively delicate skin, excessive elevation or loading can compromise tissue perfusion [12]. The apparatus should therefore be constructed according to the prescribed configuration rather than simply maximizing the vertical position of the limbs [15].

Dietzel *et al.* described a protocol in which approximately one-sixth of body weight was applied to each leg in selected children younger than three years or weighing less than 15 kg. Radiographs were obtained after 48–72 hours, and the patients underwent daily assessment for soft-tissue injury and neurovascular abnormalities. This protocol illustrates the importance of individualized loading and serial assessment. The reported loading strategy should not be interpreted as a universal prescription for all children or traction systems [14].

Hamilton-Russell traction requires accurate positioning of the knee sling and pulley system. The sling should support the limb without producing focal pressure, particularly around the popliteal region. The rope configuration must generate the intended combination of horizontal and vertical forces, while the heel and other pressure-sensitive areas should remain protected [15,20].

Buck's traction is mechanically simpler and provides a predominantly longitudinal force. In contemporary practice, it may be used as temporary immobilization while definitive treatment is arranged. Recent pediatric guidance on preoperative immobilization also includes skin traction as one possible option in selected skeletally immature patients, although the choice varies according to age, fracture characteristics, and institutional practice [23].

After application, the traction system should be reassessed rather than assumed to remain correctly positioned. The line of pull, limb position, skin condition, bandage tension, rope alignment, pulley function, and free movement of the weights should all be checked. Reassessment is particularly important after repositioning, hygiene procedures, transfers, or imaging because these activities can unintentionally alter the traction vector [15,16].

3.5. Monitoring and Prevention of Complications

Continuous monitoring is central to the safe use of skin traction. Baseline findings should be documented before application and compared with subsequent examinations.

Neurovascular assessment includes distal color and temperature, capillary refill, pulses when appropriate, motor function, and sensation. Pain should be reassessed using an age-appropriate pain scale or behavioral indicators in younger children [16,23].

Skin monitoring should include erythema, blistering, abrasions, swelling, moisture, adhesive reaction, and pressure at the traction interface. Device migration may create localized pressure even when the prescribed traction load has not changed. Children may also be unable to communicate early discomfort reliably, making direct inspection particularly important [15,16].

The traction apparatus itself should be assessed during routine monitoring. Weights should remain suspended freely, ropes should be untwisted, and pulleys should remain correctly aligned. The limb should not rest against the bed or frame in a manner that changes the intended force. If the system becomes obstructed or displaced, the prescribed traction may no longer be delivered even though the weight remains attached [15].

Skin injury is the complication most directly related to the method. Excessive tension, uneven pressure, adhesive trauma, moisture, or device migration can result in erythema, blistering, epidermal breakdown, and pressure injury. The risk is increased by prolonged treatment and poor fit of the traction device [15,16]. In the Dietzel cohort, superficial soft-tissue complications occurred in a minority of patients, reinforcing the need for regular inspection during prolonged traction [14].

Neurovascular compromise is less common but potentially serious. It may arise from excessive traction, constrictive bandaging, abnormal limb positioning, increasing swelling, or the underlying fracture itself. A historical report documented compartment syndrome as a complication associated with skin traction in children with femoral fractures, illustrating that serious complications, although uncommon, can occur. New pallor, cyanosis, coolness, delayed capillary refill, reduced pulses, motor weakness, sensory change, or disproportionate pain should prompt immediate clinical reassessment [24].

Loss of alignment is another potential problem. Traction can help maintain length and reduce movement but does not guarantee anatomical reduction. Serial radiographic assessment is therefore necessary when alignment is clinically uncertain or when treatment depends on maintaining a specific fracture position [13,14].

3.6. Radiographic Alignment, Remodeling, and Clinical Outcomes

The interpretation of radiographic alignment in children must account for the substantial remodeling capacity of the growing femur. Younger children can tolerate selected degrees of shortening and angular deformity because longitudinal growth and remodeling may improve the final alignment [4,5]. However, the degree of acceptable deformity is age-dependent, and rotational abnormalities are less reliably corrected through growth [6].

Post-fracture femoral overgrowth is another important consideration. Historical studies have demonstrated that femoral length may increase after shaft fracture, particularly in younger children [4]. This phenomenon explains why limited initial shortening may not result in a clinically important final leg-length discrepancy. Nevertheless, overgrowth is variable and should not be used to justify uncontrolled shortening during traction treatment [5].

The Dietzel series provides contemporary evidence regarding clinical outcomes after skin traction. All fractures consolidated, and the authors reported generally satisfactory clinical results despite some residual radiographic abnormalities. Some children had measurable leg-length discrepancy or axial deviation at follow-up, but these findings did not translate into reported limitations in daily activities or sports. These results emphasize

that radiographic and functional outcomes should be considered together rather than interpreted as identical measures of treatment success [14].

Older studies also demonstrated satisfactory fracture healing following traction and casting [18,25]. Home traction programs have further suggested that conservative treatment can be delivered outside prolonged inpatient hospitalization in carefully selected patients, although this requires appropriate equipment, reliable caregivers, radiographic follow-up, and access to reassessment [25,26].

3.7. Comparison With Spica Casting, Functional Bracing, and Operative Fixation

Spica casting remains an important non-operative treatment for selected young children. Its principal practical advantage over prolonged traction is that definitive immobilization can be achieved earlier, potentially reducing hospitalization [11,13]. However, spica casting also creates challenges related to hygiene, positioning, skin care, and caregiver burden. A recent systematic review comparing single- and double-leg spica casts demonstrated differences in family-impact outcomes, although the certainty of evidence was very low [27].

Functional bracing represents another alternative for selected pediatric femoral shaft fractures. A prefabricated functional femur brace can be applied without anesthesia and adjusted as swelling changes or the child grows. Compared with prolonged traction or rigid casting, functional bracing may facilitate hygiene and mobility in appropriately selected children. However, evidence remains limited, and patient selection is important because the brace must provide sufficient fracture control [27].

Operative fixation, particularly with flexible intramedullary nails, has become increasingly common among school-aged children and some younger patients [9,10]. Flexible nails can provide stable fixation and facilitate earlier mobilization, but they introduce implant-related risks and require an operative procedure. Comparative studies have therefore generally emphasized that the choice between operative and non-operative treatment should account for age, body weight, fracture stability, expected recovery, and treatment-related burden rather than fracture healing alone [13,18].

The evidence does not indicate that skin traction is universally equivalent or superior to these alternatives. Instead, its potential value is greatest when a child is appropriately selected for conservative management and traction solves a specific clinical problem, such as maintaining length before casting or providing temporary stabilization. The treatment plan should have a defined endpoint so that traction is converted to casting, bracing, or another stabilization method when continued traction no longer provides a meaningful benefit.

3.8. Family, Hospital, and Resource Considerations

Treatment effectiveness in pediatric femoral fractures extends beyond radiographic union. Prolonged traction may require hospitalization, restrict mobility, interfere with schooling, and place substantial demands on caregivers. Historical economic studies identified hospital stay as an important contributor to the overall cost of pediatric femoral fracture treatment [27]. Although healthcare systems and costs have changed, hospitalization remains an important practical consideration when comparing traction with earlier definitive immobilization.

Home traction has been investigated as an alternative to prolonged hospital-based treatment. Studies of home Bryant or Gallows traction reported reduced hospital exposure and lower treatment costs in selected children, although these approaches depended on adequate caregiver education, appropriate equipment, and access to clinical and radiographic follow-up [25]. Home traction should therefore not be regarded simply as a

less resource-intensive version of hospital traction; it transfers a substantial proportion of monitoring responsibility to the family [26].

Family communication is also important. Parents and caregivers need to understand positioning requirements, traction equipment, skin care, and warning signs of neurovascular or mechanical complications. Previous work examining parental satisfaction with overhead extension treatment emphasized the role of communication and nursing care in the treatment experience. These factors may influence adherence and early recognition of complications during prolonged treatment [27].

In settings where access to operative fixation or specialized implants is limited, skin traction may remain clinically relevant. Nevertheless, its non-operative nature does not mean that it requires minimal resources. Safe traction depends on appropriate equipment, trained staff, regular monitoring, and the ability to perform reassessment and radiographic follow-up [14,15]. Its suitability should therefore be considered within the resources of the treating facility rather than solely on the basis of avoiding surgery [16].

3.9. Evidence Gaps and Future Directions

The contemporary evidence base for pediatric skin traction has several limitations. Most available studies are retrospective, historical, or focused on complete treatment pathways rather than isolating the effect of skin traction itself. The comparison between traction followed by casting and operative fixation may therefore be influenced by differences in age, fracture pattern, treatment selection, hospital resources, and surgeon preference [13].

Future studies would benefit from standardized reporting of traction type, prescribed load, duration, fracture configuration, radiographic alignment, skin complications, neurovascular events, hospital stay, pain, caregiver burden, and functional outcomes. Consistent definitions would also improve comparison between studies and distinguish minor skin irritation from clinically significant pressure injury.

Further research is particularly needed to identify which young children derive the greatest benefit from staged traction followed by casting. Relevant subgroups may include infants, toddlers with unstable fracture patterns, children with substantial shortening, and patients with associated injuries. Contemporary prospective multicenter studies could provide stronger evidence than the small single-center series that currently dominate the literature.

Patient- and family-centered outcomes should also receive greater attention. Hospital days, missed school or work, sleep disruption, hygiene, caregiver confidence, and treatment satisfaction may substantially influence the acceptability of prolonged traction. These outcomes should be assessed alongside fracture union, alignment, and functional recovery when evaluating the role of skin traction in modern pediatric orthopaedics.

4. CONCLUSION

Skin traction remains a useful treatment option in selected pediatric patients with femoral shaft fractures, particularly infants and young children who are suitable for conservative management. Its role has become more selective with the increasing use of early spica casting, functional bracing, and operative fixation. The choice of traction should consider the child's age, body weight, fracture characteristics, alignment, skin condition, associated injuries, and the expected burden of prolonged immobilization. Safe application requires an appropriate traction load, correct limb positioning and countertraction, adequate protection of pressure-sensitive areas, and regular assessment of the skin and neurovascular status. Current evidence supports the use of skin traction as either a definitive conservative treatment in selected patients or a temporary step before casting or other stabilization.

Further contemporary studies are needed to better define which patients benefit most from skin traction and to evaluate outcomes that include hospitalization, complications, functional recovery, and family burden.

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