

Clinical practice guideline for pediatric scar prevention and treatment (2025 edition)

Chinese Burn Association*

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This guideline is an international cooperation project.

Abstract

Children constitute a key population for scar prevention and treatment because of the unique features of their skin's physiological structure and psychosomatic growth. Currently, most approaches to pediatric scar management are formulated with reference to adult-related consensus and guidelines, which fail to fully account for the specific characteristics of pediatric scars and their distinct needs in relation to growth and development. As a result, there are controversies regarding specific prevention and treatment strategies. To address this limitation, the Chinese Burn Association brought together domestic and international experts from disciplines relevant to the field of scar prevention and treatment. Guided by evidence-based medical evidence, drawing on domestic and international literature, and integrating the clinical experience of specialist physicians, the branch first conducted consultations on clinical issues and then organized multiple rounds of expert meetings for discussions. Eventually, the *Clinical practice guideline for pediatric scar prevention and treatment (2025 edition)* was developed. Focusing on 10 key aspects of pediatric scar prevention and treatment, the guideline formulates 20 recommendation opinions. It also elaborates on the remaining controversial issues in this field, aiming to provide scientific guidance for the entire process of prevention, treatment, and rehabilitation of scars in children aged 1–14 years.

Keywords: Child; Cicatrix; Therapy; Prevention; Clinical practice guideline

Highlights

- This guideline is the first clinical practice guideline focusing on the prevention and treatment of pediatric scars, and fully takes into account the pathological characteristics of pediatric scars and the specific needs of children in different growth and development stages.
- This guideline provides clinical guidance for the prevention and treatment of pediatric scars, and discussed the remaining controversial issues in this field, thus holding strong clinical guiding significance.
- This guideline aims to provide scientific guidance for the entire process of prevention, treatment, and rehabilitation of scars in children aged 1–14 years, in order to optimize the allocation of medical resources and safeguard the physical and mental health development of children with scars.

Background

Scars are pathological products resulting from the repair of skin injuries, exhibiting significant differences in appearance, texture, and microstructure compared to normal skin. They can lead to physiological impairments such as pain, itching, cosmetic disfigurement, and joint dysfunction, as well as psychological issues such as depression and anxiety. As a core concern during patient recovery from trauma or surgery, scarring remains a major challenge in the field of burn and plastic surgery.

Burn and trauma injuries are the leading causes of accidental injuries in children. Owing to the incomplete skin barrier function and thin, delicate skin in children, the pediatric wound healing process is more prone to altered collagen ratios and structural disorganization, often resulting in hypertrophic scarring after healing. Furthermore, children are in a phase of rapid growth and development, during which their swift increase in height and body surface area often mismatches the limited extensibility of scar tissue, potentially leading to cosmetic disfigurement and developmental deformities. Additionally, children's physical and psychological immaturity often result in poor compliance during scar treatment.

These factors collectively make children a key population for scar prevention and treatment.

Currently, there is a lack of specific guidelines or consensus on scar prevention and treatment for children both domestically and internationally. Strategies are often adapted from adult guidelines, without fully considering the unique characteristics of pediatric scars and the special needs related to growth and development [1–3]. To address this gap, the Burn Surgery Branch of the Chinese Medical Association has organized experts in the field of scar prevention and treatment to review and summarize the literature, clinical evidence, and diagnostic and therapeutic experience comprehensively. This guideline has been developed to provide scientific guidance for the prevention, treatment, and rehabilitation of pediatric scars.

According to the classification used in this guideline, children are categorized into the following age groups: <28 days (neonatal period), ≥28 days to <1 year (infancy), ≥1 year to <3 years (toddler period), ≥3 years to before primary school entry (6–7 years) (preschool age), primary school age (6–7 years) to <10 years (school age), and ≥10 years to

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<20 years (adolescence). Referencing the 7th edition of the medical textbook 'Pediatrics' published by the People's Medical Publishing House and considering that general hospitals often set the upper age limit for pediatric services at 14 years, this guideline defines the upper age limit for children as 14 years. While neonates and infants (<1 year) exhibit strong wound healing capacity, their skeletal and organ systems are highly underdeveloped, making them unsuited to certain scar prevention and treatment measures, such as pressure therapy or surgical interventions. Therefore, the recommendations in this guideline primarily apply to children aged 1 to 14 years.

Methods

Guideline registration

This guideline has been bilingually registered (in both Chinese and English) with the International Practice Guideline Registry for Transparency. Readers may contact the registry to request the guideline protocol.

Guideline panel composition and responsibilities

The guideline panel was composed of experts from various specialties, including burn surgery, plastic and reconstructive surgery, wound repair, anesthesiology, radiation oncology, and evidence-based medicine. The panel was structured into the following groups: Advisors, Chair, Expert Group, Methodology Expert Group, Evidence Evaluation Group, Literature Review Group, and Writing Panel. Advisors were responsible for supervising and guiding the overall guideline development process. The Chair was primarily responsible for inviting multidisciplinary experts, forming the other groups, and overseeing the overall implementation of the guideline development plan. The expert group, drawing on their professional experience, participated in the discussion and deliberation of clinical questions related to the guideline. They completed survey questionnaires and, based on the results of meetings and online surveys, selected the most representative clinical questions and formulated recommendation statements. The Literature Review Group was responsible for literature retrieval, evidence collection, and preliminary assessment of literature quality. The Evidence Evaluation Group was responsible for the preliminary grading of the evidence. The Methodology Expert Group provided methodological support and conducted the final review and approval of the evidence grades. The Writing Panel was responsible for the bilingual registration of the guideline, drafting the guideline protocol, and writing and revising the manuscript.

Scope and clinical question identification

Based on literature reviews, clinical experience, expert consultation, and panel discussions, the Writing Panel drafted a preliminary scope and list of clinical questions. These were then sent to the expert group along with a survey to evaluate the importance of each clinical question. The questions were screened and refined on the basis of the survey responses. Each clinical question was subsequently further refined according to the population/patient, intervention, comparison/control, outcome (PICO) framework. Lastly, a Delphi method was employed using an online questionnaire (435 responses were received). All the clinical questions received an importance score of greater than 4 points (scoring scale: 1 = extremely

unimportant to 5 = extremely important), confirming the final scope and clinical questions for the guideline.

Literature search and evidence evaluation

The Literature Review Group searched for literature related to the prevention and treatment of pediatric scars. The search terms in English included 'scar', 'keloid', 'cicatrix', 'pediatrics', and 'children', which were used to query PubMed, Web of Science, and the Cochrane Library, respectively. Meanwhile, Chinese equivalents of the English search terms were also applied to search the China National Knowledge Infrastructure (CNKI) and Wanfang Database. The search period spanned from the inception of each database until 1 June 2024. Manual searches supplemented the systematic database searches. The literature types targeted here included randomized controlled trials (RCTs), observational studies (cross-sectional studies, case series, cohort studies, case-control studies, etc.), systematic reviews, and expert consensus documents.

The evidence evaluation group assessed the methodological quality of the included studies using specific tools: the Cochrane Risk of Bias tool for RCTs, the Newcastle-Ottawa Scale for observational studies, and the AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews 2) for systematic reviews. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach, along with factors for upgrading or downgrading evidence (see [Tables 1 and 2](#)), was used to rate the quality of evidence supporting each recommendation in this guideline. Members of the evidence evaluation group independently evaluated each piece of evidence twice, ultimately reaching a consensus on the final evidence grade.

Formation of guideline recommendations

Based on domestic and international systematic review evidence related to each clinical issue, with reference to relevant consensus on wound and scar prevention and treatment for individual clinical issues; and combined with clinical practice experience, the drafting team initially formulated 26 recommendations. Thereafter, all the subgroups reviewed and revised the full text to form the initial draft of the guideline. The expert panel conducted two rounds of meetings to review and confirm the initial draft, and the drafting team revised the initial draft according to the opinions of the participating experts to develop the revised draft of the guideline. The drafting team submitted the revised draft and the recommendation questionnaire to all members of the expert panel and conducted two rounds of online questionnaires using the Delphi method. Each recommendation was provided with four options: 'Strong Recommendation', 'Moderate Recommendation', 'Weak Recommendation', and 'No Recommendation'. Each expert made a single selection based on four factors, namely, evidence quality, balance of benefits and harms, values/preferences, and resource utilization, and could add necessary written explanations to the recommendations. The drafting team summarized and analyzed the feedback and discussed and adjusted the detailed suggestions put forward by the experts. The first-round questionnaire was used to adjust the recommendations, whereas the second-round questionnaire was adjusted based on the first-round feedback to confirm the experts' final judgment on the recommendation strength of each item. The recommendation level

Table 1. Description of evidence levels and associated study types for recommendations based on the GRADE system

Evidence levels	Definition	Study design
High	Further research is unlikely to change the credibility of this efficacy assessment result	RCT, observational studies with a 2-level increase in grade
Moderate	Further research is likely to affect the credibility of this efficacy assessment result, and the assessment result is likely to change	RCT with a 1-level decrease in grade, observational studies with a 1-level increase in grade, high-quality systematic reviews
Low	Further research is very likely to affect the credibility of this efficacy assessment result and the assessment result is very likely to change	Systematic reviews, expert consensus, observational studies, RCT with a 2-level decrease in grade
Very low	The true value is likely to differ from the estimated value	Low-quality systematic reviews, RCT with a 3-level decrease in grade, observational studies with a 1-level decrease in grade

Table 2. Factors for upgrading or downgrading the evidence level, their explanations, and the criteria for recommendations based on the GRADE system

Factor	Explanation	Standards
Factors that can reduce the quality of the evidence	Downgrading	
Risk of bias	Incorrect randomization, no allocation concealment, no blinding implemented, excessive loss to follow-up without intention-to-treat analysis, selective outcome reporting, or premature termination of the study after observing its efficacy.	For any one of the 5 factors, the evidence level can be downgraded by 1 level (severe) or 2 levels (very severe) according to the severity of the existing problem. The evidence level can be downgraded to very low at most and should not be downgraded repeatedly.
Inconsistency	There are large differences in conclusions among different studies without reasonable explanations; the differences may be due to differences in populations, interventions, or outcome indicators.	
Indirectness	When comparing the efficacy of 2 interventions, there is no 'head-to-head' direct comparison: there are important differences between the PICO in the study and the PICO in actual application	
Imprecision	Relatively few patients enrolled in the study and observed events lead to a wide confidence interval	
Publication bias	Public evidence is limited to a few trials or negative results that fail to be published, or there is a high possibility of publication bias	
Factors that can increase the quality of the evidence	Upgrading	
Large effect size	Rigorous methodology, showing significant or very significant efficacy with highly consistent results	For any one of the 3 factors, the evidence level can be upgraded by 1 or 2 levels according to its magnitude or strength, with a maximum upgrade to high
Dose-response relationship	A clear association between intervention dose and effect size	
Negative bias	The bias affecting the study is not an overestimation but may be an underestimation of the effect	

of each item was determined by comprehensively considering both the evidence quality and the opinions of the expert panel. For items with high- or moderate-quality evidence, if the proportion of strong recommendations was $\geq 70\%$, it was designated as a 'Strong Recommendation'; if the proportion of strong recommendations was $< 70\%$ but the total proportion of strong + moderate recommendations was $\geq 70\%$, it was designated as a 'Moderate Recommendation'; if the total proportion of strong + moderate recommendations was $< 70\%$ but the total proportion of strong + moderate + weak recommendations was $\geq 70\%$, it was designated as a 'Weak Recommendation'; and if the proportion of no recommendations was $> 30\%$, it was designated as 'No Recommendation.' For items with low or very low-quality evidence, if the proportion of strong recommendations was $\geq 80\%$, it was designated as a 'Strong Recommendation'; if the proportion of strong recommendations was $< 80\%$ but the total proportion of strong + moderate recommendations was $\geq 80\%$, it was designated as a 'Moderate Recommendation'; if the total proportion of

strong + moderate recommendations was $< 80\%$ but the total proportion of strong + moderate + weak recommendations was $\geq 80\%$, it was designated as a 'Weak Recommendation'; and if the proportion of no recommendations was $> 20\%$, it was designated as 'No Recommendation'.

Clinical questions and recommendations

Clinical question 1: wound factors in scar prevention and treatment for children

Recommendation 1 (strongly recommended). Given the correlation between wound healing time and the incidence of hypertrophic scars, systematic wound management aimed at promoting wound healing should be prioritized as the primary method for scar prevention and treatment. Practice should be based on existing evidence, relevant expert consensus, and the use of available resources. Greater attention should be given to the treatment of wounds with a predicted healing time exceeding 20 days (evidence level: moderate).

Rationale: Pediatric wound healing time is positively correlated with the incidence of keloids and hypertrophic scarring, making proper wound management crucial for minimizing the degree of scar formation [4]. In accordance with existing evidence and relevant expert consensus, the treatment of pediatric superficial deep second-degree burn wounds should follow the principles of ‘prioritizing active early debridement, ensuring adequate wound coverage, and selecting skin grafting surgery conservatively.’ This approach includes early removal of necrotic tissue from the wound and covering the pediatric wound with biological dressings or functional wound dressings to accelerate wound healing [5]. Functional wound dressings have properties beyond primary wound protection and, through a variety of mechanisms, can create a physicochemical environment conducive to wound healing, facilitating autolytic debridement and promoting granulation tissue growth and re-epithelialization [6–9]. Combined with modern wound management techniques, this protocol can effectively shorten the wound healing time and reduce the incidence and degree of scar hyperplasia [10–12]. For deep second-degree or third-degree burn wounds, which are estimated to take 3–4 weeks or longer to heal, and deep wounds in functional areas such as the hands, elbows, shoulders/knees, and neck, which could result in significant functional impairment after healing, skin graft surgery should be performed as soon as possible to cover the wound promptly [13]. Infection is a risk factor for increased scar formation, and topical antibacterial agents are the primary intervention for managing infected wounds. Preferred antibacterial medications inhibit bacterial growth in the wound, do not significantly interfere with the healing process, and have no obvious adverse effects [14]. When performing wound suturing, tension-reducing sutures should be considered to minimize tension-related impacts. After wound epithelialization (or suture removal), appropriate external tension-reducing interventions should be administered for 3 to 6 months. Details on pediatric wound management can be found in the *Consensus on the management of pediatric deep partial-thickness burn wounds (2023 edition)* [5].

Clinical question 2: selection of topical anti-scar agents for children

Topical medication is the most convenient method for preventing and treating pediatric scars. When topical agents are selected, both therapeutic efficacy and potential side effects must be considered, particularly those that might have long-term effects on the child’s growth and development.

Recommendation 2 (strongly recommended). Silicone-based agents are recommended after wound epithelialization for >12 hours per day until scar maturation (high-level evidence). For established scars, the topical application of silicone gel is recommended to soften the scars and alleviate itching, pain, and redness (moderate-level evidence). For well-healed wounds, silicone gel sheets/tapes are prioritized for preventing scar hypertrophy. If the newly formed skin is thin and fragile, silicone gel may be used initially, with gradually transitioning to silicone gel sheets/tape based on wound condition (evidence level: moderate).

Rationale: Through reduced transepidermal water loss (TEWL)/hydration, silicone-based agents alleviate inflammation, improve local microcirculation, suppress excessive collagen production, and improve scar appearance, texture,

and patient-reported symptoms. Silicone-based agents, including gels, sheets, and tapes, are characterized by their ease of use, non-invasiveness, and minimal side effects and thus are strongly recommended by numerous expert consensus documents [2, 5]. Silicone gel can be used for scar prevention after the healing of various wounds. It is recommended that the gel be applied twice daily (morning and evening) to ensure that it remains on the skin for >12 hours per day until scar maturation [15–18]. With respect to sutured wounds, application can commence after suture removal. In open wounds such as burns or trauma, silicone gel application may be initiated approximately one week after re-epithelialization, depending on the quality of wound healing. Although compared with silicone gels, silicone gel sheets and tapes have superior efficacy in scar treatment, they are more prone to side effects such as skin blisters, ulceration, and rashes, which may reduce patient compliance [19, 20]. Regarding fragile new skin or symptoms such as rashes, excessive sweating, poor adhesion, or wounds in the lip area with a high risk of accidental swallowing, silicone gel is preferable initially. The transition to silicone gel sheets/tapes should proceed gradually based on the quality of the newly regenerated epidermis [17]. With respect to established pediatric hypertrophic scars and keloids, topical silicone-based agents applied once to twice daily can soften scar tissue and alleviate itching, pain, and erythema [21]. Furthermore, vitamin C-containing silicone gel can be safely used for pediatric scar treatment and has proven effective for severe hypertrophic scars and keloids, with recommendations for continuous use for more than 3 months [18]. Silicone gel containing esterified vitamin C is effective at treating postoperative scars on children’s heads and faces, significantly reducing the scores on all aspects of the Vancouver scar scale (VSS), including pigmentation, vascularity, height and pliability, and improving scar redness and hyperpigmentation [22, 23].

Recommendation 3 (moderately recommended). Topical application of medications containing onion extract on the scar surface twice daily for at least 28 days is recommended to improve scar thickness, redness, itching, hyperpigmentation, and pain (evidence level: moderate).

Rationale: Onion extract contains abundant active components, including steroidal saponins, flavonoids, and polysaccharides. These components can stabilize mast cells, reduce histamine release, and inhibit fibroblast proliferation and collagen synthesis. For pediatric hypertrophic scars, topical application of a compound gel containing onion extract, sodium heparin (to enhance anti-inflammatory effects), and allantoin (to promote stratum corneum hydration) twice daily for more than 28 days has been shown to improve scar height, redness, itching, hyperpigmentation, and pain significantly, demonstrating superior efficacy compared with that of glucocorticoid ointments [24]. Medications containing onion extracts are generally well tolerated and thus are recommended for pediatric scar treatment.

Clinical question 3: pressure therapy for pediatric scars

Recommendation 4 (strongly recommended). The recommendation is for pressure therapy to commence as soon as wound epithelialization is complete. Pressure should be maintained in the range of 2.00 ~ 5.33 kPa with a daily treatment duration of at least 23 hours (evidence level: moderate).

Rationale: Pressure therapy for hypertrophic scars and keloids should follow three principles: early initiation, sustained duration, and adequate pressure. Early pressure therapy initiated within 26–59 d (44.53 ± 2.741 days) significantly outperformed late pressure therapy initiated within 76–170 d (112.76 ± 8.449 days) in improving VSS scores, scar thickness, and color and alleviating itching and pain [25]. Pressure therapy can have significant effects on moderate to severe scars. It is recommended that the treatment duration be at least 23 hours per day, with a minimum pressure of 2.00 kPa but not exceeding 5.33 kPa, which may lead to complications such as skin ischemia, skin inflammation, and skeletal deformities [26, 27]. Using higher pressures within the therapeutic range leads to better outcomes for hypertrophic scars and keloids [28]. Pressure pads may be inserted locally within pressure garments to adjust the local pressure and improve comfort. However, the potential for pressure loss should be noted. While limb asymmetry has been observed in some children after long-term use of pressure garments, there is a lack of clinical evidence regarding the long-term impact of pressure therapy on the skeletal or muscular development of children's limbs. Continuous monitoring is necessary.

Recommendation 5 (moderately recommended). The advent of affordable 3D scanning and printing has been an important recent development allowing for tailor-made solutions. Transparent masks that are 3D-scanned and printed are recommended for pediatric facial scar prevention and treatment and can be combined with silicone to increase pressure in specific areas and protect the skin, reducing the impact on the growth and development of facial bones and teeth (evidence level: low).

Rationale: During pressure therapy for pediatric facial burn scars, traditional elastic fabric masks have significant limitations—there may be both excessive pressure on bony prominences (e.g. nose, forehead) and insufficient pressure over facial concavities. Increasing the overall garment pressure to compensate for inadequate pressure in specific areas often induces skin blistering or ulceration [29]. Moreover, owing to their opaque color and coverage of the entire head and neck, traditional elastic fabric masks often result in poor tolerance and compliance in children. The 3D-scanned and printed transparent tailor-made masks provide high facial conformity and deliver optimized pressure to mid-facial scars [30–32]. These masks can be adjusted with local reheating and/or the subsequent addition of silicone sheets. Studies have shown that children with severe facial burns who receive traditional elastic fabric full-face mask pressure therapy may experience changes in mandibular growth, whereas those treated with partial facial elastic fabric mask pressure therapy may develop dental deformities [33]. A 3D transparent pressure mask may help prevent these complications.

Recommendation 6 (moderately recommended). Combining pressure therapy with silicone-based medications or laser therapy for wounds that have achieved re-epithelialization (evidence level: moderate) is recommended.

Rationale: Current clinical practice increasingly recommends combining pressure therapy (elastic bandages, pressure garments and facial pressure masks) with adjunctive therapies such as silicone-based medications or photoelectric therapy [34, 35]. The combination of 3D transparent pressure masks and silicone-based agents provides occlusion and hydration to pediatric hypertrophic scars while delivering additional pressure to specific scar areas (such as the nasal area and

periorbital region). Furthermore, the silicone component may offer some protection against skin damage caused by mask rigidity [36]. However, some studies have suggested that the combination of pressure garments and silicone gel is not superior to pressure therapy alone when the inhibition of pediatric hypertrophic scar formation at 12 months post-burn is considered [37]. Nevertheless, based on clinical experience, for uneven or mobile areas (such as joints and the face), a thin layer of silicone gel may be applied 2–3 times daily and massaged until it is absorbed prior to compression therapy. For flat areas (e.g. the chest, abdomen, and limbs), silicone sheets may be trimmed to fit the scar before compression is applied. Compression therapy can be initiated 1–3 days after non-ablative laser therapy and 3–7 days after ablative procedures. Care must be taken to avoid skin breakdown and blistering during compression therapy.

Clinical question 4: medication injection treatment for pediatric scars

Intralesional injection therapy is a common modality for the prevention and treatment of scars. Given the differences in physiological functions and drug metabolism between children and adults, drug selection for pediatric intralesional injections requires comprehensive evaluation and careful consideration of the potential side effects in particular. Clinical decisions should adhere to the principle of a 'personalized and precise' approach to formulating an appropriate intralesional injection regimen.

Recommendation 7 (moderately recommended). For small pediatric scars associated with significant itching and pain symptoms, intralesional injection therapy with glucocorticoid steroids is recommended. Treatment dosage should be personalized on the basis of the scar thickness, area, and severity. A single-dose injection of triamcinolone acetonide ranged from 10 to 40 mg, with an injection interval of 1 to 4 weeks. Empirically, a course of treatment consisting of 4 to 8 injections is recommended, and the total monthly dose should not exceed 40 mg; a maximum dose per kg would be more useful. Subsequent treatments should be adjusted according to the therapeutic response until the scar becomes flattened and softened or until no further improvement is observed (evidence level: moderate).

Rationale: Glucocorticoids improve scars primarily by inhibiting inflammatory processes, reducing collagen synthesis, promoting collagen degradation, and suppressing fibroblast proliferation and differentiation. At present, the most frequently used glucocorticoids for the treatment of pediatric scars are triamcinolone acetonide and betamethasone. An RCT demonstrated the efficacy of triamcinolone acetonide injection for the treatment of hypertrophic scars and keloids, which ranged from 50% to 100% reductions, with recurrence rates ranging from 4% to 50% [38]. Recent clinical studies have confirmed the efficacy of this approach, demonstrating that it can significantly alleviate symptoms such as inflammation and itching while also reducing scar height, improving texture, and softening hardened nodules [39]. Clinical studies on the use of triamcinolone injection for pediatric keloids have shown that after a follow-up period of up to 30 months, the average volume of keloids decreased by 82.7%, with a recurrence rate of only 4% [40]. In a study of 15 pediatric cases of keloid excision surgery in the ear region in which triamcinolone injection was used

preoperatively, intraoperatively, and postoperatively, only one case of recurrence was observed after 18 months of follow-up [41]. A study involving 473 children with hypertrophic scars, keloids, and those requiring scar prevention after surgery revealed that triamcinolone acetonide was effective at both treating hypertrophic scars and preventing scar hyperplasia [42]. Although the efficacy of intralesional glucocorticoid therapy is well established, various side effects, including local skin atrophy, pigmentation abnormalities, telangiectasia, menstrual irregularities (in post-pubertal females), and, very rarely, iatrogenic Cushing's syndrome, have been reported in pediatric patients. The cumulative dosage from multiple treatments may have potential adverse effects on growth and development. Injection pain also hinders the wider use of glucocorticoid injections in pediatric patients. Glucocorticoids can be mixed with lidocaine in an appropriate proportion to alleviate injection-related discomfort [43]. Intralesional glucocorticoid injection may be considered for small-area scars in mobile regions (e.g. face, joints) if these scars impair the child's appearance or function. It should be noted, however, that the use of triamcinolone acetonide injection in children does not have explicit approval in China. Thorough communication with parents/guardians is essential prior to treatment, including obtaining informed consent and completing the required hospital-level review and documentation. Injection related pain should be a deep concern for all parties, child patient, the parents and the doctor.

Clinical question 5: laser therapy for pediatric scars Early laser therapy intervention for pediatric scars

Recommendation 8 (moderately recommended). Laser therapy is recommended to initiate at 1–2 weeks after traumatic wound healing, 2 weeks after burn healing, and 2–4 weeks after skin grafting (evidence level: low).

Rationale: Scar hyperplasia typically peaks 6 months after wound healing. Compared with adults, children have stronger fibroblast activity and a higher density of skin appendages and are in a rapid growth and development stage—factors that often result in more severe scar formation. Consequently, intervention should be initiated earlier rather than later [44]. Current evidence indicates that early laser intervention can more effectively alleviate scar hyperplasia and improve scar appearance [45–47].

Recommendation 9 (moderately recommended). The use of a pulsed-dye laser (PDL), intense pulsed light (IPL), or fractional CO₂ laser treatment for the prevention of scar hypertrophy is recommended (evidence level: low).

Rationale: Both the PDL and IPL effectively occlude microvessels within scars and inhibit angiogenesis, normalizing local microcirculation and limiting early scar hypertrophy [46, 48]. For the PDL, wavelengths of 585 nm or 595 nm are recommended; a 595 nm PDL results in deeper tissue penetration, making it more effective for slightly thicker hypertrophic scars. Mild purpura is the clinical endpoint [45, 48, 49]. For IPL, 590 nm or 560 nm filters and dual-pulse mode are recommended, with mild redness or paleness of the treatment area as the clinical endpoint [46]. The typical treatment interval for PDL or IPL is once a month. Existing clinical studies have reported that fractional CO₂ laser treatment can also be used in the treatment of early scars. Lower energy settings must be used as pediatric skin is thinner. Post-treatment edema and scaling are expected to resolve within 1 week, with erythema typically fading within

1 to 4 weeks [50]. The effect is superior to that of silicone gels [51]. Since fractional CO₂ laser treatment alone has no significant additional effect on scar vessels, it is often used in combination with PDL and IPL to prevent scar hypertrophy. The typical interval for fractional CO₂ laser treatment is once every 2–3 months. A topical anesthetic should be applied 30 minutes to 1 hour before the treatment [45, 46, 52].

Laser therapy for hypertrophic pediatric scars

Recommendation 10 (strongly recommended). For children with thickened scars accompanied by pain and itching symptoms, low-energy fractional CO₂ laser treatment is recommended (evidence level: high).

Rationale: Fractional CO₂ laser treatment creates microscopic treatment zones on the skin surface, stimulating collagen remodeling, which can improve the texture, thickness, and pliability of hypertrophic scars [53]. The treatment energy should be selected based on the thickness of the scar, with a recommended density of 3% to 5%. Low energy levels can enhance patient tolerance and compliance, whereas low-energy fractional CO₂ laser treatment is both effective and safe in children [54].

Recommendation 11 (moderately recommended). For pediatric hypertrophic scars accompanied by pruritus, pain, or significant thickening, a treatment regimen combining a fractional CO₂ laser with topical drug delivery is recommended (evidence level: low). PDL combined with either fractional CO₂ lasers or compression therapy are also recommended to reduce scar erythema, improve thickness, and modulate biomechanical properties (evidence level: high).

Rationale: Fractional CO₂ lasers can produce precise and uniform tissue vaporization columns, which can facilitate drug delivery through the epidermal barrier and can be combined with the application of drug suspensions for scar treatment. A fractional CO₂ laser combined with topical triamcinolone (10 mg/mL) followed by the application of clobetasol propionate gel for one week after each treatment effectively reduced VSS scores in pediatric hypertrophic scars [55]. For scars with significant erythema, the use of the PDL or IPL to target the vasculature is the first-line treatment. The combination of PDL/IPL with a fractional CO₂ laser can be particularly effective for scars that exhibit both erythema and thickness [56]. Additionally, pressure therapy can compress blood vessels and reduce the oxygen supply within the scar tissue; therefore, PDL combined with pressure therapy has been shown to alleviate scar erythema and thickness, particularly by improving the biomechanical properties of burn-related scars [57].

Laser therapy for pediatric scar contracture

Recommendation 12 (moderately recommended). An ablative fractional laser is recommended as the primary option for treating mild scar contracture in children. The appropriate laser energy should be selected based on the thickness of the scar. PDLs can also be used in combination (evidence level: moderate).

Rationale: Contractures, which are common complications of scars, can affect the range of motion of joints, leading to impaired development and function. Laser therapy is suitable for mild contractures, with early laser treatment showing better efficacy in mitigating functional impairments caused by contractures. Lasers can soften the scar sufficiently to alleviate

the local tension caused by scar traction. For severe contracture scars, a combination of physiotherapy and surgical treatment is usually needed to achieve optimal results [58, 59]. The most effective laser type for treating mild contractures is the ablative fractional CO₂ laser, which causes minimal damage and allows rapid recovery after treatment, with improvements in the height, flexibility, and tension of mild post-burn scar contractures as well as range of motion, erythema, pain, and itching [60, 61]. Notably, after six sessions of ablative fractional CO₂ laser treatment, the softness and thickness of the scar significantly improved, with an average increase of more than 10° in joint mobility [62]. Additionally, combining the PDL with an ablative fractional CO₂ laser has a synergistic effect, leading to significant and lasting improvements in scar hyperplasia and contracture [63–65].

Recommendation 13 (weakly recommended). Combining laser therapy with functional exercise and rehabilitation treatment for the treatment of pediatric scar contractures is recommended (evidence level: very low).

Rationale: The treatment of scar contracture is a long-term process. After laser therapy or surgical treatment, functional exercises and rehabilitation therapy are necessary to prevent the recurrence of scar contracture [66]. Rehabilitation therapy after laser therapy can reduce scar contracture, improve skin elasticity, increase muscle strength and joint mobility, and promote functional recovery of the affected area [67, 68]. Studies have shown that the degree of functional improvement at the site of a child's hand burn is negatively correlated with the time from laser treatment or surgical intervention to the start of rehabilitation intervention. Without compromising the effectiveness of laser treatment or surgical intervention, functional exercises should be initiated as early as possible. Therefore, pediatric scar patients need to complete various functional exercises regularly under the guidance of professional rehabilitation physicians, including grip training, finger separation training, elbow flexion training, and other joint range-of-motion exercises, to loosen and stretch the scar gradually over time [69].

Analgesic methods during laser therapy for pediatric scars

Recommendation 14 (moderately recommended). The use of local anesthetics or cold sprays during laser therapy for pain management is recommended (evidence level: moderate).

Rationale: Currently, the use of local anesthetics in laser treatment for pediatric scars is primarily extrapolated from the practice in adults. A common approach is the topical application of local anesthetics (e.g. lidocaine cream or a lidocaine/prilocaine gel) approximately 30 minutes prior to the procedure [54, 70]. However, specific clinical studies on the dosage and application protocols in pediatric patients are lacking. In newly healed skin, in which the barrier function has not been fully reestablished, systemic absorption of topical anesthetics may be increased. Caution is warranted to avoid adverse effects, including toxicity, which may include central nervous system excitation or depression, cardiovascular dysfunction, and in severe cases, respiratory depression or cardiac arrest. Strict adherence to recommended dosages and age limits is essential. Local anesthetic creams with lidocaine and prilocaine are generally licensed for use in children over one year of age, whereas tetracaine gel is licensed for children over 1 month of age. The evidence suggests that the combined use of local anesthetics and a cooling device can effectively

relieve pain during laser treatment. The temperature of the cooling device should be controlled between 10 and 15°C, kept at >20 cm from the skin, and should not be used for more than 10 minutes at a time [71]. After treatment, cold compresses or hydrogel products can be used for pain relief. In addition, the choice of pain relief method should fully consider factors such as the area of the scar being treated, the type of laser therapy, the safe dosage of topical anesthetics, and the child's compliance. For extensive scars, general anesthesia may also be considered for photoelectric therapy.

Clinical question 6: Surgical treatment of pediatric scars

Recommendation 15 (strongly recommended). When scars limit functional activity, lead to repeated ulcers, or carry a risk of impacting growth or causing cosmetic damage, surgical intervention is recommended when non-surgical therapies have been ineffective (evidence level: low).

Rationale: Severe pediatric scars can lead to significant functional limitations, ulcers, and interference with growth and development as well as cosmetic disfigurement. Contractures across joints can result in severe loss of strength and range of motion, whereas contractures along the free edges of the lips and eyelids can severely impact esthetics. This impact is detrimental to the normal physical and mental growth and development of the child, leading to impaired quality of life and obstacles to reintegration into society. Therefore, these issues should be addressed by timely surgical treatment [65]. Statistics show that the most common sites requiring surgical intervention for scar contracture are the neck and upper limbs, particularly the elbow and shoulder [72]. Scar relaxation surgery is complemented by different reconstruction surgeries, including flaps (local, regional, rotational, transposition, and free flaps), artificial dermal substitutes, and tissue expansion [73–77]. The specific surgical approach should be tailored to the individual patient's condition to develop a personalized treatment plan, with priority given to options that can 'grow' along with the patient [78]. In recent years, punch excision techniques have emerged as effective surgical methods for pediatric scar revision. As a precise and minimally invasive approach that enables the removal of scar tissue and facilitates the regeneration of normal skin, it can significantly improve scar appearance and reduce iatrogenic scarring [79].

Clinical question 7: the application of rehabilitation training in the prevention and treatment of pediatric scars

Recommendation 16 (moderately recommended). It is recommended to adopt a rehabilitation philosophy of 'early intervention, comprehensive management, and continuous follow-up' by implementing an integrated scar rehabilitation program that incorporates kinesiotherapy, scar massage, and play therapy as early as possible (evidence level: low).

Rationale: Currently, there is no research that clearly defines the optimal timing for initiating different rehabilitation treatments, nor does it specify the ideal combination of various rehabilitation methods. Additionally, there is no evidence suggesting that performing rehabilitation treatments such as orthotic assistance, scar massage, and exercise therapy before or within one week after the wound has fully healed can cause serious adverse reactions. Clinical experience indicates that once a wound has formed, attention should be given to

scar prevention and treatment, and rehabilitation treatment should be initiated as early as possible. For children with hand burns, rehabilitation treatment (scar massage, hand range of motion training, wearing finger orthotics, and games or music therapy) was started within one month after the injury, resulting in significant improvement in hand range of motion, whereas no significant improvement was observed when rehabilitation treatment was initiated one month after the injury [69]. Furthermore, rehabilitation should be implemented in a progressive manner with continuous follow-up. For children with deeper hand burns whose wounds healed within 8 to 30 days following dressing change or surgery, a combination of kinesiotherapy, hand-specific play therapy, and custom-fabricated orthoses proved more effective than using prefabricated compression gloves in restoring hand function and preventing contracture deformities [80].

Recommendation 17 (moderately recommended). It is recommended that rehabilitation therapy, including exercise routines and scar massage, be conducted under the guidance of a therapist in a healthcare facility or at home. When scar massage is performed, ample pressure should be applied to improve tissue elasticity and pliability (evidence level: very low).

Rationale: Children with deep burns are prone to deformities and functional disabilities because of scar contracture, making it crucial to choose effective, evidence-based rehabilitation treatment methods. A retrospective analysis of hand flexion training and the use of hand splints for burned children revealed that the effects of in-hospital rehabilitation treatment and home rehabilitation treatment guided remotely by rehabilitation therapists toward the recovery of limb function are similar [81]. Thus, it is not strictly necessary for burned children to receive rehabilitation treatment in medical institutions. The focus of scar massage therapy for children after burns is to apply adequate therapeutic pressure to the scars [82]. A study on scar massage involving 100 burned children revealed that specific scar massage patterns were not particularly important—the application of sufficient pressure to achieve deep circulation massage of the scar tissue improved limb function [83]. This guideline recommends strengthening home rehabilitation training and education for parents.

Clinical question 8: psychotherapy in the prevention and treatment of pediatric scars

Recommendation 18 (moderately recommended). It is recommended that medical staff closely monitor the psychological state of children using objective measurement tools where possible (evidence level: very low).

Rationale: Providing comprehensive support to children with scars can alleviate psychological burdens, mitigate negative emotions, and contribute to improved prognosis [84]. Specific approaches include one-on-one, face-to-face psychoeducation during treatment. For children who exhibit low mood or poor mental states, strategies such as verbal encouragement, providing small rewards, and age-appropriate recreational activities can be employed to promote positive emotions, maintain psychological well-being, ease tension and fear, and establish trust in healthcare providers, thereby mitigating negative emotions during scar treatment [85]. Assessing a child's psychological status, cognitive level, and physical functioning, understanding their concerns, and

providing timely feedback can enhance their levels of trust and rapport. By alleviating or reducing apprehension, compliance can be improved [86, 87]. For children with facial scars, cognitive behavioral interventions (the use of multimedia videos, images, and other formats to inform them about potential social challenges and coping strategies) can help them adjust their psychological state and improve their quality of life [88]. In addition, the timing of scar treatment should also consider its impact on a child's development and psychological well-being.

Clinical question 9: family support in the prevention and treatment of pediatric scars

Recommendation 19 (moderately recommended). It is recommended that healthcare providers and patients use digital health platforms, such as online hospital systems and WeChat, to establish a regular communication mechanism for children undergoing scar rehabilitation at home to provide timely and tailored guidance (evidence level: moderate).

Rationale: Compared to children who only receive conventional discharge rehabilitation education, caregivers receiving continuous scar rehabilitation guidance via digital health platforms (such as online hospital systems and WeChat) is more effective at suppressing scar hyperplasia, shortening the scar maturation process, and improving overall treatment outcomes [89]. When online platforms are used to guide home-based rehabilitation, clinicians may assess progress and provide recommendations based on images and videos submitted by the family. This approach has been shown to reduce scar formation after hand burns effectively and improve the joint range of motion, achieving outcomes comparable to those of hospital-based rehabilitation [81]. Therefore, tele-rehabilitation offers a viable alternative for children who are unable to receive sustained in-hospital therapy. This guideline recommends the establishment of standardized follow-up records and protocols for children at high risk of pathological scarring. Healthcare providers should use digital platforms to maintain communication with patients and caregivers, allowing for timely adjustments to treatment plans.

Clinical question 10: assessment of the treatment outcomes for pediatric scars

Recommendation 20 (moderately recommended). It is recommended that the VSS and POSAS be used to evaluate the effects of pediatric scar treatment, as supplemented by objective measurement tools (evidence level: very low).

Rationale: Various scales, such as the VSS and POSAS, have been applied to the assessment of pediatric scars, but the applicability of these scales in addressing pediatric scars still requires further testing, adjustment and validation. Studies have shown that assessing scars with the POSAS in patients with a burn area covering <20% TBSA three months post-injury can accurately predict the quality of the scars 18 months later [90]. Multiple clinical trials have confirmed the accuracy of the POSAS in evaluating hypertrophic scars and keloids in terms of pediatric scar treatment outcomes [91]. When the modified VSS (mVSS) was compared with measurements obtained using devices such as a Cutometer (measuring elasticity) and Mexameter (measuring pigmentation), the inter-rater reliability of each sub-item of the mVSS was significantly lower than that of instrumental measurements [92]. A multimodal approach combining various measurement tools

(such as ultrasound, dermoscopy, and laser Doppler imaging) should be considered to evaluate the characteristics of pediatric scars objectively, including their area, thickness, color, vascularity, and pliability.

To sum up, on the basis of evidence-based medicine and combined with expert recommendations, this guideline formulates a set of clinically practical recommendations and develops a supporting flowchart, so as to provide a decision-making basis for standardizing the prevention and treatment of pediatric scars (Figure 1).

Controversies in the prevention and treatment of pediatric scars

Numerous controversial strategies are being used in pediatric scar treatment/prevention. Given the unique physiological development characteristics of children, as well as the complexity of scar prevention and the variations in clinical experience, it is perhaps not surprising that the use of some scar prevention strategies has not yet achieved widespread consensus. It is hoped that research conducted on these more controversial strategies will provide high-quality evidence.

Application of growth factors toward the prevention and treatment of pediatric scars

Growth factors have various functions in regulating cell proliferation, migration, and differentiation and have been shown to promote wound healing in children and to reduce scar formation. Fibroblast growth factor (FGF) prevents excessive collagen deposition in the skin and reduces scar formation by regulating the expression of α -smooth muscle actin (α -SMA) and TGF- β 1 [93, 94]. Epidermal growth factor (EGF) promotes the growth of epidermal cells and accelerates re-epithelialization of deep second-degree pediatric burn wounds [95, 96]. Subcutaneous injection or topical spraying of basic fibroblast growth factor (bFGF) on pediatric wounds has been shown to be effective for scar prevention and treatment [97, 98]. These clinical studies suggest the possible role of growth factors in promoting wound healing and reducing pediatric scar formation, but research on the safety of growth factors is still limited, especially in the long term. More robust clinical studies are needed to guide the application of growth factors in the prevention and treatment of pediatric scars.

Role of diet management in the prevention and treatment of pediatric scars

A balanced diet can modulate inflammatory responses, promote tissue repair, and inhibit fibrosis through multiple mechanisms, thereby reducing the risk of scar formation [99]. The intake of probiotics and dietary fiber may indirectly alleviate systemic inflammation through modulation of the gut microbiome-immune axis; however, clinical research on this topic is relatively limited [100]. Unhealthy dietary habits can lead to an imbalance in the gut microbiota and lipotoxicity-related inflammation, which results in systemic low-grade inflammation that ultimately promotes scar proliferation. Members of the Solanaceae family (such as tomatoes, potatoes, and eggplants), which are rich in alkaloids with antibacterial and anti-inflammatory properties, facilitate wound healing and reduce scar formation, but the optimal intake for pediatric scar prevention is unclear [101]. Spicy and 'stimulant' foods such as chili peppers may activate

pro-inflammatory factors and dilate local blood vessels, exacerbating scar erythema and itching and promoting fibroblast proliferation [102]. High-fat and high-sugar diets may interfere with fibroblast metabolism, exacerbate oxidative stress reactions, and disrupt the collagen metabolism balance, impairing wound healing and promoting scar proliferation [103]. Studies have shown that supplementation with proteins and vitamins is beneficial for scar prevention. Proteins (e.g. whey protein and collagen peptides) serve as the foundation for tissue repair, accelerating epithelial regeneration and inhibiting scar hyperplasia [104]. Vitamin C is an essential cofactor for hydroxylase enzymes involved in collagen synthesis and cross-linking, and vitamin D inhibits fibroblast proliferation and regulates collagen synthesis. Recent research has focused on dietary patterns with anti-inflammatory functions, such as those rich in omega-3 polyunsaturated fatty acids (deep-sea fish and nuts) and polyphenols (green tea and berries), which can reduce NF- κ B signaling to decrease the expression of profibrogenic factors and inhibit scar proliferation [105]. Furthermore, certain foods contain photosensitive compounds and, when in the skin, can trigger reactions (e.g. erythema, edema, erosion, pruritus, and pain) when exposed to sunlight; these reactions can lead to inflammatory reactions and increased pigmentation of scars [106]. Some experts of the guideline suggest that dietary management should be regarded as an important aspect of scar prevention. On the basis of avoiding inflammatory foods, enhancing the supplementation of key nutrients is recommended.

Application of topical glucocorticoid in the prevention and treatment of pediatric scars

Topical glucocorticoids have been employed as topical medications for pediatric scar management. In children who cannot tolerate scar injections, glucocorticoid ointments can be applied externally to alleviate itching, pain, and other symptoms. Moderate or weak glucocorticoid ointments are the mainstay, whereas potent or superpotent glucocorticoid ointments can be cautiously prescribed for ≤ 12 -year-olds. Moderate-strength glucocorticoid ointments should not be used continuously for more than two weeks, and use for large areas should be avoided [107]. Glucocorticoid patches may replace scar injections in long-term scar management and offer lower doses than scar injections do [108]. However, the possible impact of long-term application of topical corticosteroids on children's growth and development cannot be ignored. The use of topical corticosteroids for the prevention of scars in children is still subject to considerable controversy. For instance, in Japan, corticosteroid ointments and creams are used as the first-line treatment for pediatric scars. Some experts of the guideline suggest being cautious when using topical corticosteroid ointments for the prevention and treatment of pediatric scars.

Application of traditional Chinese medicine for the prevention and treatment of pediatric scars

Traditional Chinese medicine (TCM) has unique therapeutic concepts to address scar prevention and treatment, with treatment methods including oral administration, topical application, and acupuncture. TCM holds that Qi stagnation and blood stasis are the core pathogenesis of scar hyperplasia; thus, herbal decoctions primarily consist of blood-activating and stasis-resolving herbs. A classic blood-activating and

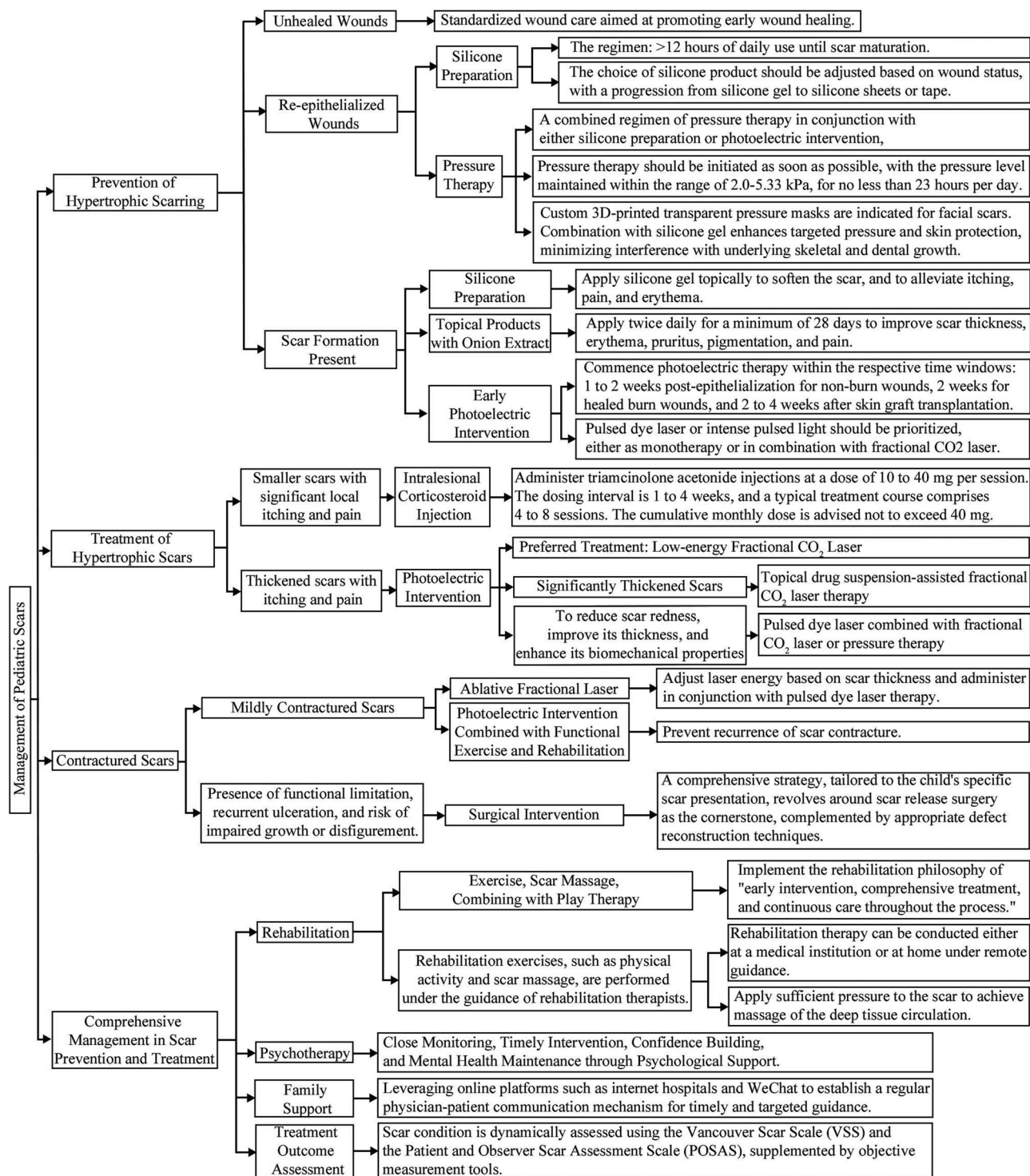


Figure 1. Recommendation flow chart of clinical practice guideline for pediatric scar prevention and treatment (2025 edition)

stasis-resolving TCM formula, Peach Blossom Four Substance Decoction (Taohua Sizi Decoction), has been clinically used to treat hypertrophic scars. In vitro studies have demonstrated the inhibition of abnormal scar fibroblast proliferation via a multi-target mechanism [109]. Topical herbal therapies or bathing treatments are also applied in the treatment of post-burn pediatric scars. An RCT confirmed that a modified version of black cloth scar ointment, made from gallnut, has a therapeutic effect similar to that of dexamethasone, with fewer side effects [110]. Three types of topical herbal

treatments, namely Fuchun Powder II, Wuzhou Huaban Mask Powder, and *Centella Asiatica* Glycoside Cream, have been shown to improve hypertrophic pediatric scars after burn injury [111]. Herbal bathing therapy using large blood vine washes has been shown to be effective at treating post-burn scars, and when combined with rehabilitation training, it can significantly improve scar symptoms and joint mobility in children with hand burns [112, 113]. Acupuncture, as a characteristic TCM therapy, can improve local blood circulation and promote the absorption of topical

medications. The combination of acupuncture and topical herbal treatment has been shown to be effective for the treatment of hypertrophic scars [114]. Reports on the clinical effects of TCM in scar prevention and treatment are limited by issues such as the lack of a traditional evidence base, unknown active components, and potential risks of side effects, which limit its widespread application. Advanced pharmacological methods to identify the active components of Chinese medicine and study their mechanisms of action may provide evidence-based support for the role of TCM in preventing and treating pediatric scars.

Application of type A botulinum toxin in the prevention and treatment of pediatric scars

Botulinum toxin type A is a potent neurotoxin that selectively inhibits the release of the neurotransmitter acetylcholine at the neuromuscular junction, relaxing postsynaptic target muscles, for example. The proposed mechanisms of botulinum toxin type A in scar treatment include reducing tension at the incision edge; decreasing the expression of transforming growth factor- $\beta 1$ (TGF- $\beta 1$); inhibiting fibroblast activity; affecting collagen synthesis and degradation; reducing scar angiogenesis; inhibiting the release of inflammatory mediators; and alleviating the inflammatory response [115, 116]. With respect to facial sites, peri-wound injection of botulinum toxin type A immediately after surgery or trauma can increase scar width and overall appearance [117, 118]. An RCT on pediatric hypertrophic scars and keloids after burn injury revealed that the injection of botulinum toxin type A (5 IU/cm²) into the scar once a month for 6 months can improve scar itching, pain, flexibility, erythema, and thickness [119]. Another RCT suggested that injecting botulinum toxin type A into hypertrophic scars and keloids is as effective as glucocorticoid injections, with better patient tolerance [120]. Additionally, botulinum toxin type A can be combined with glucocorticoids to treat hypertrophic scars and keloids, resulting in significant improvements in scar appearance and VSS scores after combined treatment, although there was no significant difference in changes in scar thickness. Botulinum toxin type A is effective for approximately 4 to 6 months; multiple injection treatments are often required [121, 122]. Caution is needed to avoid botulinum toxin poisoning in the pediatric population, which may lead to adverse systemic reactions such as ptosis, headache, and muscle weakness in areas distant from the treatment site.

Application of 5-fluorouracil in the prevention and treatment of pediatric scars

5-Fluorouracil (5-FU) is an antitumor chemotherapy drug that can inhibit nucleic acid synthesis and cell proliferation. It may exert anti-scar effects by inhibiting fibroblast proliferation, reducing type I collagen expression, and suppressing angiogenesis. Clinical studies have shown that the combination of 5-FU and glucocorticoids is more effective than monotherapy and that the combination can also reduce the dosage of glucocorticoids and the incidence of adverse reactions to 5-FU [123]. Initiation of preventive injection therapy with a combination of 5-FU and glucocorticoids 2 to 3 weeks after the excision of keloids or hypertrophic scars has been confirmed to be safe and effective [124, 125]. Currently, large-scale, high-quality clinical studies confirming the safety and efficacy of 5-FU in pediatric patients are lacking. Some experts

for the guideline conclude that for recurrent, rapidly progressing hypertrophic scars and keloids that are unresponsive to glucocorticoid injection therapy, combined 5-FU injection therapy should be cautiously considered.

Application of radiotherapy in the prevention and treatment of pediatric scars

Scar radiotherapy includes electron beam radiation therapy and superficial X-ray radiation therapy and is generally reserved for scars refractory to conventional scar treatments. It works primarily by inhibiting fibroblast proliferation and collagen synthesis, reducing scar tissue formation and preventing the recurrence of keloids. Currently, there is significant controversy regarding the application of radiotherapy to pediatric scars. Researchers treated 130 children (aged 1–16 years) with 1–13 radiotherapy sessions (mean: 5 sessions) in one study, using irradiation energies of 50–100 kV and single doses of 2–5 Gy; no significant short-term adverse effects were observed [126]. The investigators believe that radiotherapy should be considered as an optional treatment for pediatric scars when the benefits outweigh the risks. Another study suggested that the combination of superficial X-ray radiation therapy and conventional treatment for pediatric hypertrophic scars had good treatment effects based on subjective assessments, with a low incidence of adverse reactions and no new or recurrent scars during the follow-up period [127]. Some experts for the guideline conclude that radiotherapy is not an absolute contraindication for pediatric scars but must be used with extreme caution on the basis of a rigorous risk-benefit analysis, considering factors such as treatment sites, appropriate techniques, dose fractionation, and protection of other tissues. On the other hand, some experts, especially international ones, firmly oppose the use of radiation therapy for pediatric scars. The main reasons for their opposition include: first, scars formed after burns are mostly hypertrophic scars (rather than keloids), so the necessity of radiation therapy is low; second, there is currently a lack of long-term follow-up studies on the impact of radiation therapy on children's growth and development.

Treatment of abnormal pigmentation of pediatric scars

pediatric scar-related pigmentation abnormalities primarily manifest as hyperpigmentation (as defined by increased melanin density in the epidermal or dermal layers) and depigmentation (caused by a reduction in the number and functional loss of melanocytes in the basal layer of the scar epidermis). The pathological mechanism stems from the functional dysregulation of epidermal melanocytes. Among the currently available clinical treatments, tranexamic acid and hydroquinone are commonly used for hyperpigmentation, whereas tacrolimus and bimatoprost have been employed for depigmentation. Although these medications can partially improve pigmentation abnormalities, their safety in pediatric populations has not been sufficiently validated. Moreover, long-term topical application is required, posing challenges in terms of compliance, and the resulting improvement is often limited. In contrast, light-based and laser therapies have emerged as preferred options for treating pediatric scar pigmentation disorders because of their favorable safety profile, high efficacy, and minimal downtime. These modalities can safely and effectively improve scar pigmentation. With

respect to inflammatory hyperpigmentation in early post-burn scars, the primary goal is to control inflammation. IPL with 515–755 nm filters targets melanin through selective photothermolysis, reducing pigment deposition while minimizing effects on hemoglobin or water [128]. For mature scar hyperpigmentation, the main strategies include mildly exfoliating epidermal pigment and stimulating dermal pigment metabolism. Fractional CO₂ lasers are often the first choice, although picosecond lasers or IPL may also be used [129, 130]. Studies suggest that using fractional laser therapy on hypopigmented scars creates microscopic thermal zones that modulate pigmentation within the scar and provide spatial pathways for the migration of melanocytes and keratinocytes into hypopigmented areas [131–133]. Most experts prefer ablative fractional lasers, including the 2940 nm Er: YAG fractional laser and the 10 600 nm CO₂ fractional laser. Currently, clinical research on light-based and laser therapies for post-burn pigmentation changes remains limited, and there is no widely accepted standardized treatment protocol.

Conclusions

The prevention and treatment of pediatric scars are extremely common and challenging in clinical practice. Different treatment strategies for scars in different locations should be adopted, and factors such as children's growth and development characteristics, fluctuations in hormone levels, psychosocial adaptation, and daily learning activities should be comprehensively considered. Given the relatively small number of RCT studies on the prevention and treatment of pediatric scars, the evidence level for some recommendations in this guideline is relatively low, and differences among children of different races have not been considered. In the future, more high-quality clinical studies on new drugs and novel therapeutic approaches for children of the Asia-Pacific region are still needed to provide evidence support and further optimize pediatric scar prevention and treatment strategies.

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Conflict of interest

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