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Original Article

Effect of early application of a skin surface closure device combined with pulsed dye laser on the morphologic characteristics and clinical symptoms of tension scars on the backs of children

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Abstract: Objectives: Pediatric dorsal linear scars under high tension often lead to suboptimal outcomes. This study evaluated the efficacy of early mechanical offloading combined with pulsed dye laser (PDL) for these scars. Methods: This retrospective cohort included 245 children (6-14 years) treated from January 2021 to September 2024. Patients were grouped into the Early Intervention with Surface Skin Closer and Pulsed Dye Laser (EI-SSC+PDL) and the Pulsed Dye Laser Treatment with Standard Scar Care (PDL-SSC). Scar morphology, Vancouver Scar Scale (VSS) score, symptom scores, observer assessment, and parental satisfaction were compared at 6 months. Results: The EI-SSC+PDL group (n=126) showed superior outcomes versus the PDL-SSC group (n=119): significantly reduced scar width (7.48 ± 0.48 mm vs. 7.71 ± 0.57 mm, P<0.001) and lower total VSS score (2.69 ± 1.34 vs. 3.12 ± 1.62, P=0.026). Symptom relief was greater (abnormal sensation: 1.24 ± 0.61 vs. 2.13 ± 0.96, P<0.001). Observer Patient and Observer Scar Assessment Scale scores were lower (28.62 ± 5.72 vs. 31.03 ± 6.55, P=0.002) and parental satisfaction was higher (P=0.026) in the EI-SSC+PDL group. Conclusions: Early combined mechanical offloading and PDL therapy is associated with greater improvement in pediatric dorsal tension scars compared to PDL with standard care.

Keywords: Pediatric dorsal scars, linear scar, pulsed dye laser, scar width reduction, biomechanical improvement, scar management

Introduction

Linear scars on the back, particularly in high-tension areas such as the scapular and paraspinal regions, pose a significant therapeutic challenge in pediatric dermatology and plastic surgery [1]. Characterized by excessive collagen deposition, these scars lead to raised, erythematous, and pruritic lesions that can cause severe functional and psychological distress [2]. These scars are caused by trauma or elective surgery and are prone to pathologic widening, hypertrophy, and symptoms such as pruritus and pain due to the continuous mechanical tension from underlying muscle movements and skin stretching [3, 4]. The underlying pathophysiology involves a complex interplay of mechanical stress, fibroblast activation, and pro-fibrotic signaling pathways, which collectively promote the formation of abnormal scar tissue [5, 6]. Current first-line interventions, including pulsed dye laser (PDL) targeting the vascular system and silicone-based therapies regulating hydration, mainly address the biochemical aspects of scars [7, 8]. However, there remains a critical gap in directly and continuously managing mechanical tension, a key pathogenic factor in scar widening and poor quality [9]. Therefore, this study aims to investigate the combined effect of early mechanical offloading using a skin surface closure device with standard PDL treatment on comprehensive outcomes for pediatric dorsal tension scars.

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Evidence highlights the crucial role of mechanotransduction pathways in scar formation. Mechanical stress activates fibroblasts, promoting a pro-fibrotic phenotype through pathways involving Transforming Growth Factor Beta (TGF-β) and focal adhesion kinase, leading to excessive extracellular matrix production and scar contracture [10, 11]. This insight has sparked interest in mechanical offloading devices, such as skin surface closure devices, which aim to reduce the tension applied to healing tissues [12, 13]. While the principle of tension relief strategies is acknowledged, there is a lack of standardized and well-researched early application protocols, especially when combined with established modalities like PDL in pediatric populations [14, 15]. Additionally, although individual methods have been studied, the synergistic potential of early combined interventions, particularly the integration of mechanical offloading with PDL, has not been systematically evaluated.

The primary aim of this retrospective cohort study is to compare the efficacy of early combined intervention (skin surface closure device plus PDL) with PDL alone using standard scar care. The innovation of this study lies in its proactive dual-pathway approach, addressing both the biochemical (PDL) and biomechanical (tension offloading) drivers of scar formation from the earliest stages. This study holds significant clinical implications, possibly offering a more effective strategy to improve functional and aesthetic outcomes for problematic linear scars in children.

Materials and methods

Study design

This study is a retrospective cohort study that included pediatric patients aged 6-14 years who received early intervention for dorsal linear scars at Hebei Children's Hospital's plastic surgery department from January 2021 to September 2024. Patients were grouped based on whether they used a skin surface closure device. The experimental group, which received early skin surface closure device combined with PDL treatment, comprised 126 cases. The control group, which only received PDL in conjunction with standard scar care, consisted of 119 cases. The aim was to compare the effects of these two intervention protocols on scar morphologic characteristics, and on clinical symptoms.

Ethical considerations

This study protocol was approved by the Ethics Review Committee of Hebei Children's Hospital as a retrospective observational study. All data were sourced from anonymized historical medical records, and the research process did not involve any additional interventions for patients, posing no potential risks to patient privacy or rights. This study adheres to the Helsinki Declaration and, according to relevant guidelines for retrospective studies, meets the conditions for exemption from obtaining patient informed consent.

Inclusion and exclusion criteria

This study included pediatric patients aged 6 to 14 years who developed fresh linear scars due to elective surgery or clean wounds on the back. All scars were located in high-tension areas such as the scapular region or paraspinal area, with lengths of no less than 3 centimeters, and treatment began within 4 weeks after suture removal.

Patients were excluded if they had active infection or poor wound healing, were currently using or had recently used medications that affect scar healing (such as glucocorticoids), suffered from systemic diseases such as connective tissue disorders or immunodeficiency, had scars that had entered the mature and stable phase, or had a history of allergies to the skin surface closure device or pulsed dye laser components.

Treatment methods for the two groups

Patients in the Pulsed Dye Laser Treatment with Standard Scar Care (PDL-SSC) group received a treatment protocol consisting of pulsed dye laser combined with standard scar care. PDL treatment began during the early stage of scar formation after suture removal, with treatment intervals of approximately 4 to 6 weeks, and a total of 4 to 6 treatments were completed based on the scar's response. Standard care mainly included guiding patients to use silicone gel or silicone sheets long-term, strict sun protection to avoid pigmentation.

Patients in the Early Intervention with Surface Skin Closer and Pulsed Dye Laser (EI-SSC+PDL) group received an early combined treatment protocol. Within the early post-suture removal period (within 2 weeks), the skin surface closure device was applied to the normal skin on both sides of the scar. This closure device needed to be worn almost continuously, being briefly removed only for skin cleaning daily. The recommended total wearing duration was 3 to 6 months, aiming to reduce the lateral tension on the scar through sustained mechanical relief. PDL treatment was also used concurrently, with its treatment cycle, number of sessions, and parameter settings consistent with those of the PDL-SSC group.

Data collection

Baseline data: All baseline demographic and clinical characteristic data in this study were collected by systematically reviewing the patients' electronic medical records. Patient age, gender, and height and weight data were extracted from admission registration records. The cause of scar formation (trauma or elective surgery), exact location (classified as scapular region, paraspinal area, or other regions), and the specific date of suture removal were clarified through surgical records and outpatient medical records. Additionally, statements regarding the presence of a family history of hypertrophic scars and personal medical history were extracted from admission interviews or specialized scar assessment forms.

Scar morphology: The morphologic characteristics of scars were quantified using standardized direct measurement methods. At baseline and 6 months after the start of treatment, measurements were taken using a digital caliper with an accuracy of 1 mm. The maximum straight-line distance between the visually apparent endpoints at both ends of the scar along its long axis was recorded as the length (mm). The maximum width (mm) perpendicular to the long axis was measured at the most prominent or widest part of the scar. The wound length-to-width ratio was calculated by dividing the measured length by the width. All measurements were performed with the patient in a relaxed prone position, and each metric was measured three times, with the average value used for subsequent analysis.

To explore an influence of baseline scar width on treatment effect, patients were divided into a wide scar group (width ≥6 mm) based on the median baseline width (6 mm) of the entire sample for subgroup analysis.

Scar quality: Scar quality was assessed using the Vancouver Scar Scale (VSS), which is based on standardized records completed by attending physicians during regular follow-ups as documented in the medical records [16]. Before treatment and 6 months after the initiation of the respective treatment, a plastic surgeon evaluated the scars through visual inspection and palpation, scoring them on pliability (0-5 points), vascularity (0-3 points), height (0-3 points), and pigmentation (0-3 points). The total VSS score (ranging from 0 to 14 points) was obtained by summing the scores for each dimension, with a lower total score indicating that the scar is closer to normal skin.

Symptom relief: Patient-reported subjective symptoms related to the scars were quantitatively assessed using the Visual Analogue Scale (VAS). In the retrospective data collection. These scores were derived from symptom assessments completed by the children and their parents under the guidance of researchers during outpatient follow-ups. For symptoms such as itching, pain, and abnormal sensations (e.g., prickling, numbness), children marked a point on a straight line labeled from 0 to 10, where 0 indicates no symptoms and 10 represents the most severe symptoms that are intolerable. This assessment was conducted at baseline and during outpatient follow-ups 6 months after the start of the respective treatment. All VAS scores were extracted from the medical record system by the researchers, ensuring that both the children and their parents received a uniform standard explanation before the assessment.

Adverse events: Safety data during treatment were collected by systematically reviewing records of adverse events documented in outpatient medical records. During the 6-month follow-up period after the start of treatment, attending physicians recorded and evaluated the following adverse reactions based on clinical observations. Contact dermatitis/skin irritation was defined as persistent erythema, pruritus, or desquamation at the site where the closure device was applied or where silicone preparations were used. Local blisters specifically referred to small, localized blisters appearing immediately or shortly after PDL treat-

ment within the treated area. Transient hyperpigmentation referred to non-permanent darkening of color in the scar or surrounding skin. Scar infection was diagnosed clinically by the presence of purulent discharge, accompanied by redness, swelling, heat, and pain at the scar site. Red rash was recorded if there were non-specific red macules appearing in the treatment area.

Observer-assessed scar evaluation and parental satisfaction: During the outpatient follow-up 6 months after the start of treatment, the assessment of the children's scars combined objective evaluations by clinicians and subjective feedback from the child's parents. The clinical evaluation used the observer part of the Patient and Observer Scar Assessment Scale (POSAS), where the attending physician quantitatively scored the scar on five dimensions: vascularity, pigmentation, thickness, surface roughness, and pliability/elasticity. Each dimension was scored on a scale from 1 (close to normal skin) to 10 (worst), with a total score range of 5 to 50 [17].

The child's primary caregiver was invited to complete an independent satisfaction survey, which used a Likert scale with five levels: "very dissatisfied", "somewhat dissatisfied", "neutral", "satisfied", and "very satisfied" to assess their overall satisfaction with the treatment outcome.

Statistical analysis

All statistical analyses for this study were performed using R language (version 4.3.1, R Foundation for Statistical Computing, Austria). Continuous data are presented as mean ± standard deviation, while categorical data are presented as counts (percentages). Continuous variables that conform to a normal distribution were compared using independent samples t-tests. Categorical variables were analyzed using chi-square tests or Fisher's exact tests where appropriate. All statistical tests were two-tailed, with a significance level set at $P<0.05$.

Results

Baseline demographics and clinical characteristics

In the comparison of baseline demographics and clinical characteristics between the PDL-SSC group and the EI-SSC+PDL group, no significant differences were observed in age ($P=0.379$), gender distribution ($P=0.708$), cause distribution between trauma and surgery ($P=0.994$), BMI ($P=0.422$), scar location distribution across scapular area, paraspinal, and other regions ($P=0.895$), days since suture removal ($P=0.513$), family history of hypertrophic scarring ($P=0.879$), or personal history of hypertrophic scarring ($P=0.759$). These results suggesting comparability between the groups for further investigation into the effects of treatments on hypertrophic scarring (**Table 1**).

Scar morphologic outcomes

Regarding changes in scar morphology, no significant differences were observed between the two groups before treatment in terms of length ($P=0.734$), width ($P=0.514$), and wound length-to-width ratio ($P=0.753$). After treatment, there were still no significant differences in length ($P=0.376$) and wound length-to-width ratio ($P=0.540$) between the two groups. However, in terms of width, the EI-SSC+PDL group showed a significantly smaller width compared to the PDL-SSC group ($P<0.001$). This indicates that after receiving treatment, the EI-SSC+PDL group demonstrated superior effectiveness in reducing scar width (**Table 2**).

In the comparison of scar width before and after treatment in the wide scar subgroup, no significant difference was observed between the PDL-SSC and EI-SSC+PDL groups at baseline ($P=0.861$). Post-treatment, a significant difference was noted, with the PDL-SSC group showing a larger increase in scar width compared to the EI-SSC+PDL group ($P<0.001$). This suggests that the EI-SSC+PDL treatment may be more effective in controlling scar widening compared to PDL-SSC alone. These findings highlight the benefits of the EI-SSC+PDL approach for managing scar width (**Table 3**).

Scar quality assessment: Vancouver scar scale

No significant differences were observed between the two groups in terms of scar pliability ($P=0.598$), vascularity ($P=0.679$), height ($P=0.715$), pigmentation ($P=0.619$), or total score ($P=0.636$) for baseline VSS scores. This indicates that the two groups had similar baseline levels of scar quality before treatment, providing a good premise for subsequent efficacy comparisons (**Table 4**).

Table 1. Comparison of baseline demographic and clinical characteristics

Measure	PDL-SSC (n=119)	EI-SSC+PDL (n=126)	t/χ^2	P
Age	9.92 ± 1.34	9.76 ± 1.52	0.881	0.379
Gender (Female/Male)	51 (42.86%)/68 (57.14%)	57 (45.24%)/69 (54.76%)	0.141	0.708
Cause (%) (Trauma/Surgery)	50 (42.02%)/69 (57.98%)	53 (42.06%)/73 (57.94%)	0.000	0.994
BMI	16.67 ± 2.65	16.40 ± 2.53	0.804	0.422
Scar Location			0.223	0.895
Scapular Area	60 (50.42%)	65 (51.59%)		
Paraspinal	55 (46.22%)	58 (46.03%)		
Other	4 (3.36%)	3 (2.38%)		
Days Since Suture Removal	10.26 ± 2.10	10.45 ± 2.34	0.656	0.513
Family History of Hypertrophic Scarring	7 (5.88%)/112 (94.12%)	8 (6.35%)/118 (93.65%)	0.023	0.879
Personal History of Hypertrophic Scarring	10 (8.40%)/109 (91.60%)	12 (9.52%)/114 (90.48%)	0.094	0.759

PDL-SSC: Pulsed Dye Laser Treatment with Standard Scar Care; EI-SSC+PDL: Early Intervention with Surface Skin Closer and Pulsed Dye Laser; BMI: Body Mass Index.

Table 2. Changes in scar morphologic indices

Measure	PDL-SSC (n=119)	EI-SSC+PDL (n=126)	t	P
At Baseline				
Length (mm)	45.54 ± 8.84	45.17 ± 8.36	0.340	0.734
Width (mm)	5.68 ± 0.73	5.74 ± 0.79	0.653	0.514
Wound Length-to-Width Ratio	7.94 ± 1.91	7.86 ± 1.85	0.315	0.753
Post-Treatment				
Length (mm)	43.29 ± 8.73	42.33 ± 8.28	0.888	0.376
Width (mm)	7.71 ± 0.57	7.48 ± 0.48	3.427	<0.001
Wound Length-to-Width Ratio	5.54 ± 1.29	5.45 ± 1.15	0.614	0.540

Table 3. Comparison of scar width before and after treatment in the wide scar subgroup (Baseline Width ≥6 mm)

Measure	PDL-SSC (n=54)	EI-SSC+PDL (n=70)	t	P
At Baseline	6.31 ± 0.29	6.30 ± 0.31	0.176	0.861
Post-Treatment	7.80 ± 0.52	7.43 ± 0.50	4.012	<0.001

In the VSS scores at 6 months after treatment, the PDL-SSC group scored significantly higher in scar pliability compared to the EI-SSC+PDL group (P=0.032), and similarly, the PDL-SSC group scored significantly higher in scar height compared to the EI-SSC+PDL group (P<0.001). Although the difference in vascularity between the two groups approached but did not reach statistical significance (P=0.051), no significant difference was observed in pigmentation (P=0.185). In terms of total score, the PDL-SSC group was also significantly higher than the EI-SSC+PDL group (P=0.026). These results indicate that at 6 months post-treatment, the EI-SSC+PDL group showed superior performance in reducing scar height and improving pliability, suggesting that this combined therapy may have advantages in improving scar quality (**Table 5**).

Subjective symptom relief

Regarding the VAS scores for scar-related symptoms, there were no significant differences between the PDL-SSC group and the EI-SSC+PDL group before treatment in terms of itching (P=0.893), pain (P=0.633), and abnormal sensations (P=0.492). After treatment, the PDL-SSC group had significantly higher scores than the EI-SSC+PDL group in itching (P=0.002), pain (P=0.003), and abnormal sensations (P< 0.001). These results suggest that the EI-SSC+

Table 4. Baseline Vancouver scar scale scores

Measure	PDL-SSC (n=119)	EI-SSC+PDL (n=126)	t	P
Pliability	3.13 ± 0.64	3.08 ± 0.79	0.527	0.598
Vascularity	1.85 ± 0.47	1.83 ± 0.43	0.415	0.679
Height	1.48 ± 0.46	1.51 ± 0.52	0.366	0.715
Pigmentation	2.04 ± 0.63	2.08 ± 0.59	0.497	0.619
Total	8.43 ± 1.11	8.36 ± 1.16	0.474	0.636

Table 5. Vancouver scar scale scores at 6 months post-treatment

Measure	PDL-SSC (n=119)	EI-SSC+PDL (n=126)	t	P
Pliability	0.42 ± 0.21	0.37 ± 0.18	2.157	0.032
Vascularity	0.61 ± 0.26	0.54 ± 0.24	1.964	0.051
Height	1.12 ± 0.59	0.85 ± 0.31	4.543	<0.001
Pigmentation	0.97 ± 0.24	0.93 ± 0.19	1.330	0.185
Total	3.12 ± 1.62	2.69 ± 1.34	2.243	0.026

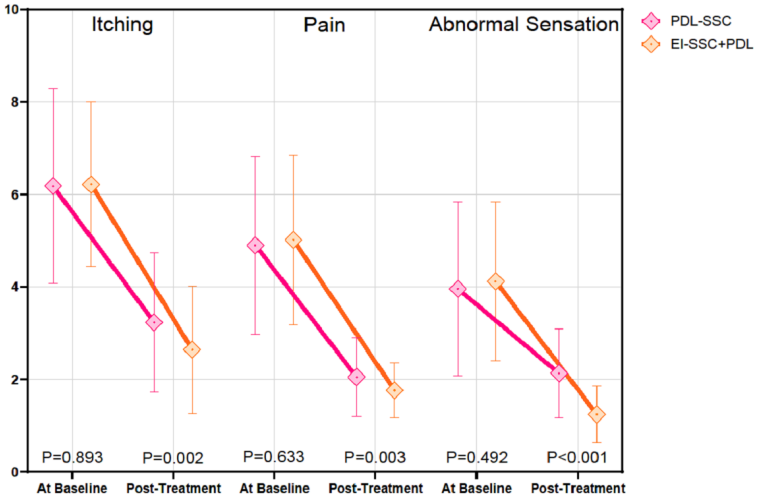

Figure 1. Visual analogue scale scores for scar-related symptoms. PDL-SSC: Pulsed Dye Laser Treatment with Standard Scar Care; EI-SSC+PDL: Early Intervention with Surface Skin Closer and Pulsed Dye Laser.

PDL therapy may have better efficacy in reducing itching, pain, and abnormal sensations caused by scars (**Figure 1**).

Safety profile

During the 6-month treatment period, there were no significant differences between the PDL-SSC group and the EI-SSC+PDL group in terms of contact dermatitis/skin irritation (P=0.423), local blisters (laser-related) (P=0.655), transient hyperpigmentation (P=0.569), scar infection (P=0.977), and red rash (P=0.818) for the incidence of adverse events. This indicates that the two groups experienced similar rates of adverse events during the treatment process (**Table 6**).

Observer-assessed scar evaluation and parental satisfaction

At the 6-month post-treatment assessment, observer scar evaluation and parental satisfaction showed that the PDL-SSC group had significantly higher POSAS scores than the EI-SSC+PDL group (P=0.002), indicating that according to the physicians' assessments, the scar conditions in the PDL-SSC group were relatively worse. In terms of parental satisfaction, there was also a significant difference between the two groups (P=0.026). Compared to the PDL-SSC group, a higher proportion of parents in the EI-SSC+PDL group reported being very satisfied, while fewer parents expressed dissatisfaction or neutrality regarding the treatment outcome. These results suggest that the EI-SSC combined with PDL therapy not only received higher evaluations from doctors in terms of improving scar appearance, but also achieved greater parental satisfaction (**Figure 2**).

Discussion

This retrospective cohort study provides clinical evidence supporting the synergistic benefits of early mechanical offloading through a skin surface closure device combined with PDL treatment for pediatric dorsal linear scars in high-tension areas. The findings indicate that this dual-pathway strategy, which addresses both the biochemical and biomechanical drivers of scar formation, yields superior outcomes across multiple dimensions without increasing

Table 6. Incidence of adverse events during the 6-month treatment period

Measure	PDL-SSC (n=119)	EI-SSC+PDL (n=126)	χ^2	P
Contact Dermatitis/Skin Irritation	13 (10.92%)/106 (89.08%)	10 (7.94%)/116 (92.06%)	0.642	0.423
Local Blisters (Laser-related)	2 (1.68%)/117 (98.32%)	2 (1.59%)/124 (98.41%)	0.200	0.655
Transient Hyperpigmentation	14 (11.76%)/105 (88.24%)	12 (9.52%)/114 (90.48%)	0.324	0.569
Scar Site Infection	1 (0.84%)/118 (99.16%)	0 (0.00%)/126 (100.00%)	0.000	0.977
Red Rash	4 (3.36%)/115 (96.64%)	6 (4.76%)/120 (95.24%)	0.053	0.818

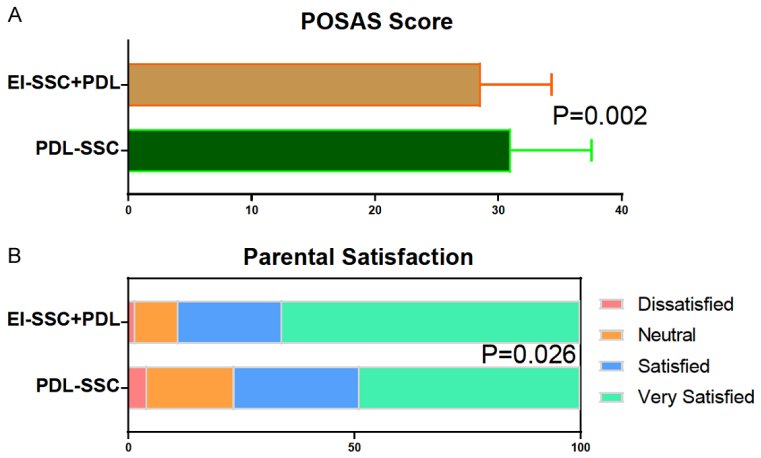

Figure 2. Observer scar assessment and parental satisfaction at 6 months after treatment. A. POSAS Score; B. Parental Satisfaction. POSAS: Patient and Observer Scar Assessment Scale.

the risk of adverse events. The therapeutic advantage appears to stem from a fundamental disruption of the mechanobiological feedback loops that propagate pathologic scar remodeling.

The most immediate morphologic benefit observed was the reduction in scar width in the combined treatment group. Previous studies have shown that mechanical tension can perpetuate fibroblast activation and extracellular matrix deposition through mechanotransduction pathways such as focal adhesion kinase and TGF-β signaling [18]. By applying the skin surface closure device immediately after suture removal, this study effectively interrupted this harmful feedback loop, thereby blocking mechanically-driven pro-fibrotic stimuli at the source of signal transduction, thus limiting lateral scar expansion. While PDL modulates angiogenesis and collagen turnover, it does not directly counteract these physical forces [19]. Therefore, our findings highlight the critical limitations of purely biochemical interventions and validate the principle that sustained mechanical offloading during the early remodeling phase is essential to prevent scar widening. Previous studies on other anatomic sites using tape or tension-releasing sutures have hinted at this effect, but our data provide robust quantitative confirmation for the challenging region of the back in children, where significant dynamic tension exists [20]. Further subgroup analysis showed that this reduction in width was still notable in patients with wider baseline scars, suggesting that mechanical offloading may be particularly valuable for high-risk scar populations, providing a basis for the development of personalized treatment strategies.

In addition to width, the comprehensive intervention demonstrated more pronounced improvement in overall scar quality as measured by the VSS, particularly in terms of scar height and pliability. This can be attributed to the vascular-targeting effects of PDL. By selectively photothermally decomposing hemoglobin-rich vessels, PDL can reduce erythema and modulate inflammatory mediators, a process that may also indirectly affect the infiltration and function of local immune cells, creating a more favorable environment for scar remodeling [21]. The reduction in scar height may reflect decreased fibroblast activity and collagen accumulation, which are direct downstream effects of reduced mechanotransduction signaling [22]. It is well known that mechanical stress activates pro-fibrotic pathways, including TGF-β1/Smad and FAK-ERK-MAPK, promoting hypertrophic phenotypes [23]. By reducing mechanical input, the closure device can directly downregulate the activity of these mechanically-sen-

sitive pathways, thereby decreasing contractile forces within the scar and preventing excessive collagen synthesis. This creates a cellular environment more conducive to the vascular regression and collagen remodeling effects of PDL. The superior flexibility further supports this, indicating that the scar matrix is softer and more pliable under the synergistic effect of tension relief and laser refinement. This synergistic effect on quality metrics extends the findings of studies using laser or silicone monotherapy, suggesting that biomechanical interventions enhance their efficacy in improving scar architecture [24].

In the combined treatment group, the relief of itching, pain, and abnormal sensations highlighted the functional benefits of addressing both the biomechanical and vascular factors of scar pathology. Pruritus and pain in hypertrophic scars are associated with neurogenic inflammation, aberrant innervation, and the release of histamine and neuropeptides, processes influenced by mechanical stress and inflammatory mediators [25]. The selective photothermal decomposition of microvessels by PDL can reduce neurogenic inflammation [26]. Mechanical offloading contributes further by decreasing ischemia-reperfusion injury at the scar margins and reducing physical irritation of nerve endings embedded in the stiff collagen matrix [27]. The impact on abnormal sensations may be related to reduced skin nerve tension. These findings are consistent with previous studies, indicating that early laser intervention can enhance tissue elasticity and reduce scar-related pain and pruritus, especially when combined with compression or tension-modulating strategies [28].

The incidence of adverse events was comparable between the two groups, indicating that adding the mechanical closure device does not increase the risk of complications such as contact dermatitis, blisters, or hyperpigmentation. This safety profile is crucial for pediatric populations, where treatment tolerance and compliance are essential [29].

In the combined treatment group, higher observer POSAS scores and greater parental satisfaction integrated both objective and subjective benefits into a global assessment of success. Clinicians noted better vascularity, thickness, and pliability, which directly correlated with quantitative VSS. High parental satisfaction is particularly important in pediatric care, reflecting not only improvements in appearance but also relief of discomfort for the child and compliance with a clearly defined management plan [30]. We included rigorous caregiver satisfaction reports, aligning with contemporary value-based care models that emphasize patient and family experience [31].

This study has several limitations that must be acknowledged. Despite statistical comparability at baseline, due to its retrospective design, this study showed associations, not causality. Lack of randomization introduces selection and performance biases, and unmeasured confounders may affect results. Symptom and satisfaction assessments are prone to recall and reporting biases. Assessments of symptoms and satisfaction, while based on standardized scales, are subject to recall and reporting biases inherent in retrospective chart reviews. As a single-center study, the generalizability of the findings may be limited to other populations or healthcare settings. A 6-month follow-up period, although sufficient to evaluate early remodeling, was insufficient to assess long-term scar maturation, stability, and the potential for late recurrence of hypertrophy or contracture. Scar maturation can continue over a much longer period.

Future studies should address these limitations through prospective, randomized, multicenter trials with longer follow-up periods. Incorporating non-invasive biomarkers, such as high-frequency ultrasound for skin density or tricolor analysis via reflectance confocal microscopy, could provide deeper structural correlations. Additionally, future studies should explore the combined treatment's effects on the local immune microenvironment. Clinical trials should include scar tissue sampling to detect changes in immune markers using techniques like immunohistochemistry or single-cell sequencing, clarifying the molecular mechanisms of synergistic anti-fibrotic effects. More refined neuropathic symptom assessment tools can also be adopted to distinguish between different types of sensory abnormalities such as stinging, numbness, and burning sensations, thereby addressing the limitations of the VAS in assessing sensory dimensions. Investigating the optimal duration of closure

device wear and its interaction with different laser parameters would refine this protocol.

Conclusion

The early integration of a skin surface closure device with PDL treatment appears to offer a synergistic approach for managing linear scars prone to tension in children. By addressing mechanical pathogenic factors, this combination may be associated with enhanced efficacy of existing biophotonic therapies, correlating with narrower, softer, and more elastic scars, fewer symptoms, and higher satisfaction. These findings suggest that this combined modality could be considered as an intensified regimen for preventing adverse outcomes in pediatric dorsal scars, although further prospective studies are warranted to confirm causal relationships.

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Disclosure of conflict of interest

None.

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