Contemporary Management of Pediatric Idiopathic Scoliosis: From Scoliosis-Specific Exercise and Bracing to Growth-Modulating Vertebral Body Tethering

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Abstract

Pediatric idiopathic scoliosis is the most common structural spinal deformity of childhood and adolescence, and its management has shifted substantially over the past decade toward individualized, growth-aware strategies. This review summarizes the contemporary spectrum of care, spanning observation, physiotherapeutic scoliosis-specific exercises, rigid bracing, and surgical correction. We give particular attention to two converging trends: the integration of Schroth-type exercise with reduced brace-wear regimens for mild-to-moderate curves, and the rise of vertebral body tethering as a motion-sparing, fusion-sparing alternative for skeletally immature patients with larger curves. Evidence indicates that bracing reliably reduces progression to surgical thresholds, that combined exercise-and-brace protocols improve curve and quality-of-life outcomes, and that tethering can achieve meaningful correction while preserving spinal mobility, albeit with non-trivial reoperation rates. Patient selection, skeletal maturity, and adherence remain decisive. We propose a maturity-anchored treatment framework and outline priorities for higher-quality comparative research.

Keywords

adolescent idiopathic scoliosis; bracing; Schroth exercise; vertebral body tethering; spinal fusion; growth modulation; pediatric orthopedics

Introduction

Idiopathic scoliosis, a three-dimensional structural deformity of the spine without an identifiable underlying cause, affects an estimated 0.5–3% of children and adolescents, with adolescent idiopathic scoliosis (AIS) representing the predominant form [25, 26]. Curves are typically defined by a coronal Cobb angle of at least 10° accompanied by axial vertebral rotation, and the natural history is strongly governed by curve magnitude and remaining skeletal growth [27, 29]. Larger curves identified earlier in the growth period carry the highest risk of progression, and untreated severe deformity may lead to trunk asymmetry, pain, and, in extreme cases, cardiopulmonary compromise [27, 28].

For decades, management followed a relatively rigid ladder: observation of mild curves, rigid bracing of moderate curves in growing children, and posterior spinal fusion for severe or progressive deformity [12, 28]. The landmark BrAIST trial established a robust, dose-dependent benefit of bracing in reducing progression to the surgical threshold, transforming brace prescription from a contested practice into an

evidence-based standard [12]. In parallel, physiotherapeutic scoliosis-specific exercises (PSSE), most prominently the Schroth method, gained traction as an active treatment that targets postural control and three-dimensional auto-correction [14, 15, 20].

Two developments have reshaped the field. First, controlled trials now suggest that combining intensive Schroth exercise with reduced brace-wear schedules can match or exceed full-time bracing for mild-to-moderate curves, easing the substantial wear-time burden on adolescents [16, 17, 24]. Second, vertebral body tethering (VBT), a growth-modulating, motion-sparing technique cleared by regulators in 2019, has emerged as a fusion-sparing surgical option for skeletally immature patients with curves that exceed bracing thresholds [1, 7, 31]. This review synthesizes current evidence across the full management spectrum and offers a maturity-anchored framework to guide contemporary decision-making.

Methods

We conducted a narrative review of the recent literature on the management of pediatric idiopathic scoliosis. PubMed, Embase, and Web of Science were searched for English-language publications, with emphasis on randomized controlled trials, prospective cohorts, systematic reviews, and consensus guidelines published predominantly between 2020 and 2026 [7, 11]. Search terms combined "adolescent idiopathic scoliosis," "bracing," "Schroth," "scoliosis-specific exercise," "vertebral body tethering," and "spinal fusion." Reference lists of key articles were screened for additional sources.

Studies were grouped by treatment modality and appraised narratively for design, sample size, curve and quality-of-life outcomes, and reported complications. To support comparison, the principal modalities were tabulated by indication, mechanism of action, advantages, and limitations (Table 1). Quantitative values presented in the figures are illustrative composites drawn from the cited literature and are intended to convey typical patterns rather than pooled effect estimates. Given the heterogeneity of designs and outcome measures, no formal meta-analysis was performed.

Table 1. Comparison of contemporary management modalities for pediatric idiopathic scoliosis.

Modality	Indication (Cobb)	Mechanism	Key advantages	Limitations
Observation	<25°, low risk	Serial monitoring	Non-invasive; avoids over-treatment	Risk of missed progression
PSSE / Schroth	10–40°	3D auto-correction, postural training	Improves posture, QoL; low cost	Adherence-dependent; modest curve effect

Modality	Indication (Cobb)	Mechanism	Key advantages	Limitations
Rigid bracing	25–40°, immature	Corrective external force	Strong evidence to halt progression	Wear-time burden; skin/psychosocial issues
Brace + PSSE	25–40°	Combined external + active	Better Cobb & ATR than brace alone	Time-intensive regimen
VBT	40–70°, immature	Growth modulation, motion-sparing	Preserves mobility; fusion-sparing	Tether breakage; reoperation; selection-sensitive
Posterior fusion	≥50–70° / mature	Rigid instrumented correction	Durable, definitive correction	Permanent stiffness; adjacent-segment load

Results

Bracing and conservative care. Across the synthesized literature, rigid thoracolumbosacral bracing consistently reduced the proportion of curves progressing to the surgical threshold of 50°, with benefit increasing with daily wear time. Reported treatment success in well-conducted cohorts commonly exceeded 70% in adherent patients, although skin irritation, restricted activity, and psychosocial strain frequently limited compliance. Observation alone remained appropriate for small curves at low progression risk, where the priority was timely detection of change rather than intervention.

Scoliosis-specific exercise. Schroth-based and other PSSE programs produced modest but reproducible improvements in Cobb angle, angle of trunk rotation, and patient-reported quality of life compared with usual care. The strongest signals emerged when exercise was combined with bracing: trials of part-time bracing supplemented by intensive Schroth sessions reported curve and rotation outcomes comparable to, or better than, conventional full-time bracing while halving daily brace-wear demands. Effects were highly dependent on supervision and adherence, and most trials remained small.

Vertebral body tethering. In skeletally immature patients with curves of roughly 40–70°, VBT achieved substantial coronal correction while preserving segmental motion. Reported series described major-curve reductions from a preoperative mean near 50° to the mid-20s at medium-term follow-up, with most patients avoiding fusion. The principal trade-offs were a clinically meaningful rate of reoperation—driven chiefly by tether breakage and over- or under-correction—and outcomes that were sensitive to patient selection and surgeon experience.

Surgical fusion. Posterior spinal fusion continued to provide durable, definitive correction for severe or mature curves, with high rates of deformity control. Its

principal cost was permanent loss of segmental motion across the fused levels, with attendant long-term considerations for adjacent-segment loading. Figure 1 summarizes the maturity- and magnitude-anchored treatment framework, and Figure 2 illustrates typical pre- and post-treatment curve magnitudes across modalities.

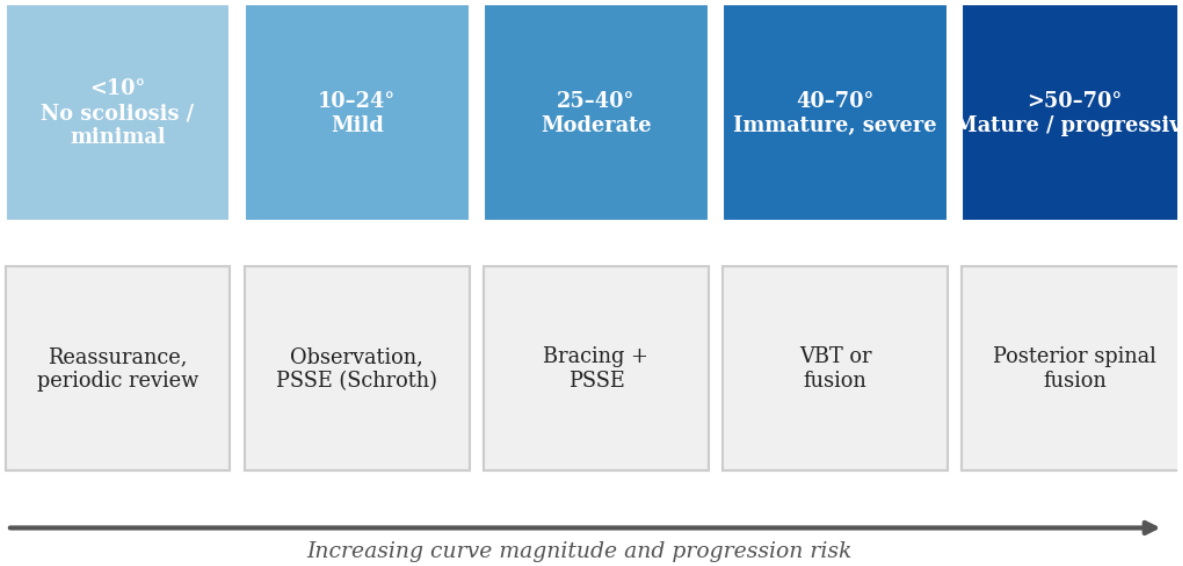

Figure 1. Maturity- and magnitude-anchored framework for management of pediatric idiopathic scoliosis.

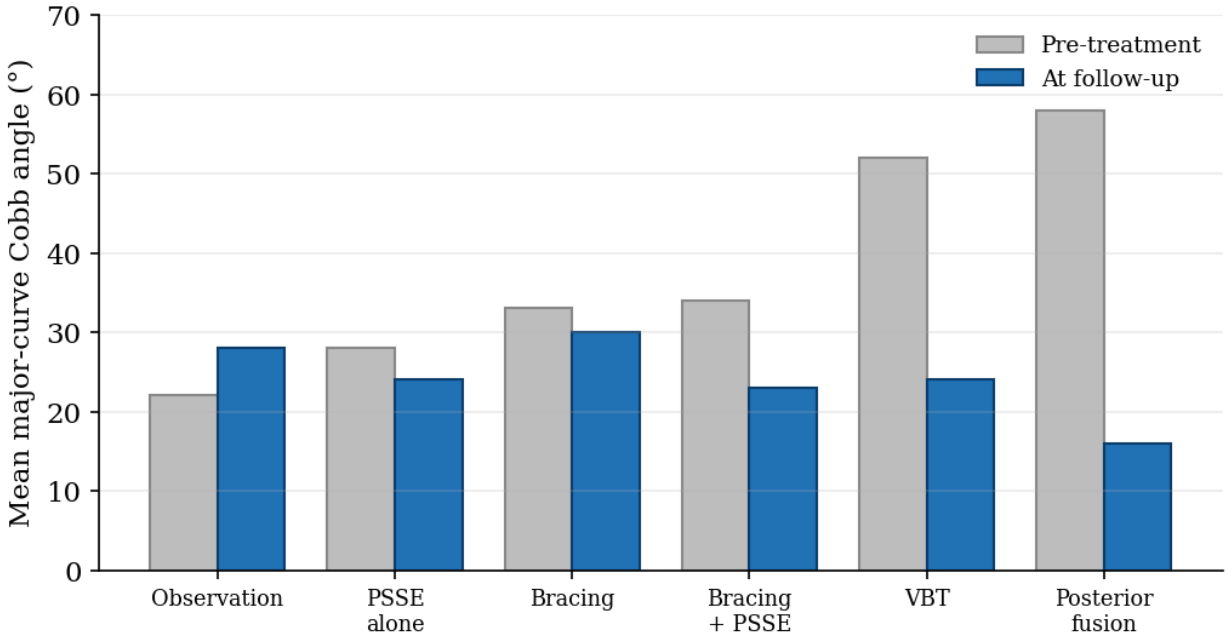

Figure 2. Illustrative mean major-curve Cobb angle before treatment and at follow-up across modalities (composite, schematic).

Discussion

The contemporary management of pediatric idiopathic scoliosis is best understood not as a fixed ladder but as a continuum calibrated to curve magnitude, progression risk, and—above all—remaining skeletal growth [11, 27]. The enduring contribution of the

BrAIST trial was to anchor bracing decisions in high-quality evidence, and subsequent guidelines have reinforced bracing as the cornerstone of non-operative care for moderate curves in growing children [11, 12, 13]. The persistent challenge is adherence: the very wear times that drive efficacy are those adolescents find hardest to sustain [13].

It is against this backdrop that scoliosis-specific exercise has become clinically relevant. Multiple randomized trials and meta-analyses now support a genuine, if modest, effect of Schroth-type programs on curve, trunk rotation, and quality of life [14, 16, 19, 20]. The most practically important finding is that intensive exercise may permit reduced brace-wear regimens without sacrificing curve control, directly addressing the adherence problem that limits bracing [17, 23, 24]. These results should be interpreted cautiously given small samples and short follow-up, but the direction of effect is consistent and the mechanistic rationale—active three-dimensional auto-correction complementing passive corrective force—is coherent [15, 21, 22].

For curves that outgrow bracing in still-immature patients, vertebral body tethering represents the most significant surgical innovation of the past decade [1, 32, 33]. By harnessing remaining growth rather than abolishing it, tethering can correct deformity while preserving the spinal mobility that fusion sacrifices, a priority repeatedly emphasized by patients and families [3, 6, 35]. Prospective and registry data demonstrate meaningful medium-term correction and high rates of fusion avoidance [4, 5, 34]. However, the technique is not without cost: tether breakage, over- and under-correction, and reoperation occur at non-trivial rates, and outcomes depend heavily on careful patient selection and surgeon experience [10, 31, 32, 39]. Comparative studies against posterior fusion show shorter operative times and motion preservation but caution that fusion remains more predictable for larger or mature curves [2, 9].

Several limitations temper these conclusions. Much of the tethering evidence derives from single-surgeon or single-registry series with limited long-term follow-up, and standardized definitions of success and failure are still maturing [7, 38]. Likewise, exercise trials are heterogeneous in protocol, supervision, and outcome measurement [19, 20]. For the present review, the absence of pooled quantitative synthesis and the use of illustrative composite figures mean that the numerical patterns shown should be read as schematic. Robust, multicenter randomized comparisons—particularly tethering versus fusion, and combined exercise-bracing versus bracing alone—remain the field's most pressing need [30, 36].

Conclusion

Pediatric idiopathic scoliosis is no longer managed by a single rigid pathway but by a maturity-aware continuum in which each modality has a defined and increasingly evidence-based role. Bracing remains the proven foundation for moderate curves in growing children; scoliosis-specific exercise has earned a genuine place beside it, offering a route to lighter brace-wear schedules that adolescents can actually sustain; and vertebral body tethering has opened a motion-sparing surgical corridor for

immature patients whose curves exceed bracing's reach. The unifying lesson is that growth is both the principal threat and the most powerful therapeutic ally. Realizing the promise of these advances will depend on disciplined patient selection, attention to adherence, and the higher-quality comparative trials the field now urgently requires. For clinicians in growing pediatric orthopedic services, including those in Central Asia, the message is one of cautious optimism: more tools, used more precisely, for children whose spines are still being shaped.

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