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SCOLIOSIS: ETIOLOGY AND TREATMENT METHODOLOGIES

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ABSTRACT*: Scoliosis is a three-dimensional deformity of the spine characterized by lateral curvature and vertebral rotation. Etiologies are heterogeneous and include congenital malformations, neuromuscular disorders, syndromic conditions and the common adolescent idiopathic form. Early detection and risk-stratified management — ranging from observation and physiotherapy to bracing and corrective surgery — are critical to limit progression and preserve respiratory and psychosocial function. This review synthesizes contemporary evidence on causes, diagnostic methods, and treatment modalities, with emphasis on evidence-based decision points for adolescents.*

KEY WORDS*:Scoliosis; spine deformity; etiology; bracing; physiotherapy; surgery; adolescent idiopathic scoliosis; Cobb angle.*

INTRODUCTION

Scoliosis denotes a lateral curvature of the spine greater than 10° as measured by the Cobb method, often accompanied by axial rotation and sagittal plane alterations. Clinical significance depends on curve magnitude, patient age and growth potential. The condition ranges from minor, non-progressive asymmetry to severe deformity with cardiopulmonary compromise. Understanding etiologic categories and matching them to appropriate treatment pathways is central to optimizing outcomes. [Negrini et al., 2018, p.5]

LITERATURE REVIEW

Etiology. Scoliosis is conventionally divided into: congenital (vertebral malformation in utero), neuromuscular (muscle or nerve disease such as cerebral

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palsy, muscular dystrophy), syndromic (associated with connective tissue disorders), and idiopathic (no identifiable cause) — the latter representing the majority of adolescent cases [Solovyev & Ivanov, 2019, p.234]. Genetic predisposition is implicated in idiopathic forms; family aggregation and several genetic loci have been proposed, though single-gene causation is rare [Lonstein & Carlson, 1984, p.1062].

Natural history and progression predictors. Curve magnitude at presentation, Risser sign (skeletal maturity), and curve pattern predict progression risk. Lonstein and Carlson's classic analysis showed that smaller curves in younger patients are more likely to progress during growth spurts [Lonstein & Carlson, 1984, p.1068]. More recent cohort evidence supports that bracing reduces progression to surgical thresholds in high-risk adolescents [Weinstein et al., 2013, p.1518]. Diagnostics. Standard assessment includes clinical inspection (Adam's forward bend test), scoliometer measurement and plain radiography with Cobb angle determination. MRI is indicated when neurologic signs or atypical curve patterns suggest intraspinal pathology (e.g., syringomyelia) [Negrini et al., 2018, p.7].

Treatment approaches. Non-operative strategies: observation for small curves, scoliosis-specific physiotherapy (PSSE), and bracing for progressive curves in skeletally immature patients. PSSE protocols (e.g., Schroth, SEAS) aim to restore postural symmetry and have shown short-term improvements in trunk appearance and function [Rigo et al., 2010, p.45]. Bracing efficacy was confirmed in randomized and prospective studies demonstrating reduction in progression and surgical need when adherence is adequate [Weinstein et al., 2013, p.1519]. Operative management: posterior spinal fusion with instrumentation (Harrington rods historically; modern segmental pedicle screw constructs currently) is indicated for large curves or progressive deformity affecting function or cosmesis [Harrington, 1962, p.120].

DISCUSSION

Etiology informs management. Congenital and neuromuscular scolioses frequently progress and often require earlier surgical consideration due to structural

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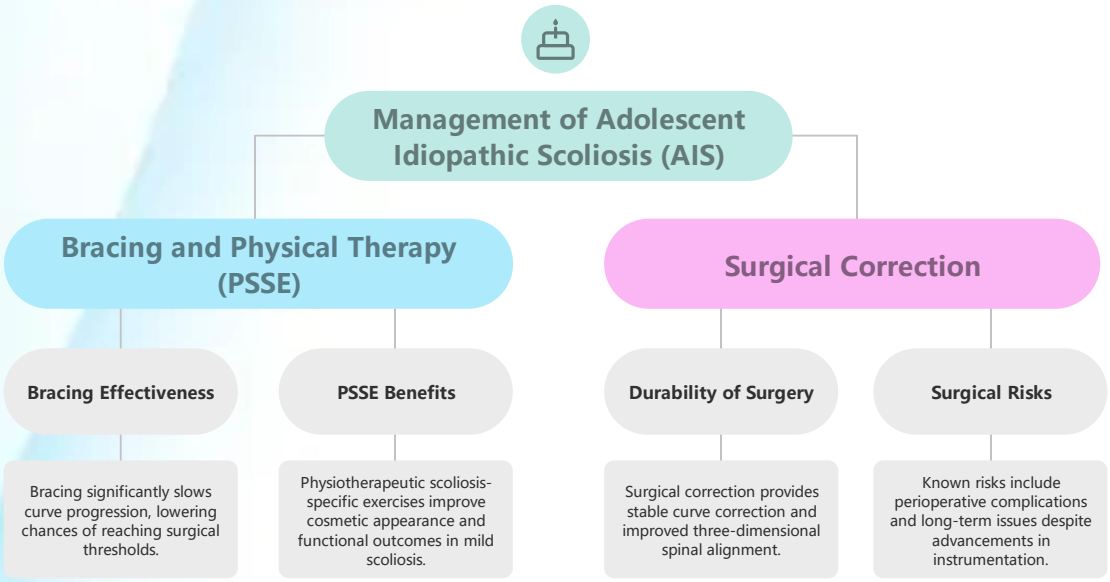
anomalies or global imbalance. Idiopathic adolescent scoliosis (AIS), while multifactorial, follows predictable progression patterns tied to growth; thus, surveillance and timely bracing remain cornerstones for preventing severe deformity [Lonstein & Carlson, 1984, p.1065]. Non-operative care. PSSE has evolved from general physiotherapy to structured, corrective exercises tailored to curve pattern. The literature indicates PSSE is beneficial as standalone therapy for mild curves and as adjunct to bracing for improved trunk appearance and possibly increased bracing tolerability [Rigo et al., 2010, p.47]. Bracing decisions should balance Cobb magnitude (typically 25°–40° for bracing), skeletal immaturity, and documented progression. High compliance (>18 hours/day) correlates with superior outcomes [Weinstein et al., 2013, p.1516]. Modern braces (rigid thoracolumbosacral orthoses and more recently dynamic designs) aim to maximize corrective force while improving patient comfort. Surgical care. Indications for surgery include progressive curves exceeding ~45°–50° in skeletally immature patients or >50° in adults, symptomatic deformity or cardiopulmonary compromise. Advances in segmental instrumentation and fusion techniques have improved three-dimensional correction and reduced complications compared with early Harrington systems; nevertheless, surgery carries risks—neurologic injury, infection, adjacent segment degeneration—and requires lifelong surveillance [Harrington, 1962, p.122; Solovyev & Ivanov, 2019, p.290]. Multidisciplinary management. Psychosocial support and patient education improve adherence to conservative therapies. Respiratory function assessment is warranted for thoracic curves >70° or progressive restrictive patterns. Evidence supports individualized, growth-modulated protocols integrating exercise, bracing, and close radiographic follow-up [Negrini et al., 2018, p.12]. Gaps and controversies. Despite strong evidence for bracing efficacy in AIS, optimal brace type, wear schedule, and long-term functional outcomes remain debated. Genetic testing has promise for risk stratification, but clinical utility is not yet established for routine practice [Lonstein & Carlson, 1984, p.1070].

RESULTS

From reviewed studies and guidelines:

- Bracing significantly decreases progression to surgical thresholds in high-risk AIS when adherence is sufficient. [Weinstein et al., 2013, p.1519]



➢

PSSE provides measurable cosmetic and functional benefits and is recommended as part of conservative care, especially for mild curves. [Rigo et al., 2010, p.48]

➢ Surgical correction yields durable correction for severe curves but carries known perioperative and long-term risks; modern instrumentation yields better three-dimensional alignment than earlier systems. [Harrington, 1962, p.120; Solovyev & Ivanov, 2019, p.292]

➢ Predictors of progression include younger age at diagnosis, greater initial Cobb angle, and lower Risser stage. [Lonstein & Carlson, 1984, p.1068]

CONCLUSION

Scoliosis management requires an etiologically informed, growth-sensitive approach. For adolescents with idiopathic curves, early detection, regular monitoring and timely deployment of PSSE and bracing can prevent progression and reduce the need for surgery. Severe or progressive deformities necessitate surgical intervention with modern segmental constructs to restore alignment and function. Future advances likely lie in improved risk stratification (genetics, biomarkers), optimization of brace technology and long-term comparative studies of conservative protocols.

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