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Modern Management of Adolescent Idiopathic Scoliosis: Where Do We Stand?

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Abstract

The management of adolescent idiopathic scoliosis is inherently complex which includes observation, orthosis and operation. This is dependent on patient demographics, aetiology and potential for progression leading to adverse effects on function and quality of life. Exercise and physiotherapy regimes can delay the progression of disease by providing functional mobility. Spinal brace therapy can stabilise and prevent progression of curvature. Exercise and brace therapy can be combined for conservative management to prevent requirement for invasive surgery. Surgical intervention can offer definitive treatment for scoliosis with correction of the deformity, but endures high risk. Modern surgical technologies including magnetic growth rods and non-fusion methods can improve prognostic outcomes and reduce complications. School screening programs can potentially identify patients with adolescent idiopathic scoliosis viable for conservative treatment prior to disease progression requiring surgery. We summarize the assessment and current concepts of management of scoliosis in the modern day.

Keywords: Adolescent Idiopathic Scoliosis; Orthosis; School Screening Programs

Abbreviations: AIS: Adolescent Idiopathic Scoliosis; SOSORT: International Scientific Society on Scoliosis Orthopaedic and Rehabilitation Treatment; SEAS: Scientific Exercise Approach to Scoliosis; UKNSC: United Kingdom National Screening Committee; MAGEC: Magnetically Controlled Growth Rod Systems

Introduction

Galen first coined the term "scoliosis" which has an origin from the ancient Greek word "skolios" which translates to crooked/curved. The disease of scoliosis can be defined as the umbrella term for the abnormal lateral curvatures of the spinal segments greater than 10° resulting in a three dimensional deformity [1]. The aetiology of this disorder can be categorized into congenital, neuromuscular, syndromic and idiopathic (Table 1). This developmental disorder affects males primarily in early childhood and females represent up to 90% during adolescence and are associated with greater severity. Adolescent idiopathic scoliosis (AIS) is the most prevalent form of scoliosis which affects up to 3% of the population [2]. The Scoliosis Research Society (SRS) have characterized AIS as presenting in patients aged from 10 years until skeletal maturity with aminimum Cobb angle of 10° on a standing radiograph with accompanying asymmetry with forward bending [3]. The descriptive classification of spinal curvatures in scoliosis was first proposed by Dr Igancio Ponseti in the 1950s which have been subsequently developed by the SRS (Figure 1). The classical patterns of scoliosis are right sided thoracic deformities seen in AIS and left sided deformities seen in juvenile scoliosis [4]. The clinical presentation of AIS can vary depending on its nature and progression. The most widely used grading system for AIS is the Lenke Classification that has three categories: Curve patterns, Lumbar spine modifiers and Sagittal thoracic modifier. This classification helps surgeons in identifying the appropriate instrumentation for surgical interventions [5]. Mild to moderate disease is initially painless, but may become painful with increasing severity. Severe disease (Cobb angle >60°) has the potential to cause thoracic insufficiency syndrome resulting in respiratory complications [6]. The treatment of AIS has traditionally been multidisciplinary and patient centered in modern healthcare [7]. The aims of treatment include maintenance of function, control of symptoms with postural correction, alleviation/prevention of spinal nerve compression and respiratory dysfunction [8]. This clinical review evaluates the current treatment methodologies of AIS. The aim will be to critically evaluate the effectiveness of management strategies from prevention to treatment in current practice and assess whether scoliosis school screening should be reintroduced in the UK.

Methods

We identified high quality literature providing evidence for AIS management. A range of search engines were used including PubMed, NICE Evidence Search and Trip Database. Core literature was obtained from PubMed using Boolean algorithms to refine search. This systematic method is outlined in (Figure 2). The inclusion criteria for this clinical review included the following search terms "Adolescent Idiopathic Scoliosis AND management" with adjuncts using "physiotherapy", "exercise, "brace" and "surgical". These terms were further refined to the

Classification	Vertebral Level
Cervical	C_2 - C_6
Cervicothoracic	C_7 - T_1
Thoracic	T_2 - T_{11}
Thoracolumbar	T_{12} - L_1
Lumbar	L_2 - L_4
Lumbosacral	Below L_4

Figure 1: Scoliosis Research Society Classification

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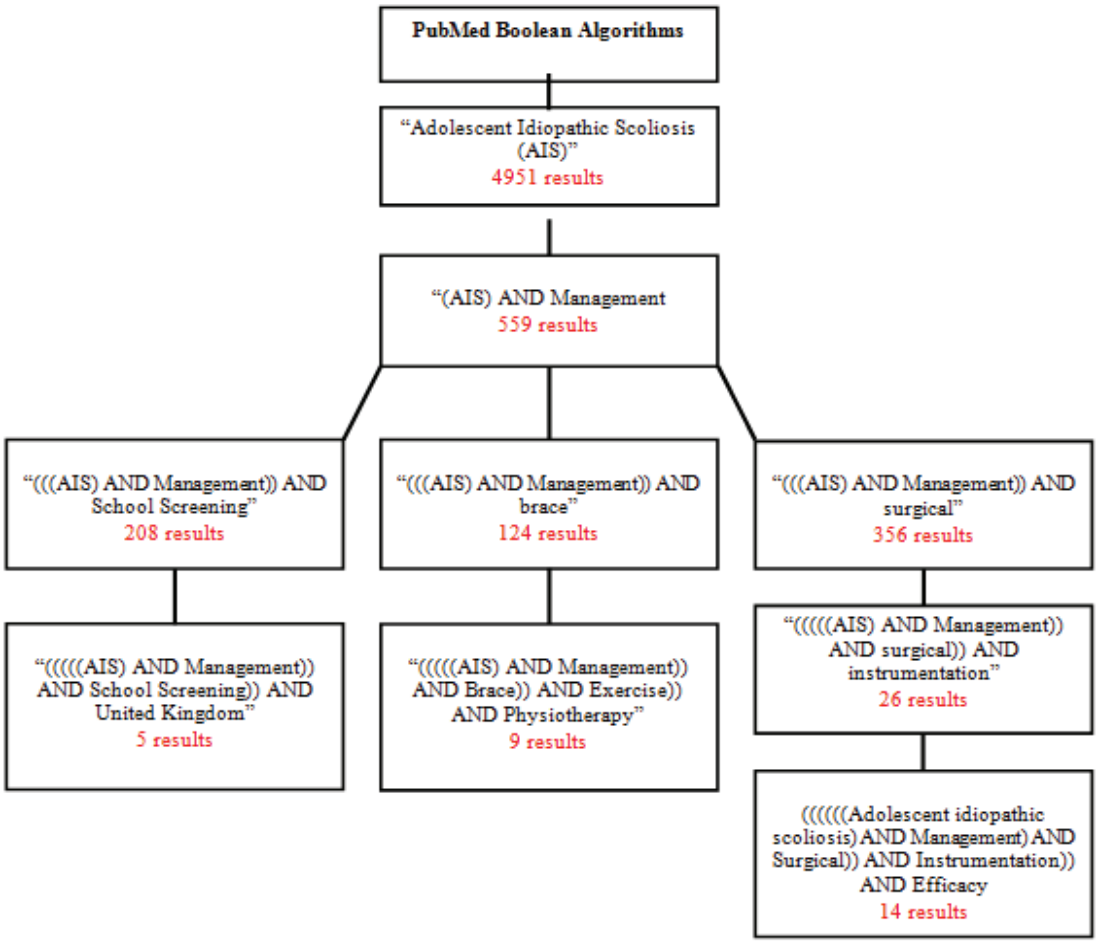

Figure 2: PubMed Boolean Algorithms used in literature search

Table 1: Aetiologies of Scoliosis and related conditions

Aetiologies of Scoliosis	Conditions
Idiopathic	Infantile (0-3 years)
	Juvenile (3-10 years)
	Adolescent (10+ years)
	Adult (18+ years)
Neuromuscular	Cerebral Palsy
	Spina Bifida
	Poliomyelitis
Dysmorphic Syndromes	Neurofibromatosis
	Marfan's Syndrome
	Osteogenesis imperfecta
Congenital	Congenital malformation of vertebrae
Metabolic	Hunter's Syndrome
Other	Crush fractures from trauma
	Osteoporosis
	Tuberculosis
	Malignancy
	Rickets
	Arnold-Chiari Malformation
	Syringomyelia

"United Kingdom", "School Screening" and "Clinical Trials" to obtain the most relevant literature. The types of literature used include randomised clinical trials (RCT), retrospective cohort studies and epidemiological studies. Studies focusing on current management in the UK, USA and Hong Kong were preferentially identified to support arguments for the reintroduction of scoliosis school screening. Exclusion criteria included individual case studies, opinion articles and spinal deformities caused by trauma.

Discussion

The modern management of AIS has been devised to correlate the disease state and progression with prognostic indicators. This can be categorised into "Observation", "Orthosis" and "Operation" as recommended by the International Scientific Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) [9]. The identifiers for AIS curve progression include female gender, early onset, early menarche, double curves and magnitude of curve at first presentation [10]. The heterogeneity of AIS progression and varying ages at first presentation increase the complexity of management.

Physiotherapy and Exercise Management

The SOSORT consensus has advocated the benefits of physiotherapeutic and exercise related activities for AIS patients who are at risk of brace therapy [11]. Brace therapy is a daunting prospect for most AIS patients

and can result in loss of self-esteem, induce depression and increase the risk of physical injury from stress and impaired lung function [12]. Currently, the evidence supporting general physiotherapy and exercise for AIS management is controversial with inconsistent long term results [13]. The Schroth Physiotherapeutic Scoliosis-Specific Exercises (PSSE) have recently provided evidence from randomised controlled trials supporting efficacy in AIS management by stabilising and improving curves. General physiotherapeutic exercises include low-impact stretching and strengthening activities whereas PSSE uses spinal curve specific exercise protocols that are individual to patients [14]. Schreiber et al reported results of a six month Schroth PSSE intervention from an assessor and statistician blind RCT [15]. The trial included 50 AIS patients between the age range of 10 - 18 years with curves measuring between 10° - 45° and Risser 0 - 5. Intervention group patients had daily 30 - 45 minute PSSE programmes with weekly supervision. Indications of treatment success were dependent upon changes in Cobb angles over the six month period. Results stated that Schroth PSSE group patients had significantly reduced Cobb angle curves by -3.5° (95% CI -1.1° to -5.9°, p = 0.006) compared to the control group who had standard exercises. The average changes in Cobb angle curvatures were from 51.2° at baseline to 49.3° for PSSE group and 55.1° in control group after six months. These results provide evidence for the efficacy of PSSE programmes in curve reduction and delayed disease progression. Results must be viewed with caution as the study had limitations including an insufficient statistical power, AIS subject heterogeneity and the quality of life for patients was not formally evaluated. The rigorous PSSE programme included five one hour private sessions with a trainer and subsequent 45 minute group sessions. The personalised nature of PSSE is labour intensive and time consuming. Provision of services to larger populations whilst maintaining quality of PSSE programmes will be the logistically difficult. Kuru et al. [16]. provided further evidence to support the efficacy of Schroth PSSE from a RCT with 45 AIS patients. Similar findings stating reductions in Cobb angle was observed in the intervention group after 6 months whereas the control group showed clinical progression of AIS. This study found no significant differences in quality of life in either group. The long term outcome of PSSE on AIS progression was assessed by Monticone et al. [17] in an RCT with 110 AIS patients. The PSSE programme was shown to be superior to traditional exercises in reducing curve angles with no impacts on patient quality of life. The effects of the programme lasted for at least one year post intervention. This suggests that PSSE programmes may result in greater patient compliance compared to brace therapy of similar duration. It remains to be seen whether the effects of PSSE programmes provide sustained benefits for AIS patients. Long term PSSE trials with surveillance into adulthood will determine whether AIS patients progressed to brace therapy or surgery.

Orthosis Management

Orthosis refers to the use of spinal braces to stabilise and prevent curve progression in AIS patients. It has been recommended for skeletally immature patients who have a curve magnitude between 25-40° - (SRS bracing criteria – Risser 0 - 2 and curves between 25° - 40°). Recommendations state patients are required to apply the brace for 23 hours a day for the greatest efficacy [18]. There are a number of difficulties in evaluating the efficacy of the use of spinal braces due to variances in design across services and the unpredictability of patient adherence to treatment. Until recently there has not been any strong evidence supporting the use of a brace to affect the natural history of the AIS curve, and therefore its use had declined. Weinstein et al published the BRAIST study which is a multicenter randomized control trial measuring the effects of bracing in patients with AIS [19]. This study included 242 adolescents with typical indications for brace treatment, 116 were randomly assigned to brace treatment or observation and 126 were given the choice of treatment. The intervention group were designated a minimum of 18 hours per day of brace use. The indication of treatment failure was the progression of skeletal curvature beyond 50° and treatment success was maintaining curvature below 50° until skeletal maturity. The results were so overwhelmingly positive that the trial was stopped early at interim analysis. Treatment success was 72% in the intervention group and 48% in the observation group. There was a significant correlation ($p<0.001$) between the number of hours' brace was worn and treatment success. Although these results show promising outcomes, there are a number of deficiencies in the methodology. There was selection bias in half of the cohort where they were given a choice of treatment and the intervention group was assigned only 18 hours of brace use when the recommendations are 23 hours. The parameter for treatment success was to maintain spinal curvature below 50°, this limit doesn't take into account patient symptomology including pain, immobility, respiratory complications and psychological distress. However, this study provides strong evidence of the positive effects of brace treatment on AIS curve stability. The duration of daily bracing has been a subject of discussion between full time and part time bracing. A recent large meta-analysis has indicated that ordinary part time bracing is associated with a high rate of curve progression. But the study also included juvenile cases of scoliosis with greater skeletal immaturity compared to patients with AIS [20]. A retrospective study on exclusively AIS patients has shown that part time hyper corrective bracing (8-10 hours) was more effective at preventing curve progression than ordinary full time bracing (22 hours) [21]. The effects of hyper corrective part time bracing on patient quality of life must be assessed for consideration for long term use. There is currently no clear evidence supporting either schedule to provide better prognostic outcomes for AIS patients. This is partly due to abundant evidence to suggest brace therapy in any form is beneficial for the patient, and the unethical nature to repeat positive studies in a RCT. Evidence needs to be observed with caution due to competing brace manufacturers claiming conflicting outcomes. Using an arbitrary spinal curvature angle as the only parameter for treatment success in current brace therapy trials does not adequately represent the patient's quality of life. Subsequent trials should incorporate patient expectations, experiences, function and symptomology to assess treatment success. Strategies also need to be in place to improve patient education and compliance with bracing, as this is a limiting factor to its success [22,23].

Surgical Management

For over 100 years the definitive treatment for scoliosis has been through surgical interventions [24]. The indication for surgery is spinal curves greater than 45° with the purpose of preventing further progression with corrective alignment for mechanical stability and cosmetic appearance. Surgical management options for AIS patients are dependent on the anatomical level and severity of disease. The most common procedures include posterior fusion with instrumentation, segmental pedicle screws and hybrid constructs combining anterior and posterior approaches [25].Generally, thoracic deformities are treated via posterior approach and thoracolumbar deformities via anterior approach due to the shorter inter-vertebral fusion levels. Non-fusion procedures such as vertebral wedge osteotomies can be used to aid skeletal growth and delay eventual fusion surgery, but these have been less beneficial for AIS patients who have reached skeletal maturity [26]. Historically the Harrington rods have been the leading instrumentation for AIS treatment [27]. A retrospective study was conducted to determine whether the newer and more expensive Cotrel-Dubousset instrumentation provided any added benefit [28]. In the 2 year follow up, there was no significant difference in quality of life or functionality between the two instrumentations. A long term follow up study has stated high rates of revision surgery required for the Cotrel-Dubousset instrumentation due to late onset infections and operative site

pain [29]. Long term follow up data comparing surgical instrumentation is required to provide better guidelines to manage varying severities of AIS. A recent survey completed by 45 orthopedic consultants and 5 fellows in the UK showed a lack of agreement on which procedure was the most favorable [30]. Findings suggested discrepancies in the use of pedicle screw constructs, composite of implants and the anatomical location of bone grafts. This controversial variance in practice may lead to conflicting published literature; it also reiterates the complexity of current surgical AIS management. Modern procedures such as lateral inter body fusion and magnetically controlled growth rod systems (MAGEC) systems are emerging in practice to further innovate treatment [31,32]. The MAGEC system removes the need for repeated invasive surgery as the rods can be lengthened without the need of anesthesia or pain relief. This system also reduces psychological trauma and improves quality of life the child from less time off from school [33]. Preliminary studies for the MAGEC device have predominantly been for the management of early onset scoliosis patients; there is currently no long term data available for this device in AIS patients. Novel non-fusion techniques for scoliosis correction are currently being investigated in preclinical studies. Samandi et al.[33]. Retrospectively analyzed anterior vertebral tethering in 32 skeletally immature AIS patients. Early results indicate adequate safety for this intervention but long term follow up studies will be required to assess clinical efficacy. The difficulty in developing a standardized surgical management guideline is due to the complex individuality of AIS cases and the need for a multi-disciplinary approach to decide which instrumentation will provide long term benefits for the patient.

Scoliosis School Screening

The purposes of scoliosis school screening programs are to detect spinal abnormalities within the population at an age where conservative management is viable. The rationale is to detect cases of AIS with potential for progression and initiate non-surgical treatment. The aim is to prevent AIS curve progression beyond 45° which may require surgery. The concept of imposing a national screening program in schools has historically been a controversial topic. In the late 1980's The British Scoliosis Society and the British Orthopaedics Society decided against the policy for a national screening program in the UK [34]. This decision was influenced by the burden on the orthopedic services due to over referral from false positive measurements. Yawn et al. performed a large retrospective analysis in the US studying the outcome of school screening programs across 26 states with over 2000 children. The results concluded that 448 children needed to be screened for 1 child to receive treatment [35]. Fong et al. carried out a population based cohort study of 400,000 children with a 10 year follow up to identify the prevalence and sensitivity of the detecting curves of 20° or greater [8]. Screening was conducted via radiographic diagnosis of scoliosis across the five consecutive annual cohorts. The prevalence for curves of 20°or greater increased by 0.23% (95% CI, 0.21-0.25%; p<.001) and sensitivity increased by 0.76% (95% CI, 0.43-1.04%; p<.001) per year. The difficulty in comparison of results from multiple screening programs is the variance in methodology of detecting spinal curves, lack of consistent grading system and referral criteria. Despite this drawback, the SOSORT Consensus for scoliosis school screening acknowledges the significant advantages of early detection and state a number of recommendations to refine the process [36]. The United Kingdom National Screening Committee (UKNSC) currently does not recommend scoliosis screening due to low quality evidence for the effectiveness of early treatment through non-surgical methods [37]. The UKNSC are due to reassess current evidence in 2019 to update recommendations. In light of new evidence supported by the BRAIST trial, in 2013 the SRS taskforce established parameters for scoliosis screening to obtain a sufficient positive predictive value [38]. This states that females should be screened twice aged 10 and 12, males once at age 13. The test is deemed positive with a scoliometer value between 5-7° and a positive forward bend test. Ultimately, the long term implementation of a national screening programme for AIS requires a well-defined management plan once a child is referred. Currently there are no globally accepted management protocols for AIS with a number of controversies [39].

Conclusion

This clinical review summarizes the latest evidence based management of AIS from prevention to treatment. Physiotherapeutic and exercise regimes such as PSSE have shown reductions in AIS curves and functional stability. Spinal bracing methods have proved to be an efficacious noninvasive method to stabilize and prevent progression of spinal curvature. Recent evidence supporting the clinical efficacy of brace therapy warrants further development of bracing methodologies to standardize practice. Surgical interventions have long been the definitive treatment for AIS with a range of successful instrumentations available. Innovative technologies including the MAGEC system and vertebral tethering methods may offer improved prognostic outcomes and require fewer revision surgeries. The future prevention of AIS may depend on the development of a well refined school screening program to identify children with spinal curvatures which can be detected early for conservative management. Further refinement and agreement of management strategies for AIS will lead to higher quality literature and better patient centered care for the future.

References

1. Parent S, Newton PO, Wenger DR (2005) Adolescent idiopathic scoliosis: etiology, anatomy, natural history, and bracing. Instr Course Lect 54: 529-536.
2. Konieczny MR, Senyurt H, Krauspe R (2013) Epidemiology of adolescent idiopathic scoliosis. J Child Orthop 7(1): 3-9.
3. Altaf F, Gibson A, Dannawi Z, Noordeen H (2013) Adolescent idiopathic scoliosis. BMJ 346: f2508.
4. Janicki JA, Alman B (2007) Scoliosis: Review of diagnosis and treatment. Paediatr Child Health 12(9): 771-776.
5. Lenke LG, Betz RR, Harms J, Bridwell KH, Clements DH, et al. (2001) Adolescent idiopathic scoliosis: a new classification to determine extent of spinal arthrodesis. J Bone Joint Surg Am 83-A(8): 1169-1181.
6. Negrini S, Aulisa AG, Aulisa L, Circo AB, de Mauroy JC, et al. (2012) 2011 SOSORT guidelines: Orthopaedic and Rehabilitation treatment of idiopathic scoliosis during growth. Scoliosis 7(1): 3.
7. Borden TC, Bellaire LL, Fletcher ND (2016) Improving perioperative care for adolescent idiopathic scoliosis patients: the impact of a multidisciplinary care approach. J Multidiscip Healthc 9: 435-45.
8. Burton MS (2013) Diagnosis and treatment of adolescent idiopathic scoliosis. Pediatr Ann 42(11): 224-8.
9. Negrini S, Aulisa AG, Aulisa L, Circo AB, de Mauroy JC, et al. (2011) SOSORT guidelines: Orthopaedic and Rehabilitation treatment of idiopathic scoliosis during growth. Scoliosis 7(1): 3.
10. Wong HK, Tan KJ (2010) The natural history of adolescent idiopathic scoliosis. Indian J Orthop 44(1): 9-13.
11. Weiss HR, Negrini S, Hawes MC, Rigo M, Kotwicki T, et al. (2006) Physical exercises in the treatment of idiopathic scoliosis at risk of brace treatment - SOSORT consensus paper 2005. Scoliosis 1: 6.
12. Asher MA, Burton DC (2006) Adolescent idiopathic scoliosis: natural history and long term treatment effects. Scoliosis 1(1): 2.
13. Fusco C, Zaina F, Atanasio S, Romano M, Negrini A, et al. (2011) Physical exercises in the treatment of adolescent idiopathic scoliosis: an updated systematic review. Physiother Theory Pract 27(1): 80-114.

14. Bettany-Saltikov J, Parent E, Romano M, Villagrasa M, Negrini S (2014) Physiotherapeutic scoliosis-specific exercises for adolescents with idiopathic scoliosis. Eur J Phys Rehabil Med 50(1): 111-21.

15. Schreiber S, Parent EC, Khodayari Moez E, Hedden DM, Hill DL, et al. (2016) Schroth Physiotherapeutic Scoliosis-Specific Exercises Added to the Standard of Care Lead to Better Cobb Angle Outcomes in Adolescents with Idiopathic Scoliosis - an Assessor and Statistician Blinded Randomized Controlled Trial. PLoS One 11(12): e0168746.

16. Kuru T, Yeldan İ, Dereli EE, Özdinçler AR, Dikici F, et al. (2016) The efficacy of three-dimensional Schroth exercises in adolescent idiopathic scoliosis: a randomised controlled clinical trial. Clin Rehabil 30(2):181-90.

17. Monticone M, Ambrosini E, Cazzaniga D, Rocca B, Ferrante S (2014) Active self-correction and task-oriented exercises reduce spinal deformity and improve quality of life in subjects with mild adolescent idiopathic scoliosis. Results of a randomised controlled trial. Eur Spine J 23(6): 1204-1214.

18. Schiller JR, Thakur NA, Eberson CP (2010) Brace management in adolescent idiopathic scoliosis. Clin Orthop Relat Res 468(3): 670-678.

19. Weinstein SL, Dolan LA, Wright JG, Dobbs MB (2013) Effects of bracing in adolescents with idiopathic scoliosis. N Engl J Med 369(16): 1512-1521.

20. Aulisa AG, Giordano M, Falciglia F, Marzetti E, Poscia A, et al. (2014) Correlation between compliance and brace treatment in juvenile and adolescent idiopathic scoliosis: SOSORT award winner. Scoliosis 9: 6.

21. Janicki JA, Poe-Kochert C, Armstrong DG, Thompson GH (2007) A comparison of the thoracolumbosacral orthoses and providence orthosis in the treatment of adolescent idiopathic scoliosis: results using the new SRS inclusion and assessment criteria for bracing studies. J Pediatr Orthop 27(4): 369-374.

22. Helfenstein A, Lankes M, Ohlert K, Varoga D, Hahne HJ, et al (2006) The objective determination of compliance in treatment of adolescent idiopathic scoliosis with spinal orthoses. Spine (Phila Pa 1976) 31(3): 339-344.

23. Dede O, Sturm PF (2016) A brief history and review of modern casting techniques in early onset scoliosis. J Child Orthop 10(5): 405-411.

24. Hasler CC (2013) A brief overview of 100 years of history of surgical treatment for adolescent idiopathic scoliosis. J Child Orthop 7(1): 57-62.

25. Maruyama T, Takeshita K (2008) Surgical treatment of scoliosis: a review of techniques currently applied. Scoliosis. 3: 6.

26. Kim KT, Park KJ, Lee JH (2009) Osteotomy of the spine to correct the spinal deformity. Asian Spine J 3(2): 113-123.

27. Lovallo JL, Banta JV, Renshaw TS (1986) Adolescent idiopathic scoliosis treated by Harrington-rod distraction and fusion. J Bone Joint Surg Am 68(9): 1326-1330.

28. Ameri E, Ghandhari H, Hesarikia H, Rasouli HR, Vahidtari H, et al. (2013) Comparison of harrington rod and cotrel-dubousset devices in surgical correction of adolescent idiopathic scoliosis. Trauma Mon 18(3): 134-138.

29. Mueller FJ, Gluch H (2012) Cotrel-dubousset instrumentation for the correction of adolescent idiopathic scoliosis. Long-term results with an unexpected high revision rate. Scoliosis 7(1): 13.

30. Michael AL, Loughenbury PR, Rao AS, Dunsmuir RA, Millner PA (2012) A survey of current controversies in scoliosis surgery in the United Kingdom. Spine (Phila Pa 1976) 37(18): 1573-1578.

31. Pawar A, Hughes A, Girardi F, Sama A, Lebl D, et al. (2015) Lateral Lumbar Interbody Fusion. Asian Spine J 9(6): 978-983.

32. Jenks M, Craig J, Higgins J, Willits I, Barata T, et al. (2014) The MAGEC system for spinal lengthening in children with scoliosis: A NICE Medical Technology Guidance. Appl Health Econ Health Policy 12(6): 587-599.

33. Samdani AF, Ames RJ, Kimball JS, Pahys JM, Grewal H, et al. (2015) Anterior vertebral body tethering for immature adolescent idiopathic scoliosis: one-year results on the first 32 patients. Eur Spine J 24(7): 1533-1539.

34. Burwell G (1988) The British decision and subsequent events. Spine (Phila Pa 1976) 13(10): 1192-1194.

35. Yawn BP, Yawn RA, Hodge D, Kurland M, Shaughnessy WJ, et al (1999) A population-based study of school scoliosis screening. JAMA 282(15): 1427-1432.

36. Grivas TB, Wade MH, Negrini S, O'Brien JP, Maruyama T, et al. (2007) SOSORT consensus paper: school screening for scoliosis. Where are we today? Scoliosis 2: 17.

37. Commiteee UNS (2011) Screening for Adolescent Idiopathic Scoliosis: External review against programme appraisal criteria for the UK National Screening Committee (UK NSC) 3.

38. Labelle H, Richards SB, De Kleuver M, Grivas TB, Luk KD, et al. (2013) Screening for adolescent idiopathic scoliosis: an information statement by the scoliosis research society international task force. Scoliosis. 8: 17.

39. Sud A, Tsirikos AI (2013) Current concepts and controversies on adolescent idiopathic scoliosis: Part I. Indian J Orthop 47(2): 117-28.