

Scoliosis—treatment indications according to current evidence

HR Weiss^{1*}, M Moramarco^{2*}

Abstract

Introduction

Long-term follow-ups of untreated patients with adolescent idiopathic scoliosis (AIS) indicate that the consequences of AIS over a lifetime are minimal, sometimes moderate in more severe cases, however, never life-threatening. In light of these findings, the historical indications for treatment should be investigated according to current evidence. This critical review discusses the treatment methods for scoliosis.

Materials and methods

Recent reviews have been investigated for their contribution to evidence in the field of scoliosis treatment, especially the impact of the results obtained on the historical modes of treatment.

Results

From these findings, we may conclude that there is promising evidence for the application of physiotherapy in the treatment of scoliosis in children or adolescents and for adults with curvatures exceeding 35° Cobb. There is a stronger evidence for the application of (hard) braces during growth. There is no evidence for spinal fusion surgery for AIS. The use of surgery should be limited in patients with scoliosis of other origin.

Conclusion

There is some evidence for the use of physiotherapy as a treatment for scoliosis. There is strong evidence for the use of hard braces during growth.

*Corresponding author

Email: hr.weiss@skoliose-dr-weiss.com, marc@drmoramarco.com

¹ Orthopedic Rehabilitation Services 'Gesundheitsforum Nahetal', Gensingen, Germany

² Scoliosis 3DC, Baldwin Green Common, Suite 204, Woburn, MA, USA

Introduction

Scoliosis is a lateral deviation of the spine, commonly exhibiting different patterns of curvature. The basic curve patterns are named after the location of the major curve (e.g. thoracic, lumbar, thoracolumbar, double major, double thoracic), but there are also other specific classifications found in the literature¹. In structural scoliosis, there is usually a certain amount of spinal torsion and a disturbance of the sagittal profile coupled to lateral deformation (Figure 1). Therefore, scoliosis must be more accurately regarded as a three-dimensional deformity of the spine and trunk, which may progress quickly during periods of rapid growth^{2–5}.

Although scoliosis may be an expression or a symptom of certain diseases (e.g. neuromuscular, congenital, due to certain syndromes or tumours), the majority of the patients with scoliosis (80–90%) are 'idiopathic' as a certain underlying cause is not apparent¹.

Treatment indications for scoliosis are usually dependent on the magnitude of the curvature at presentation and the maturity of the patient^{6,7}.

Treatment of scoliosis historically consists of:

- Observation in mild curvatures during growth
- Physiotherapy in moderate curvatures during growth and exceeding 35° after growth

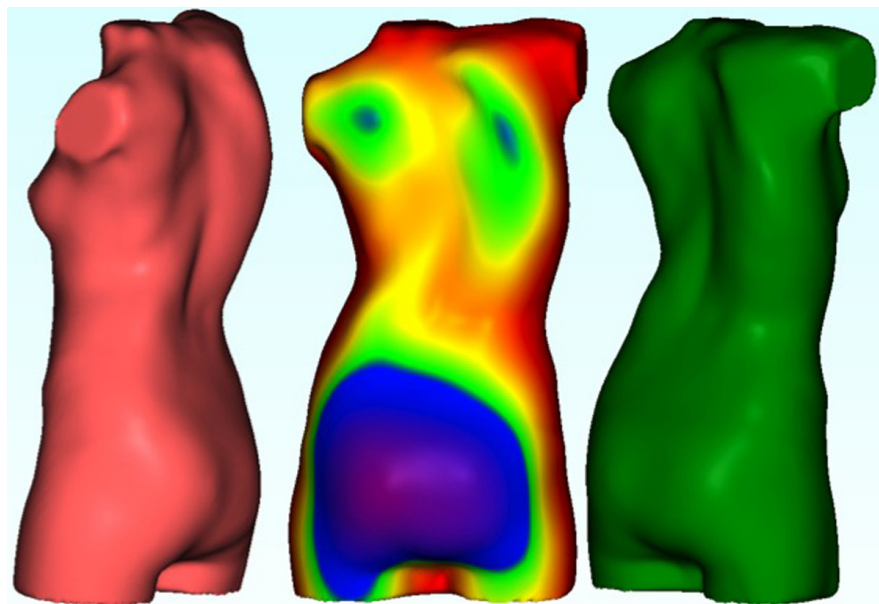


Figure 1: Computer animated model of a decompensated thoracic curvature showing the three-dimensional deformation of the trunk. Left: Rib hump on the right is clearly visible. Middle: Moiré pattern showing the most prominent parts of the trunk in blue and the least prominent ones in red. Right: Oblique view from the right. The thoracic hollow back is clearly visible, which is the deformation of the trunk in the sagittal plane.

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- *Brace treatment in curvatures exceeding 20° during growth*
- *Spinal fusion surgery*^{4,6,7}.

In principle, adolescent idiopathic scoliosis (AIS) (80–90% of all cases with scoliosis) describes a spinal curvature in an otherwise healthy individual. According to the Scoliosis Research Society (SRS), the prevalence of AIS is 2–3% in the general population⁸. AIS is more commonly found in females (female: male ratio = 7:1) and except for extreme cases, AIS does not typically cause any health problems during growth.

Long-term follow-ups of untreated patients with AIS indicate that the consequences of AIS over a lifetime are minimal, sometimes moderate in more severe cases, however, never life-threatening⁹. In light of these findings, the historical indications for treatment should be investigated according to the current literature. This critical review assesses the different methods of treatment and how successful these methods are.

Materials and methods

Recent reviews and long-term follow-up studies have been investigated for their contribution to evidence in the field of scoliosis treatment, especially the impact of the results as they relate to historical modes of treatment.

Results

Observation in mild curvatures during growth

This in principle is no treatment, with minimal side effects other than the consequences of subsequent exposure to radiation. By using clinical tools for measurement (i.e. Scoliometer™), the exposure for radiation can be reduced.

Physiotherapy in mild/moderate curvatures during growth and curvatures exceeding 35° after growth

There is some evidence for the use of exercises in the treatment of scoliosis. This is reflected in an actual Cochrane review¹⁰. However, the results as presented in literature are compromised by the fact that in most papers patient samples have been under treatment, which, according to the current guidelines would have no indication for treatment¹¹. Only one paper contains a subgroup of patients at actual risk, but this sample has not been followed until skeletal maturity¹².

Brace treatment in curvatures exceeding 20° during growth

There is one prospective controlled multicentre investigation by the SRS clearly showing that Boston-brace treatment during growth may be beneficial for the patients¹³. One prospective controlled long-term follow-up from Sweden also supports the hypothesis that Boston-brace treatment at least can halt curvature progression in adolescents during growth¹⁴ as does another long-term follow-up study from Norway¹⁵. A prospective controlled trial comparing the Chêneau brace to soft brace treatment with a patient sample complying with the SRS criteria for studies of bracing¹⁶ shows the superiority of hard braces to soft braces. This has been confirmed independently in another randomized controlled trial from Hong Kong¹⁷ clearly showing that currently there is no advantage to the utilization of soft braces compared with hard braces. The results as presented here are discussed in more detail in another Cochrane review¹⁸; however this review has been found to be incomplete¹⁹.

Spinal fusion surgery

A systematic review on spinal fusion surgery indicates lack of evidence supporting the positive effects on various health-related issues associated with scoliosis which may develop²⁰.

In this paper, a wide range of possible short- and long-term complications have been revealed. Consequent reviews^{21–24} did not find papers to support the hypothesis that there was a medical indication for surgery in scoliosis. Complications have to be expected in more than 50% of the population operated on²⁵, and in a recent paper a re-surgery rate of nearly 50% was found to be the long-term result²⁶.

Discussion

The authors have referenced some of their own studies in this review. These referenced studies have been conducted in accordance with the Declaration of Helsinki (1964) and the protocols of these studies have been approved by the relevant ethics committees related to the institution in which they were performed. All human subjects, in these referenced studies, gave informed consent to participate in these studies.

There is evidence for the use of physiotherapy in treatment of patients with spinal deformities. However, during the pubertal growth spurt, brace treatment is the most important mode of treatment. It has been shown that in-brace correction and compliance correlate with outcome²⁷; therefore more asymmetric braces with increased corrective effect are preferable (Chêneau style)^{16,27,28} to the more symmetric Boston braces^{13–15}. Soft braces should be restricted, especially those promoting unlimited mobility in the brace, which of course must be at the cost of in-brace correction^{16,17}.

Currently, CAD/CAM technology allows for the manufacture of high-correction hard braces worldwide, through the use of scan and brace files sent via the Internet (Figure 2).

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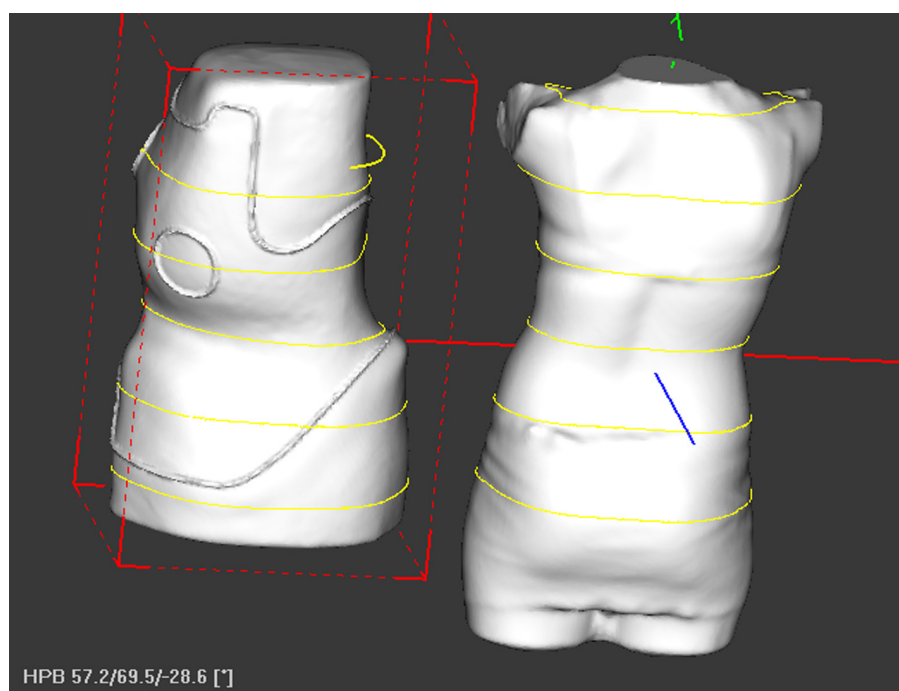


Figure 2: Virtual brace adjustment on the computer for the production of a CAD/CAM brace from a scan file of a patient using a new adjustment software. The brace can be manufactured from hand measurements or a patients' scan (as in this example). First, the appropriate brace from the library is taken for the specific deformity. Second, this brace is adjusted using the software. Then the STL file can be exported and sent to a carving service via email. A polyurethan (PU) foam block is carved to gain the final brace model. In this model, the heated polyethylene (PE) sheet is vacuumed, cut after cooling down and finalized.

From the evidence available today, we may conclude that using the Boston-brace standard (Figure 3), progression can be stopped to a large extent¹³⁻¹⁵. For cosmetic (and also radiologic) improvements in patients at risk, the highest possible in-brace correction should be provided²⁸, while taking comfort into account to ensure the necessary compliance. The Chêneau standard today provides pattern-specific asymmetric brace models with improved in-brace corrections, especially when standardized CAD/CAM brace libraries are used. In a recently published paper, gains in final corrections and cosmetic improvements (Figure 4) were exhibited in larger patient samples²⁸ than noted in aforementioned studies¹³⁻¹⁷.

All reviews on surgical treatment of scoliosis do not provide any evidence for the application of these procedures²⁰⁻²⁴. Spinal fusion surgery may correct the spinal curvature in the x-ray; however, the rib hump may re-appear as early as 1 year after surgery²⁰. To date, there is no proof that spinal fusion surgery would change the signs and symptoms of AIS. Until now, there is no Cochrane review available investigating the use of surgery in patients with AIS, but surgery for scoliosis in Duchenne muscular dystrophy was the subject of a Cochrane review²⁹. The authors concluded that since there were no randomized controlled clinical trials available to evaluate, no evidence based recommendation can be made

for clinical practice. People with scoliosis should be informed about the uncertainty of benefits and potential risks of surgery.

Of course, not all types of scoliosis can be halted conservatively. A clear indication for early surgery is given in congenital scoliosis cases with defects of segmentation (unilateral bar; rib synostosis involving >3 segments). In all other congenital scolioses (defects of formation like hemivertebrae or wedged vertebrae), conservative management should be considered first before surgical intervention is considered. Some mild congenital curves do not require any treatment, even during the pubertal growth spurt³⁰.

Hawes has revealed many possible short- and long-term complications, which may occur as a result of surgery²⁰. Moreover, in a more recent review, it was calculated that scoliosis patients in the long term would be at risk for complications at or exceeding 50%, with a re-surgery rate of up to 25%²⁵. A recently published paper revealed an unexpected high re-surgery rate of nearly 50% in the long term²⁶. Therefore, we may assume that long-term problems and complications after scoliosis surgery are far more common than previously assumed.³¹

In the majority of scoliosis cases, AIS is a benign condition^{4,9}. From the findings in the current literature, it may be concluded that for many the problems caused by spinal fusion surgery are far greater than the problems caused by the disease itself and for others they create an uncertain future, at best.

An exception, of course, would be early-onset idiopathic scoliosis (EOS), a rare condition that, when untreated, is at risk of progression to a Cobb angle of more than 100°. Since it is known that mortality increases at curves greater than 100°, surgery may be considered following unsuccessful conservative management^{2,4}.

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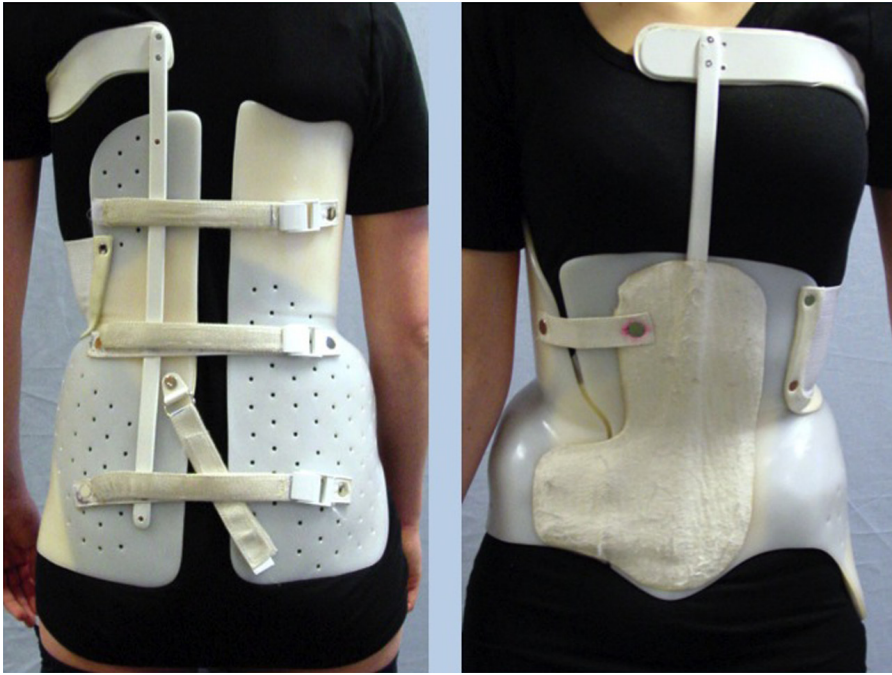


Figure 3: Boston-brace derivate with axillar support. Without the axillar support, this is the typical Boston brace used worldwide, which has been slightly developed during the last 5 years. However, usually there is no real asymmetry visible. It is a more symmetric brace with pad additions to increase the pressure on the most prominent parts of the trunk.



Figure 4: Immature AIS patient with 48° according to Cobb with a right thoracic curve at the start of treatment in 2008 (left). In the middle, the asymmetric brace as used is shown mirroring the deformity quite well leading to an in-brace overcorrection. On the right, the result at weaning is visible with a 24° curve at 16 and a well-balanced appearance in 2012.

New techniques using unilateral stapling have been developed for spinal fusion in the Cobb angle range where bracing is indicated. This surgery has not been successful with a

re-operation rate exceeding 50% within 2 years after the first operation³². The indication for this surgery mainly is derived from a genetic saliva test (\$2,000–\$3,000) claiming to

distinguish between patients at risk for progression and patients with a benign course during growth³³. However, with today's bracing technology, greater than 95% of the population with AIS during growth can be stopped or improved²⁸. Bracing management is conservative and considered effective, and until long-term proof of superiority of alternatives is proven there is not yet an indication for this kind of surgical management³².

The task for scoliosis management should be the continued focus on development of the highest quality brace technology (Figures 4 and 5), as this is the most important mode of treatment during growth, with continued work in the area of scoliosis-specific physical exercise. When managed properly, the two can have a synergistic effect for a positive outcome for the patient. Therefore, brace development in the future should focus on improving the corrective effect and patient comfort, and it should focus on improving brace compliance. It is also important for a caring practitioner to address patient concerns, encouraging psychological support if necessary, concurrently, to ensure the likelihood of a successful outcome.

If a patient is wearing a brace for 18–20 h per day, it is important the patient be trained in activities of daily living (ADLs) for their specific curve pattern allowing for conscious out-of-brace corrections. These ADLs provide beneficial lifetime management skills. While ADLs and scoliosis-specific exercise should be pursued in conjunction with bracing, these skills are also imperative for patients who absolutely refuse bracing and are at risk for progression.

An intensive program of instruction consisting of three-dimensional scoliosis education based on a patient's specific curve pattern and instruction in scoliosis-specific exercises and ADLs³⁴ should be the focus.

Any physiotherapy approach should strive to achieve correction or overcorrection. An example of

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overcorrected mobilizing and stabilizing exercises (Figure 6) demonstrates safe conditioning according to the patient's curve pattern while assuming corrected postures in ADLs³⁴. Exercising for 20–30 min daily *may* not substantially change the course of large, rigid curvatures, but a patient's conscious management focusing on ADLs can be extremely effective³⁵.

Physiotherapy is the treatment of choice for children and adolescents with mild curves during growth, moderate curves in conjunction with a brace and for adults with curvatures exceeding 35° when they want to halt or decrease the risk of curve progression during adulthood^{2–5}. During growth, however, progressive curves should be treated with hard braces immediately and commence with a program of ADLs and scoliosis-specific exercise.

It is most important to treat mild to lower moderate curves (20–30°) in immature patients during growth since there can be correction to a large extent, sometimes within 6 months of treatment^{27,28}. Occasionally, the first author has observed the potential to reduce brace wearing time during growth when an intermediate correction to less than 20° can be achieved.

Early intervention, when applied with the highest possible in-brace correction, may potentially reduce brace treatment time, improve the patients' quality of life and create a successful positive outcome without the potential for long-lasting detrimental effects.

Finally, when the most effective measurements for conservative management are chosen, the final cosmetic results of treatment in patients with curvatures between 50° and 60° are more than comparable with the late cosmetic results as achieved after surgery (Figure 7).

Conclusion

There is some evidence for the application of physiotherapy in the treatment of scoliosis, mainly in mild curvatures in children or adolescents,



Figure 5: At the start of the pubertal growth spurt, the curves of AIS patients are usually still flexible, allowing a high in-brace correction which is the precondition for an early beneficial outcome.



Figure 6: Mirroring the deformity in a patient with right thoracic scoliosis during specific exercises within the setting of rehabilitation as applied in the Ukraine (from Borysov and Borysov).

moderate curves when accompanied by bracing and for adults with curvatures exceeding 35° Cobb.

There is stronger evidence for the application of (hard) braces during growth.

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Figure 7: Comparison of clinical outcomes after surgery versus conservative treatment with physiotherapy and braces. All patients started surgery or conservative treatment with a curve of 50–60°. The upper line of pictures and lower left show scoliosis patients 3 or more years after surgical intervention still with significant deformations of the trunk. On the lower right, a 22-year-old woman can be seen treated with braces and rehabilitation in the late 1990s and a 18-year-old young man with a right thoracic decompensated curve initially of 56°, final measurement 43° upon completion of treatment. The pictures have been published (open access) in another order at: <http://www.pssjournal.com/content/2/1/25>.

There is a lack of evidence for spinal fusion surgery in the treatment of patients with AIS. The use of surgery should be largely restricted for patients with scoliosis of other origin.

Competing interests

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All patients visible on the pictures and their parents have kindly agreed to the publication of their photos within this article.

Abbreviations list

ADLs, activities of daily living; AIS, adolescent idiopathic scoliosis; EOS,

early-onset idiopathic scoliosis; SRS, Scoliosis Research Society

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