Pathophysiology

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Research study

Adolescent Idiopathic Scoliosis: Etiological concepts and implication for treatment

HR Weiss[1*], S Seibel[1], M Moramarco[2]

Abstract

Introduction

Idiopathic scoliosis is a lateral deviation of the spine of unknown origin. Initiation and progression of AIS may result from vertebral column overgrowth through a lordoscoliotic maladaptation of the spine to the subclinical (functional) tether of a relatively short spinal cord.

Implications for treatment however have not yet been derived from the findings as published so far with the exception of spinal manipulation described by Tomaschewski or neurosurgical release of the filum terminale as described by Royo-Salvador.

Following the rationale of Tomaschewski external manipulation might influence the 'flatback' contracture as found in the lower thoracic area in patients with beginning AIS and have a beneficial effect on the 3D deformity of the spine and trunk. The hypothesis for this pilot investigation was that with the application of extracorporeal shock wave therapy, the 'flatback' contracture as commonly found in the lower thoracic area of patients with AIS can be reduced.

Materials and methods

Inclusion criteria for the study were: Girls with a Cobb angle between 20 and 50° (average 35.3°, SD 9.6), age 12 to 15 years (average 14.1years SD 1.1).

The methodology included (1) Surface Topography (Formetric Diers) before, (2) after 5 min in the treatment position without application of extracorporeal shock wave therapy and (3) after the application of extracorporeal shock wave therapy.

Results

Lateral deviation (RMS = Root Mean Square) and Surface Rotation (RMS) both were consistently reduced after the intervention. The sagittal parameters kyphosis angle and lordosis angle both were consistently increased after the intervention. The results were consistent but not significant.

Conclusion

The concept of a functional tethering of the spinal cord in patients with AIS is supported by the results from this investigation. The application of extracorporeal shock wave therapy in patients with AIS seems to have a beneficial influence on 3D deformity and the subjective feeling of a tensed back. Manipulation of the 'flatback' contracture as commonly found in the lower thoracic area may be beneficial as pointed out by Tomaschewski.

*Corresponding author
Email: hr.weiss@skoliose-dr-weiss.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 literature[1,2]. In structural scoliosis, there is usually a certain amount of spinal torsion and a disturbance of the sagittal profile coupled with lateral deformation. 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[1,2].

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 apparent[1,2].

In the absence of any accepted scientific theory for the aetiology of idiopathic scoliosis, treatment remains pragmatic with a very incomplete scientific basis[3].

In severe adolescent idiopathic scoliosis (AIS) compared with normal subjects, the thoracic vertebral column is significantly longer without detectable change in spinal cord length evaluated as cord-to-vertebral length ratios[4]. The authors speculate that the initiation and progression of AIS result from vertebral column overgrowth through a lordoscoliotic maladaptation of the spine to the subclinical tether of a relatively short spinal cord. This interpretation accommodates both the lordotic and the dorsal shear force concepts for the pathogenesis of AIS[3,4].

Although functional tethering of the spinal cord is partly accepted as a concept of AIS aetiology restriction of neck flexion – a possible sign for tethering (Figure 1) - with AIS has not been reported except for a special group of boys[5,6].

The hypothesis of asynchronous neuro-osseous growth[3] proposes that the relative short cord can lead to hypokyphosis in the thoracic area and hence curve initiation with or without progression of the scoliosis. Therefore, it might be the starting point as well as an aggravating factor in the 'vicious cycle' hypothesis of Dr Stokes[7]. However the 'vicious cycle' concept[7] does not explain why a congenital curve of 28° does not progress during the pubertal growth spurt even if untreated[8], while in AIS patients a curve of this size during the pubertal

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Figure 1: Functional tethering of the spinal cord can express itself as a stiffness in the Adams bending test (left). Additional head flexion can be painful, sometimes a tension is felt at the coccygeal area where the filum terminale is fixed to (right).

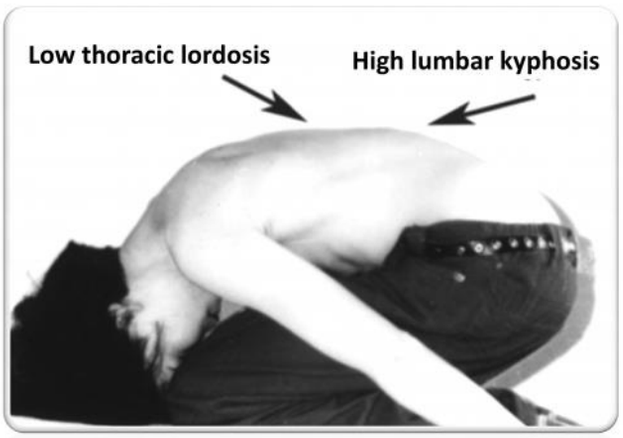

Figure 2: Diagnostic position as proposed by Tomaschewski (see text). A low thoracic flatback contracture is visible as a high lumbar kyphosis in the initioal stages of scoliosis development.

growth spurt has a nearly 100% chance of being progressive[9].

The concept of functional tethering with a thoracic flatback also does not fit for lumbar curve patterns which rarely go hand in hand with a thoracic flatback and to the experience of the author mainly present together with a thoracic hyperkyphosis instead of a hypokyphosis.

Tomaschewski in her thesis[10] has found functional impairment of forward flexion (IFF) to be the precursor of a structural spinal deformity (Figure 2). In 16.5% of 686 healthy school children in the prepubertal ages of 9 and 10 years, she found IFF in at least one motion segment. 27 % of these children developed AIS during the follow-up within one year after the first screening.

Her findings speak for the theory of functional tethering, however in younger age groups IFF is highly prevalent and considered as being physiological[11].

So there are still many open questions in the theoretical concepts of scoliosis etiology[3]. Implications for treatment however have not yet been derived from the findings as published to date with the exception of spinal manipulation described by Tomaschewski[10] or neurosurgical release of the filum terminale as described by Royo-Salvador[12]. Retethering after sectioning of the filum terminale has been described[13].

Following the rationale of Tomaschewski[10], external manipulation might influence IFF, the 'flatback' contracture as found in the lower thoracic area in patients with beginning AIS and have a beneficial effect on the 3D deformity of the spine and trunk. Manipulation as a chiropractic intervention possibly can be replaced by mechanical shock wave applications which can be tested on a more standardized basis. Therefore voluntary subjects under conservative treatment with the condition of AIS could be exposed to extracorporeal shock wave application to the 'flatback' contracture in the lower thoracic area in order to investigate the impact of the mobilizing effect of such treatment.

Extracorporeal shock wave therapy frequently is used for the treatment of myofascial pain syndromes. Although many studies and reviews support the application of extracorporeal shock wave therapy[14,15,16,17] a recent RCT revealed contradictory results[18].

However for the application of extracorporeal shock wave therapy in patients with AIS we are looking for a mechanical effect. Therefore, a less focused applicator can be used as provided for the treatment of myofascial trigger points[19].

The hypothesis for this pilot investigation was that with the application of extracorporeal shock wave therapy, the 'flatback' contracture as commonly found in the lower thoracic area of patients with AIS can be reduced. If this 'flatback' contracture induces 3D deformity in patients with AIS[10] by increasing sagittal mobility in the lower thoracic spine, the 3D deformity should be reduced after application.

Table 1: (1) Surface Topography (Formetric Diers) before, (2) after 5 min in the treatment position without application of extracorporeal shock wave therapy and (3) after the application of extracorporeal shock wave therapy. The mean values for (1), (2) and (3) are documented here together with the standard deviation (SD).

	Lateral deviation	Surface Rotation	Kyphosis Angle	Lordosis Angle
(1)	10.6 SD 5.9	6.7 SD 2.6	49.1 SD 9.9	38.7 SD 8.4
(2)	10.5 SD 5.8	6.9 SD 3.0	49.1 SD 9.0	38.7 SD 8.6
(3)	9.3 SD 5.9	6.3 SD 2.5	50.2 SD 8.5	39.2 SD 7.4

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Materials and methods

This work conforms to the values laid down in the Declaration of Helsinki (1964). The protocol of this study has been approved by the relevant ethical committee related to our institution in which it was performed. All subjects gave full informed consent to participate in this study.

Inclusion criteria for the study were: Girls with a Cobb angle between 20 and 50° (average 35.3°, SD 9.6), age 12 to 15 years (average 14.1years SD 1.1).

The methodology included (1) Surface Topography (Formetric Diers) before, (2) after 5 min in the treatment position without application of extracorporeal shock wave therapy (Figure 3, Figure 4 and Figure 5) and (3) after the application of extracorporeal shock wave therapy using the trigger point applicator in the treatment position as described with 2000 impulses distributed bilaterally in the lower thoracic typical 'flatback' contracture area. The Storz Medical MasterpulsÒ MP 100 radial shockwave system was used.

Average age was 14 years (SD 1.1) and the patient group had an average Cobb angle of 35.3° (SD 9.6).

Lateral deviation (RMS), Surface Rotation (RMS), kyphosis angle and lordosis angle as provided by the Formetric Surface Topography system have been evaluated. Average values have been compared and the student's t-test has been performed to compare the measurements of (1) and (2) defined as the control test (CT) with the measurements of (1) and (3) as defined as the intervention test (IT).

The Formetric surface topography system

Surface topography uses the back shape of a patient to calculate the existent asymmetry with the help of 'triangulation'[20]. The system projects stripes of white light (raster lines) on the back of a standing patient and captures a digital photo of the image to assess pinpoint surface asymmetry and identify bony landmarks[21]. The projected parallel lines are distorted by the back surface of the trunk (Figure 6) and the degree of their distortion is the basis for the calculation[20,21,22,23].

The technical error of this system has been evaluated in studies[20,21,24,25].

Results

The mean values for (1) Surface Topography (Formetric Diers) before, (2) after 5 min in the treatment position without application of extracorporeal shock wave therapy and (3) after the application of extracorporeal shock wave therapy can be seen in table 1. The t-values of the Control Test (CT) and the Intervention test (IT) are documented in Table 2.

Discussion

After looking at the raw data the first author did not see any consistent differences between the measurements, however it was decided to publish the results even if no effect was apparent. However, after statistical analysis of the average values, surprisingly, a clear and consistent tendency has been found throughout all values comparing (1) Surface Topography (Formetric Diers) before and (3) after the application of extracorporeal shock wave therapy. No consistent tendency has been found comparing (1) Surface Topography (Formetric Diers) before and (2) after 5 min in the treatment position without application of extracorporeal shock wave therapy.

Lateral deviation (RMS) and Surface Rotation (RMS) both were consistently reduced when compared to the initial value (1) after the intervention (3) while less differences appeared comparing the initial value (1) to (2 = after 5 min in the treatment position without application of extracorporeal shock wave therapy).

Figure 3: Radial Shockwave System as used (Storz Medical Masterpuls® MP 100). On top of the system the applicator used for this study is shown.

Figure 4: Application of extracorporeal shock wave therapy to the low thoracic area.

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Table 2: Lateral deviation (RMS), Surface Rotation (RMS), Kyphosis Angle and Lordosis Angle as provided by the Formetric Surface Topography system have been evaluated. Average values have been compared and the students t-test has been performed to compare the measurements of (1) and (2) defined as the control test (CT) with the measurements of (1) and (3) as defined as the intervention test (IT). The t-values of the Control Test (CT) and the Intervention test (IT) are documented in this table.

	Lateral deviation	Surface Rotation	Kyphosis Angle	Lordosis Angle
CT	t = 0.93	t = 0.85	t = 0.98	t = 1
IT	t = 0.65	t = 0.72	t = 0.74	t = 0.87

Figure 5: Low thoracic flatback contracture during treatment. The flat area is clearly visible. Treatment has been done both sides of the spinous processus (never directly on bony tissue).

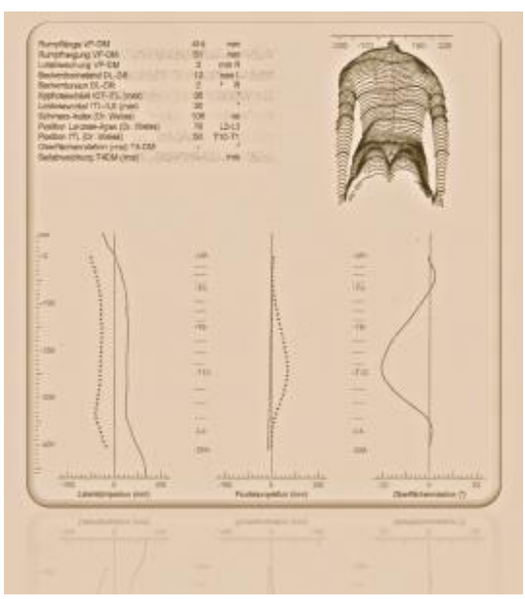

Figure 6: Printout of the results as provided by the Formetric surface reconstruction system.

The sagittal parameters kyphosis angle and lordosis angle both consistently increased when compared to the initial value (1) after the intervention (3) while less (no) differences appeared comparing the initial value (1) to (2 = after 5 min in the treatment position without application of extracorporeal shock wave therapy).

Lateral deviation (RMS) and Surface Rotation (RMS) both are measures for trunk asymmetry and have been reduced. Kyphosis angle and lordosis angle both are measures for a physiologic sagittal profile and have been increased (improved). Increased kyphosis angle and lordosis angle is a beneficial sign since AIS is a flatback disorder known to appear with reduced sagittal angles of curvature[1,2].

As demonstrated in Table 1 and 2, all values have a clear tendency toward an improved condition which is also supported by a diminished t-value in the IT compared to the CT.

The differences between the three measurements were not significant and did not exceed the limits of technical error[24,25], however, the consistent tendency can be weighted as a possible effect of the intervention.

It must be taken into account that for this pilot study only one intervention was tested in a sample of only 15 patients. Therefore, we would suggest increasing the number of patients and the number of interventions per patient. The application of extracorporeal shock wave therapy in patients with AIS is also supported by the fact that most patients had the subjective feeling of a relaxed back for the first time, a feeling which vanished after a few days.

According to the results as achieved within this investigation and the concept of functional tethering of the spinal cord in patients with AIS, we suggest to focus on the flat area in the lower thoracic region coupled with a high lumbar kyphosis. The results suggest the existence of a functional tether which may be influenced with systematic extracorporeal therapy or spinal manipulation.

Conclusion

The concept of a functional tethering of the spinal cord in patients with AIS is supported by the results from this investigation.

The application of extracorporeal shock wave therapy in patients with AIS seems to have a beneficial influence on 3D deformity and the subjective feeling of a tensed back.

Manipulation of the ‚flatback' contracture as commonly found in the lower thoracic area may be beneficial as has been pointed out earlier by Tomaschewski[10].

An increased number of patients have to be treated before final conclusions can be drawn.

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Conflict of interests & Competing interests

HR Weiss is advisor of Koob GmbH & Co KG, S Seibel and M Moramarco: none declared related to the content of this paper.

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