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Original article

SCOLIOSIS THERAPY, A LINK BETWEEN THE SCHROTH-3D SCOLIOSIS PROGRAMAND THE GENSINGEN BRACE

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Abstract

Scoliosis it is a 3D deformation in frontal plane, transverse plane, and sagittal plane.

Frontal plane - Lateral deviation to the convex side of a curve leads to a lateral flexion of the spine.

Transverse plane - Rotation mainly in the apex of the curve in the same direction with lateral deviation.

Sagittal plane - Hypokyphosis in thoracic area, hypolordosis in lumbar part with hypermobility in the lumbosacral junction.

Conservative scoliosis treatment is targeting towards deceleration or prevention of progression to avoid bracing and most important preventing from surgery.

Schroth-3D Scoliosis Program also includes teaching and planning scoliosis specific exercises and breathing techniques following the principles of Schroth posture variations to enable and encourage patients to perform a home-exercise program and achieve postural changes in activities of daily living. The intensity of the treatment program must be individually tailored to the exercise capacity of the patients and the inherent risk of progressions.

The Gensingen brace by Dr Weiss® is the first orthotic treatment for scoliosis that is evidence based.

The Gensingen brace is the "child" of Dr. Hans-Rudolf Weiss, a third generation Schroth family with a lifetime's dedication to the advance of conservative treatment for scoliosis. Dr. Hans-Rudolf Weiss has worked tirelessly on brace development since the 1990s.

The purpose of this study was to evaluate the Schroth-3D Scoliosis Program, and the link, with Gensingen brace.

For scientific research we used: documentation, case study, observation, statistical results, and graphical representation.

Keywords: Schroth-3D Scoliosis Program, scoliosis, posture variations, Gensingen brace.

Introduction

Scoliosis is a more or less fixed spinal axial deviation depending on the functional and structural aspects of the disease followed by typical trunk deformities. The structural components of scoliosis mainly the mechanical adaptations of discs, vertebrae, ribs are not reversible in short terms. It depends on the growth potential if in long terms these structures have the chance to be reversed using braces and exercises. If the curvatures are not in correct alignment due to disease, poor posture or through congenital abnormalities such as idiopathic scoliosis, far greater muscular activity over the affected area is then required to maintain the upright posture (Jean Oliver & Middleditch, 1991, p. 296).

Scoliosis it is a 3D deformation in frontal plane, transverse plane, and sagittal plane:

- In frontal plane means a lateral deviation to the convex side of a curve who leads to a lateral flexion of the spine;
- In transverse plane means a rotation mainly in the apex of the curve in the same direction with lateral deviation;
- In sagittal plane means a hypokyphosis in the apical lumbar part with a supplementary hyperlordosis combined with hypermobility in the lumbosacral junction (Lehnert-Schroth, 2007, p. 9).

Scoliosis can be categorized into three major types - congenital, syndromic, and idiopathic.

- Congenital scoliosis refers to spinal deformity caused by abnormally formed vertebrae.
- Syndromic scoliosis is associated with a disorder of the neuromuscular, skeletal, or connective tissue systems, neurofibromatosis, or other important medical condition.
- Idiopathic scoliosis; despite much clinical, epidemiological, and basic science research, the a etiopathogenesis of idiopathic scoliosis remains unknown.

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Idiopathic scoliosis can be subdivided based on the age of onset:

- infantile idiopathic scoliosis (IIS) includes patients aged 0-3 years;
- juvenile idiopathic scoliosis (JIS) includes patients aged 4-10 years;
- and adolescent idiopathic scoliosis (AIS) affects people aged 10-18 years.

Adolescent idiopathic scoliosis (AIS) is the most common pediatric spinal deformity. It progresses most rapidly during the pubertal growth spurt(Cheng et al. 2015).

Idiopathic scoliosis is a deformity of the torso, characterized by lateral deviation and axial rotation of the spine. Although good anatomic descriptions of the structural changes seen in scoliosis were first made by the ancient Greeks, we have not yet elucidated its pathogenesis. The deformity always develops from a straight spine into a curved spine, usually accompanied by a rib cage deformity, during the growth period in general and, in particular, in the rapid growth period. In the growing scoliotic spine, the loss of mechanical stability results in deformation of the vertebral bodies and ribs. The eventual magnitude of an idiopathic scoliotic curve varies and is unpredictable. The extent of the alterations in the shape of the vertebrae and ribs is strongly related to the severity of the scoliotic curve. Pain is a rare symptom, and the patient seems unaware of his or her condition. The idiopathic scoliotic curves follow a geometric pattern: (1) primary thoracic; (2) thoraco-lumbar; (3) primary lumbar (4) double primary.

The primary curve invariably has associated secondary curves which follow similar geometric pattern. The axial rotation of the vertebrae is towards the convexity of the curve (Boos & Aebi, 2008). The most important problem related to scoliosis is progression of the deformity, i.e. worsening of the scoliotic curve.

The amount of progress in adolescent idiopathic scoliosis is different for each patient, in some patient's progress is rapid, in others it does not progress at all. Earlier when the growth velocity of the spine is 20 mm/year or more, the idiopathic scoliosis is nearly always progressive (Wapstra & Veldhuizen, 2012). When growth is completed progression generally stops, although research has shown that the risk of curve progression is primarily related to periods of rapid skeletal growth of the patient, most often during the pubertal growth spurt. The prevalence of scoliosisis approximately 4% of the children between 10 and 16 years of age. However, adolescent idiopathic scoliosis does not necessarily progress, and the prevalence of children having a Cobb angle larger than 45 degrees, and therefore needing operative treatment, is approximately 0.1%. Spontaneous improvement is however rare and almost never seen in moderate to large curves. Although many types or causes of scoliosis are known, the idiopathic variety comprises the largest group (80%) and its aetiology unknown.

Aim of the study

The natural history of Adolescent idiopathic scoliosis (AIS) involves an initial stage in which a small curve develops due to a small defect in the neuromuscular control system and a second stage, during adolescent growth, in which the scoliotic curve is exacerbated by biomechanical factors, whereas neurological dysfunction may play a role in the extent of progression during normal growth (Dobosiewicz, 1997).

Background

For the medical rehabilitation of spinal deformities, the goal is to maintain function and prevent secondary symptoms in the short- and long-term. In patients with scoliosis, predictable signs and symptoms include pain and reduced pulmonary function.Outpatient and inpatient programs are available worldwide for the rehabilitation of patients with impairments or disabilities in various medical fields. Particularly in Germany, there is a long history of inpatient rehabilitation for various diseases. The German Pension Insurance scheme has introduced a comprehensive practice guidelines program for the development of process guidelines for inpatient rehabilitation.There are numerous papers providing evidence that outpatient rehabilitation is as effective as inpatient rehabilitation (Weiss, 2010, p. 2).

Rehabilitation is the process of assisting someone to improve and recover lost function after an event, illness or injury that has caused functional limitations. But how can we define rehabilitation in the context of spinal deformities? First we need to acknowledge the functional limitations in patients with spinal deformities.

An overview is given in the SOSORT consensus paper on physical exercises (Weiss, Negrini, Hawes, et al. 2006).For children/adolescents with scoliosis, therefore, optimal treatment goals include reversing curvature magnitude and/or preventing curvature progression, pain, and pulmonary dysfunction over a lifetime.

Children and adolescents with spinal deformities without further limitations have to be treated according to the indication guidelines (Weiss, Negrini, Rigo, et al. 2006). Overtreatment as well as undertreatment can be avoided when these guidelines are respected. In case there is an indication for physiotherapy, outpatient programs are recommended to avoid brace treatment or, in case of a brace indication to support mobility of the spine as well as the compliance of the patients (Weiss, 2010, p. 8).

The purpose of this study was to evaluate the possible link and connection, between performing a specific individual treatment based on Schroth-3D Scoliosis Program method, and the new "Brace technology" with Gensingen brace™in patients recovery with Adolescent Idiopathic Scoliosis (AIS).

Materials and methods

The study has been performed in three distinct parts:

- The collection and analysis of theoretical information from the systematic literature search on the topic of Adolescent Idiopathic Scoliosis (AIS)Program;
- The collection and analysis of theoretical information from the systematic literature search on the topic of the Schroth-3D Scoliosis Program;
- The collection and analysis of theoretical information from the systematic literature search on the topic of the Gensingen brace™ and ScoliOlogiC™ concept.

Systematic literature search

First, we aimed at identifying all papers that could have faced the medical topic of our paper. We searched the Cochrane Library and Medline database, using free text, from the date of inception to January 2020, for relevant literature and entered the following search terms: "the spine", "adolescent idiopathic scoliosis", "late onset scoliosis", "scoliosis", "Schroth-3D Scoliosis Program","scoliosis brace" AND "Gensingen brace™", without applying any language restriction. We used the words adolescent idiopathic scoliosis and set the limits editorial, guideline, meta-analysis, and randomized controlled trial. According to the abstract, we selected the final papers that were read to search relevant information on the topic, to be introduced in our document.We mainly selected literature from the past 15 years, but did not exclude commonly referenced and highly regarded older studies.

We included systematic reviews, randomized controlled trials, and good quality prospective observational studies, but did not exclude seminal papers from before this time.We also searched the reference lists of articles identified by this search strategy and selected those we judged relevant. Pertinent review articles and book chapters were also included.

Schroth-3D Scoliosis Program

Based upon typical physiotherapeutic principles, the Schroth-3D Scoliosis Program was developed by Katharina Schroth in 1920, and continuously refined through the treatment of approximately 3,000 scoliosis cases per year. The Asklepios Katharina Schroth Spinal Deformities Rehabilitation Centre in Germany offers a scoliosis-specific intensive inpatient rehabilitation program.

The broad network of therapists enables the continuation and actualization of the Schroth-3D Scoliosis Program throughout much of the world, including in Germany, Russia, and many other European countries, in Canada and the United States, in Australia, and several countries in Asia.

The main goals of the Schroth-3D Scoliosis Program are to provide effective treatment for patients, and training and education for physiotherapists. The treatment approach includes both intensive inpatient rehabilitation and residential outpatient physiotherapy provided by certified Schroth therapists (Weiss, 2011).

Schroth system of scoliosis curve classification

The Schroth-3D system of scoliosis curve classification (Lenhert-Schroth, 2007) is derived from the Schroth principle of dividing the body into 'Body Blocks'. This symbolic description helps to explain the scoliotic alterations as compensatory adaptations.

The "Body Blocks" depict the trunk deformation as a change in their geometric form from a rectangle to a trapezium shape. Side-shift and rotation as well as compression on the concave side and expansion on the convex side are clearly visible. In the standing static position, the "Body Blocks" should be aligned perpendicularly with their center of gravity integrated in the central sacral line (CSL).

The Schroth-3D system of scoliosis curve classification gives the direction of the side deviation and rotation of the main important "Body Blocks" (major curves) and a clear orientation for the standardized therapy plan which includes the therapy diagram, exercise-program with home-exercises, and necessary mobilizing technique (Berdishevsky, Lebel, Bettany-Saltikov, et al. 2016).The scoliotic trunk asymmetry is a loss of symmetry and shows the blocks skewed and off-center (See figure 1).

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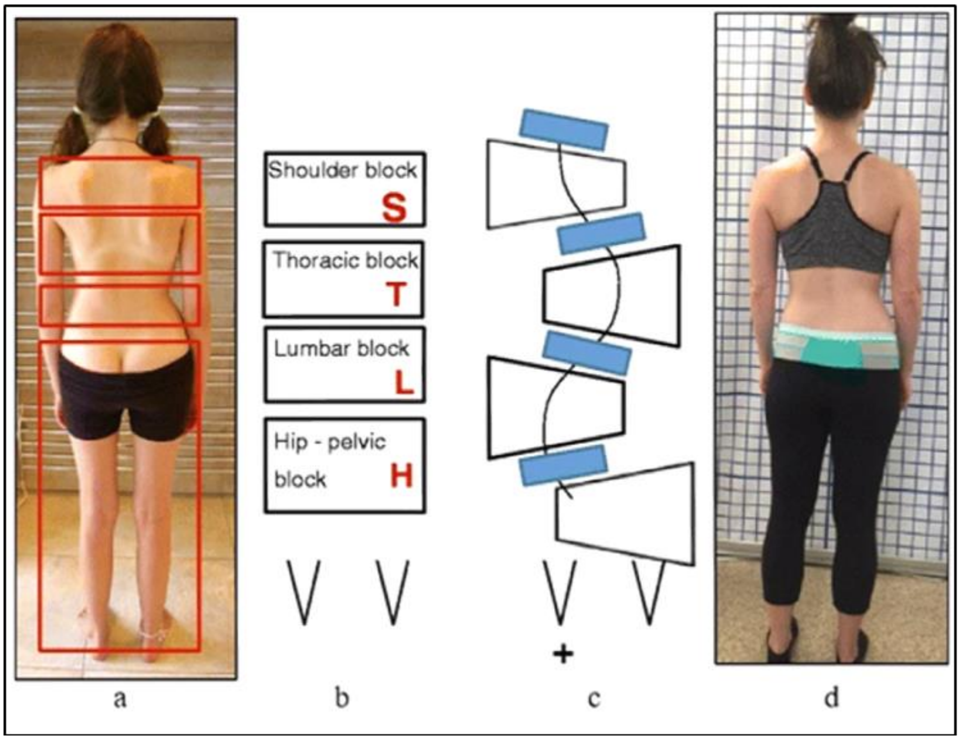

Figure 1. (a, b, c, d) Schroth "Body Blocks"

(Berdishevsky, H., Lebel, V.A., Bettany-Saltikov, J. et al. (2016). Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools. Scoliosis Journal, https://doi.org/10.1186/s13013-016-0076-9)

The Schroth-3D system of scoliosis curve classification is derived from the Schroth principle of dividing the body into "Body Blocks" as pictured anatomically (a) and schematically (b). Scoliosis causes the "Body Blocks" to become deformed, changing their geometric shape from a rectangle (b) to a trapezium (c). A patient with a major lumbar scoliosis left convex curve has a lumbar block shifted to the left and a hip-pelvic block shifted to the right (d).

According to the Schroth system of scoliosis curve classification, the different scoliosis types always start with the major curve and are followed by relevant secondary curves.

The uppercase letters represent the body blocks and the lowercase letters describe the direction of the lateral deviation and rotation: right = ri, left = le.

Schroth-3D "Body Blocks"

H – Hip-pelvic block including the lower limbs reaching the lower end vertebra (LEV) of the lumbar curve.

L – Lumbar block enclosed by upper end vertebra (UEV) and lower end vertebra (LEV) of the lumbar curve or thoracolumbar curve respectively.

T – Thoracic block between upper end vertebra (UEV) and lower end vertebra (LEV) of the thoracic curve.

S – Shoulder block represents the cervical thoracic (proximal thoracic) curve located between upper end vertebra (UEV) of the thoracic curve and upper end vertebra (UEV) of the proximal thoracic curve.

The following is an overview of the classifications:

1.Thoracic scoliosis (means that the major curve is located in the thoracic spine, and the curve can be to the right or to the left):

a. Thoracic only;

b. Thoracic with lumbar to opposite side with hips in center;

c. Thoracic with lumbar and hips protruding to the opposite side of the thoracic curve(along with the lumbar).

2.Lumbar scoliosis (means that the major curve is located in the lumbar spine, and the curve can be to the right or to the left):

a. Lumbar only with hips protruding to the opposite side of the curve;

b. Lumbar curve with thoracic and hips protruding to the opposite side of the lumbar curve;

c. Lumbar and thoracic curves with hips in center.

3.Sagittal plane deformities including increased thoracic kyphosis (round back), decreased thoracic kyphosis (flat back) and increased lumbar kyphosis or loss of the normal anatomical lordosis (curve) of the lumbar spine.

Treatment indications and goals

Treatment indication for the Schroth-3D Scoliosis Therapy is based on the SOSORT guidelines (Negrini, Aulisa, Aulisa, et al. 2011).

Both individual and group treatments share these same goals:

1.Proactive spinal corrections to avoid surgery.

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2.Postural training to avoid or decelerate progression.

3.Information to support a decision-making process.

4.Teaching a home-exercise program.

5.Support help for self-help.

6.Prevention and coping strategies for pain.

Age specifics for Schroth-3D Scoliosis Program

The Schroth-3D Scoliosis Programis primarily used for idiopathic scoliosis, including Adolescent Idiopathic Scoliosis (AIS) and late Juvenile Idiopathic Scoliosis (JIS). Sagittal plane deformities such as hyper-kyphosis (Scheuermann's kyphosis) and lordosis (inverted back) can also be treated with Schroth exercises. Treatment of Juvenile Idiopathic Scoliosis (JIS) involves a less intense and modified Schroth-3D Scoliosis Program as well. Treatment of Adolescent Idiopathic Scoliosis (AIS) using strict Schroth-3D principles is aimed at preventing curve progression before the end of growth.

Schroth-3D ScoliosisProgramCorrection concept

In the Schroth-3D Scoliosis Programthere are five pelvic corrections that are assumed prior to the execution of the main principles of correction. These five pelvic corrections ensure that the pelvis is best aligned with the trunk prior to the major corrections.

The five principles of the Schroth-3D Scoliosis Programare:

1) Auto-elongation (detorsion);
2) Deflection;
3) Derotation;
4) Rotational breathing;
5) Stabilization.

During the application of these principals, the patient is taught how to de-collapse the concaved areas of the trunk and how to reduce the prominences.

The use of breathing mechanics, muscle activation, and mobilization in Schroth-3D Scoliosis Program

The success of the method is based on strengthening exercises tailored to each individual scoliosis patient and their specific curve pattern.

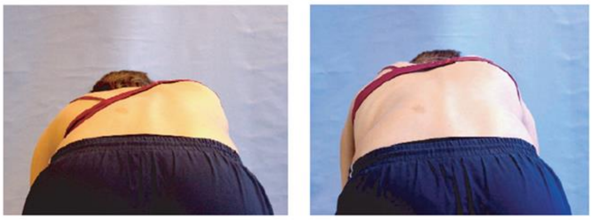
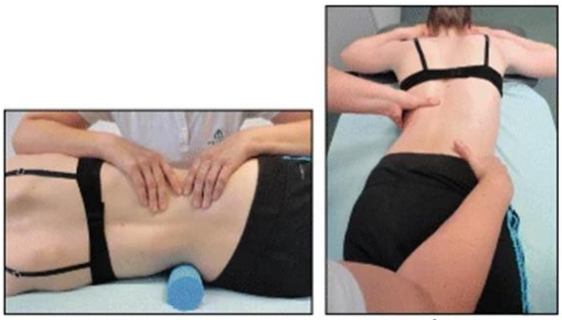


Figure 2. Rotational Angular Breathing (RAB) demonstrated in forward bending position

(Berdishevsky, H., Lebel, V.A., Bettany-Saltikov, J. et al. (2016). Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools. Scoliosis Journal, https://doi.org/10.1186/s13013-016-0076-9)

Unique Rotational Angular Breathing (RAB) exercises originally developed by Katharina Schroth help in vertebral and rib cage derotation and in increasing vital capacity (See figure 2).

This unique breathing technique helps expand the ribs from inside the rib cage by pushing the ribs "sideways and backwards" and helps return the vertebrae closer to their normal, untwisted position. Muscle activation of core muscle groups, like the iliopsoas, thoracic and lumbar fascicles of the erector spinae and quadratus lumborum, help stabilize and maintain the expanded ribs and derotated vertebral bodies. Breathing is directed dorsally and laterally as can be seen on the right picture.Encouraging mobilization and flexibility (See figure 3) helps to release tension and assists in postural correction. Wall bars, pads, poles, belts, straps, mirrors, elastic-bands, dowels, balls, yoga blocks, stools, and foam rollers are equipment commonly used to assist Schroth exercises.



a b

Figure 3. (a) Lumbar mobilization exercise; (b) Curve flexibility exercise
(Berdishevsky, H., Lebel, V.A., Bettany-Saltikov, J. et al. (2016). Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools. Scoliosis Journal, https://doi.org/10.1186/s13013-016-0076-9)

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Schroth-3D Scoliosis Programexercises

Three of the most commonly used exercises in the Schroth-3D Scoliosis Program are the *"50 x Pezziball"* exercise, *"Prone"* exercise, *"Sail"* exercise, and the *"Muscle-cylinder"* exercise. All these exercises can be used for all curve types.

The *"50 x Pezziball"* exercise works on auto-self-elongation and activation of muscles in the trunk that force the convexities in the trunk "forward and inward", the concavities "outward and backward" (See figure 4).

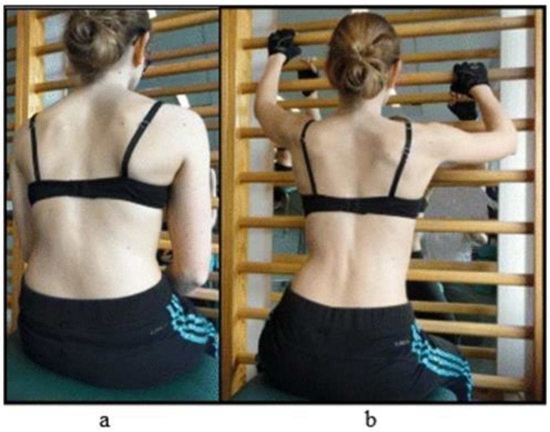

Figure 4. (a) "50 x Pezziball" exercise the patient sits on a Swiss-ball in front of a mirror;
(b) the patient performs active 3D auto self-correction using the wall bar
(Berdishevsky, H., Lebel, V.A., Bettany-Saltikov, J. et al. (2016). Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools. Scoliosis Journal, https://doi.org/10.1186/s13013-016-0076-9)

The "*Prone"* exercise corrects the thoracic curve using Shoulder Traction (ST) and Shoulder Counter-Traction (SCT) and the lumbar curve via activation of the iliopsoas muscle (See figure 5).

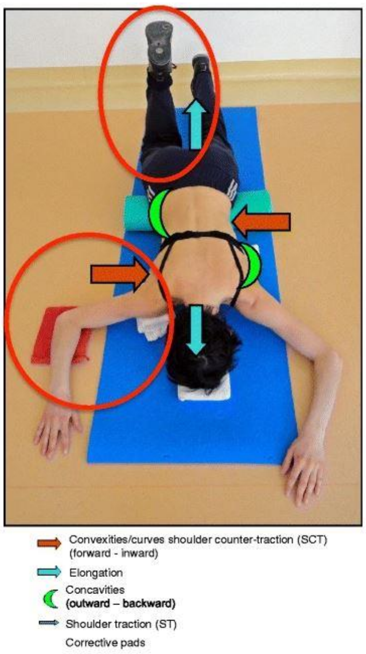

Figure 5. The Schroth "Prone" exercise withactivation of the iliopsoasmuscle, right hip flexion
(Berdishevsky, H., Lebel, V.A., Bettany-Saltikov, J. et al. (2016). Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools. Scoliosis Journal, https://doi.org/10.1186/s13013-016-0076-9)

In figure 5,the signs represent:

- *Blue arrows* represent trunk elongation with caudal and cranial forces.
- *Red arrows*represent areas of muscle activation around the convexities towards the midline.
- *Green half-moons* represent areas of expansion of the concavities.

- *Red circles* around the right lower extremity and the right upper extremity represent iliopsoas activation and shoulder traction/counter-traction, respectively, resulting in correction of the lumbar and thoracic curves.

The *"Muscle-cylinder"* use the quadratus lumborum muscle to correct the lumbar curve against gravity (See figure 6). The "Muscle-cylinder" exercise (also known as the "Side-lying" exercise), focusing mainly on the correction of the lumbar scoliosis curve. During this exercise, the patient lies on the lumbar convex side.

The lumbar convexity is supported by a rice bag to help align the spine in the horizontal plane. The patient's right leg is supported by a stool (in case of 4C/major lumbar scoliosis) and the patient's right arm is supported on a chair during the exercise.

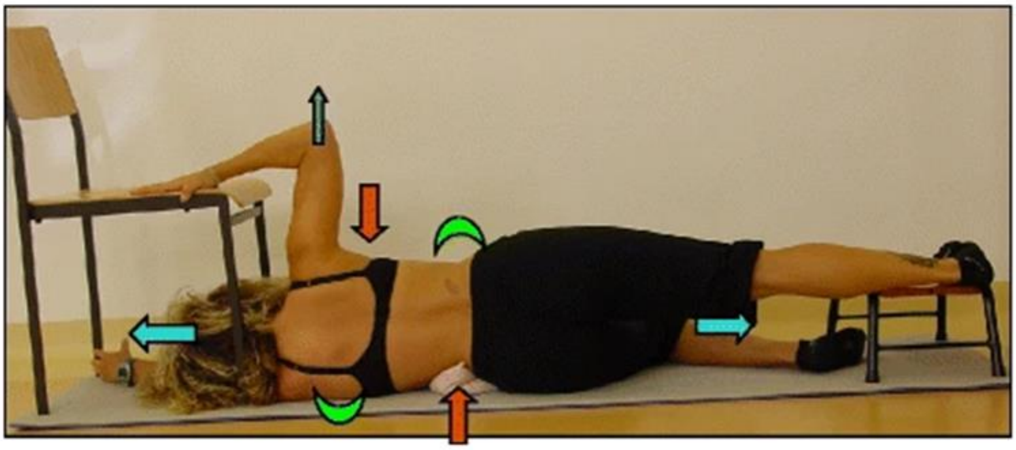

Figure 6. The "Muscle-cylinder" exercise

(Berdishevsky, H., Lebel, V.A., Bettany-Saltikov, J. et al. (2016). Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools. Scoliosis Journal, https://doi.org/10.1186/s13013-016-0076-9)

In figure 6,the signs represent:

- *Light blue arrows* - trunk elongation with cranial and caudal forces.
- *Green half-moons* - areas of expansion of the concavities.
- *Red arrows*- areas of muscle activation, approximating the convexities towards midline, and the direction of the correction.
- *Dark blue arrow* pointing upwards from the right elbow represents the shoulder traction, which is an isometric tension from the shoulder in a lateral/outward direction with a fixed scapula as a continuation of the transversal expansion in the proximal thoracic region.

Gensingen brace™ in the treatment of scoliosis

Bracing concepts in use today for the treatment of scoliosisinclude symmetric and asymmetric hard bracesusually madeof PE on the one hand and soft braces onthe other. The latest developments in the field of bracing,aim at improving specificity with respect to theindividual curve pattern of the patient treated and ata restoration of a proper sagittal realignment.Although the effect of brace treatment has been questioned (Goldberg, Moore, Fogarty, Dowling, 2001), there is evidence that brace treatment canstop curvature progression (Emans, Kaelin, Bancel, Hall, Miller, 1986), reduce the frequencyof surgery (Rigo, Reiter, Weiss, 2003)and improve cosmetic appearance. Poor cosmetic appearance for the patient maybe the most important problem, which can be solved orat least reduced by the use of advanced bracing techniquesincluding the best possible correction principlesavailable to date (Rigo, 1999).

The plaster cast method worldwide seems to be themost practiced technique for the construction of hardbraces at the moment. CAD (Computer Aided Design)systems are available, which allow brace adjustmentswithout plaster. Another new development is the ScoliOlogiC™ off the shelf system enabling the technicianto construct a light brace for scoliosis correction froma variety of pattern specific shells to be connected toan anterior and a posterior upright. This Chêneaulight™ brace, constructed according to the Chêneauprinciples using the brace parts from the ScoliOlogiC™off the shelf system, promises a reduced impedimentof quality of life in the brace.

A satisfactory in-bracecorrection exceeding 50% of the initial Cobb angle hasbeen achieved with this brace, which was used asthe basis for the development of the Gensingen brace™ (See figure 7).

Figure 7. Three examples of Gensingen braces™
(Weiss, H. R. (2010). "Brace technology" thematic series - the Gensingen brace™ in the treatment of scoliosis. Scoliosis, https://doi.org/10.1186/1748-7161-5-22)

In the figure 7, on the left there is a brace to address a double curve (3CL, 4C), in the middle, a brace to address single thoracic curves (3C, 3CH) and on the right, a brace for the treatment of a thoracolumbar curve pattern.

History of the Gensingen brace™

The Gensingen brace™ is a Chêneau derivative in principle.The Chêneau brace was developed before 1978 (Chêneau,1994). As the first developments were made in Münster, Germany, the brace was initially called CTM-brace (Chêneau-Toulouse-Münster). Jacques Chêneau, whoused to live in Toulouse, spent a few years in Münster, where he braced patients at the orthopedic department of the university. In 1985 the first end-result study was published with in-brace correction effects of more than 40% of the initial value (Hopf,Heine,1985) and final results superior to the end-results of the Milwaukee study from the same center (Heine, Götze,1985). The initial Chêneau brace was upgraded in 1995 and from this year on, a new version each year was promoted by the inventor during the courses organized in Germany together with Dr. Weiss in Bad Sobernheim and Prof. Neff in Berlin.A working relationship between Dr. Chêneau, Dr. Weiss and Dr. Rigo began in Bad Sobernheim towards the end ofthe 90's, which resulted in a collaborationpublishing a book presenting the1999standardof theChêneau brace (Weiss, Rigo, Chêneau, 2000). At the beginning of the new century Dr. Chêneau was working on the first CAD/CAM system supported by a company called IPOS. Other CAD/CAM systems developed in Germany applying the Chêneau principles, such as the Regnier™ system and the RSC™brace. In the summer of 2006, the fabrication of the ScoliOlogiC® off the shelf bracing system for the adjustment of Chêneau light™ braces began. The Chêneau light™ brace is available for right thoracic and left lumbar curvatures, only. For thoracolumbar curvatures, no Chêneau light™ shells are available. Another limitation for the application of the Chêneau light™ brace is the limited number of shell sizes not allowing to brace patients with small trunks as well as in children aged ten or under.Therefore, it has been necessary to use plaster based bracing or a CAD/CAM system in addition to the Chêneau light™ brace.

Therefore, with the help of Orthomed Scoliocare, Orthopedic Technical Services in Gensingen a new CAD/CAM system was developed in Spring 2009 with the aim to overcome the shortcomings of the CAD/CAM systems already available in Germany and to enable brace adjustments for patients of all possible curve patterns (See figure 7) and trunk sizes. A slight lumbar lordosis has been introduced into the braces included into our library (See figure 8), which can be augmented by using foam pads and the "Stop Point" against rotational forces (Point 37 according to Chêneau) has been set laterally in order to have a better relation to the anterior superior iliac spine on the rib hump side.

Although, dependent on the pelvic geometry of the individual patient, there are still experiencing some rotation instabilities in the new design, it was possible to reduce this problem drastically.

Figure 8. Sagittal alignment of a Gensingen brace™ 4C
(Weiss, H. R. (2010). "Brace technology" thematic series - the Gensingen brace™ in the treatment of scoliosis. Scoliosis, https://doi.org/10.1186/1748-7161-5-22)

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On the right, in figure 8, the implementation of a physiologic sagittal profile is visible with apronounced lumbar lordosis and a slight thoracic kyphosis.

Brace description

The advantage of the Gensingen brace™ is that the brace is available in a short time (3 days with overnight milling service, or even shorter), is easily adjustable and is very comfortable to wear, because many compression effects - in frontal and sagittal plane as well - apparent within other specific, non symmetric CAD/CAM systems - have been ruled out in this system of bracing.

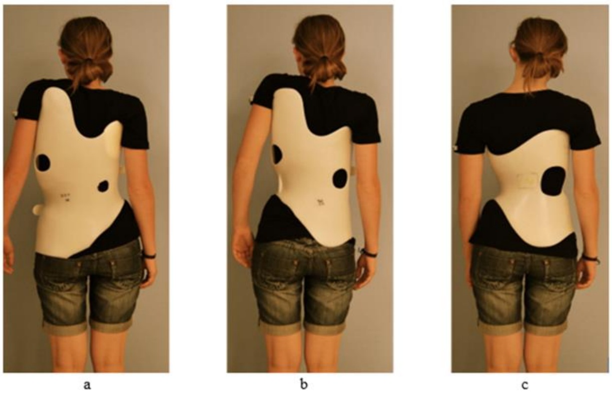

Figure 9. The Gensingen brace™ a:3-curve patterns; b: 4-curve patterns; c: thoracolumbar curve patterns
(Weiss, H. R. (2010). "Brace technology" thematic series - the Gensingen brace™ in the treatment of scoliosis. Scoliosis, https://doi.org/10.1186/1748-7161-5-22)

As a matter of fact, many other CAD/CAM Chêneau derivates lack a balanced distribution of pressure areas. Braces to address functional 3-curve patterns (See figure9a), braces to address functional 4-curve patterns (See figure 9b) are available, as are braces for thoracolumbar curve patterns (See figure 9c). There are more than 35 different braces in our library including models for athletic trunks as well as models for small children.

No extra models are used for double thoracic curvatures as these easily can be addressed by fine adjustment of the models from the library. The brace is usually adjusted to the patients' body with the help of the pattern specific blueprints as a raw "try on" brace first as it has been cut from the foam positive (See figure 9)

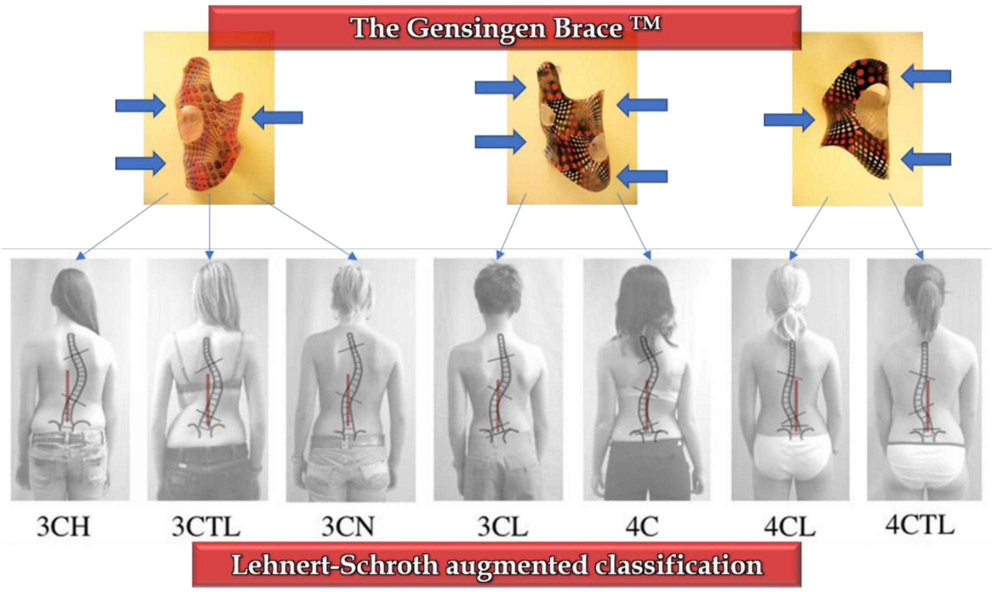

Figure 10 The Gensingen brace^{TM} development from Lehnert-Schroth augmented classification

The use of the Gensingen brace™leads to sufficient in brace corrections, when compared to the correction effects achieved with other braces as described in literature (Weiss, 2010) and(Weiss, Werkmann, Stephan, 2007).

Short case with "link" between Schroth-3DScoliosis programandGensingen brace™

Dr.MarcMoramarco, in February 2015, present an article, in online Journal Cision PRWeb, the case of a fourteen-year-old girl with adolescent idiopathic scoliosis (AIS).She presented for treatment at Scoliosis 3DC, Boston, when she was thirteen yearsold and a Risser 3. Her initial spinal Cobb angles measured 44º thoracic and 38º lumbar. She was fitted with the Gensingen brace in December 2013 and participated in a twenty-hour Schroth-3D Scoliosis Program under the instruction of Schroth therapists Dr. Marc Moramarco and Amy Heller OTR/L. The patient continues to be compliant with her treatment plan, wearing her brace twenty-two hours a day and doing her daily Schroth-3D program. Fourteen months later, the patient's Cobb angles now measure 31º thoracic and 20º lumbar when out of brace for 24 hours. This is a 30% curve reduction in the thoracic spine and a 47% curve reduction in the lumbar spine (note: all x-rays were taken at an independent facility). While it is too early to document the overall effect of this two-pronged treatment approach, the effectiveness of the Schroth-3D Scoliosis program and the Gensingen brace™ are both individually supported by published research.

Although scoliosis progression is unpredictable and each spine is different, this patient's result provides hope for growing adolescents with idiopathic scoliosis. Research suggests that most curves that hold to 30° (or less) at skeletal maturity will stabilize. Therefore, this patient is well on her way to achieving what most physicians say is impossible - scoliosis curve reduction.

Her scoliosis experience shows that the right treatment, implemented at the right time, can mean a world of difference for adolescent with scoliosis. Before beginning her Schroth-3D Scoliosis program, this patient's primary curve measured 44°, making her a likely candidate for surgery. Instead, she is now nearing skeletal maturity and has improved her scoliosis to the point where progression in adulthood may no longer be a concern.

Conclusions

The primary goals of Gensingen brace™is for curve stabilization and/or reduction and postural improvement. The Gensingen brace™ differs significantly from traditional scoliosis braces due to its asymmetric style - designed to induce a mirror image of the patient's scoliosis. The goal of this is overcorrection, which dependent on curve severity and spinal flexibility. Each brace is designed according to individual curve pattern and strategically placed openings allow for derotational breathing, which is similar to a Schroth-3D exercise. Bracing can be done alone or in conjunction with a Schroth-3D Scoliosis program; in this case the patients that combine both treatment options typically have the best outcome.

Authors contribution

All authors contributed equally to this study and should be considered as main authors.

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