Scope of Orthotic Management for Adolescent Idiopathic Scoliosis in Developing Countries- A narrative review

Minakshi[1], Lekshmy Priya[2]
[1]*Member Mobility India Rehabilitation Research and Training Centre, Bengaluru*
[2]*Mobility India Rehabilitation Research and Training Centre, Bengaluru*

***Abstract* - Adolescent idiopathic scoliosis (AIS) is one of the most common spinal deformities in this era. The term scoliosis refers to a three-dimensional deformity resulting in an abnormal lateral deviation in the axis of a person's spine. By definition, adolescent idiopathic scoliosis is the lateral curvature of the spine exceeding about 10oof Cobb's angle occurring in late childhood or adolescent age (above 10 years of age) until skeletal maturity1. The affected spine will be subjected to lateral deviation accompanied by vertebral rotation within the curvature.**

Orthotic management has a dominant role in the non – operative treatment of adolescent idiopathic scoliosis, with the availability of a huge variety of braces. But it is observed that in the developing counties there is a lack of awareness, knowledge, and skill about the myriad types of braces in the service provision as well as in the prosthetic and orthotic (P & O) education. Considering this as a fundamental need, a narrative review has been conducted to craft a detailed review on globally available design concepts to enlighten students as well as P and O practitioners in developing countries.

Create awareness of the scope of orthotic management in AIS among p &o students and clinicians of developing countries. Narrative review -Method

This readily available resource material will assist the P&O professionals in making the appropriate prescription. Also, this article will address the issues in identifying the material and technology selection for the orthotic intervention of AIS.

***Index Terms* - adolescent, bracing, deformity, evidence, non - operative, orthosis, scoliosis.**

INTRODUCTION

The scoliosis research society describes scoliosis radiologically as a lateral spinal curve exceeding 10 degrees in a radiograph, with vertebra rotation. Whereas The International Scientific Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT) came up with a detailed description of scoliosis where is defined as a complex three-dimensional deformity of the spine and trunk, which appears in apparently healthy children and can go into progression due to multiple factors, during any rapid period of growth or even later in life [2].

Even though there are a variety of braces available for treating scoliosis, a massive lack of awareness, knowledge, and skill about the various design concepts is still experienced among the students and clinical practitioners. The harsh effects of untreated scoliosis have a substantial role in the development of scoliosis braces.

The history of treating spinal deformities starts from the 5th century BC, the era of Hippocrates where a combination of diet and longitudinal extension is utilized to treat the deformity [3]. But as time passes, a lot of advancements came into the field came into practice. A variety of factors can contribute to the progression of the spine including both biological and mechanical factors (Table 1).

Prevalence

Adolescent idiopathic scoliosis is a common disease with an overall prevalence of 0.47–5.2 %. The female to male ratio ranges from 1.5:1 to 3:1 and increases substantially with increasing age. In particular, the prevalence of curves with higher Cobb angles is substantially higher in girls than in boys: The female to male ratio rises from 1.4:1 in curves from 10° to 20° up to 7.2:1 in curves >40° [4].

Classification of scoliosis

The depth and perimeter of scoliosis as a subject gave birth to intense research and hence many informative articles are currently available on the topic. Different scholars have classified scoliosis in different ways. Dominant ones among them are the structural and non-structural classification and classification based on onset (table 2).

The standard method for assessing the curvature is by measurement of Cobb's angle, the angle between the uppermost vertebrae and lowermost vertebrae involved in the curve. In 1958, Joseph C. Risser introduced the Risser sign as an indirect measure of skeletal maturity by evaluating the degree of ossification of iliac apophysis has achieved massive popularity and is still considered as one of the established methods of measuring scoliosis [3].

MATERIALS AND METHODS

A journey of thorough analysis has been carried out to dig into the various design concepts in the orthotic management of AIS globally, its evidence-based practices, and its efficiency. Articles in electronic databases such as Google Scholar, Pub Med, o and p library, research gate, the US national library of medicine, etc. have been utilized to a great extend along with other sources such as books. Inclusion and exclusion criteria have been created (Table 3).

The fundamental aims of this study include: -

- To understand the history of bracing techniques and their efficiency
- Deeply analyze the current advancements in bracing, globally.
- To look on to the future of bracing
- To generate awareness among p and o students and clinicians about the various designs involved in AIS treatment

Table 1 – Biological and mechanical factors contributing to scoliosis [48]

BIOLOGICAL FACTORS	MECHANICAL FACTORS
Age	Initial curve magnitude
Gender	Axial stiffness
Skeletal maturity	Torsional rigidity
Type of curve	Geometrical changes

Figure 1: - Types of scoliosis

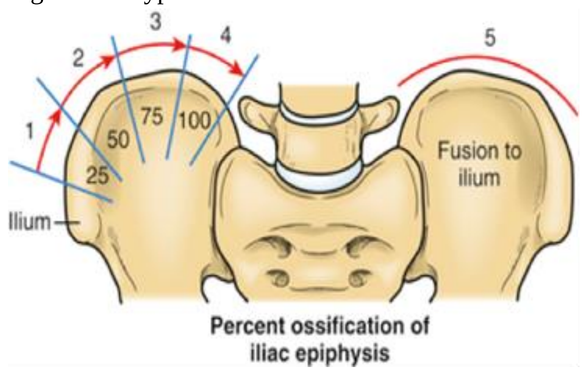

Figure 2: - Schematic representation of Risser sign [34]

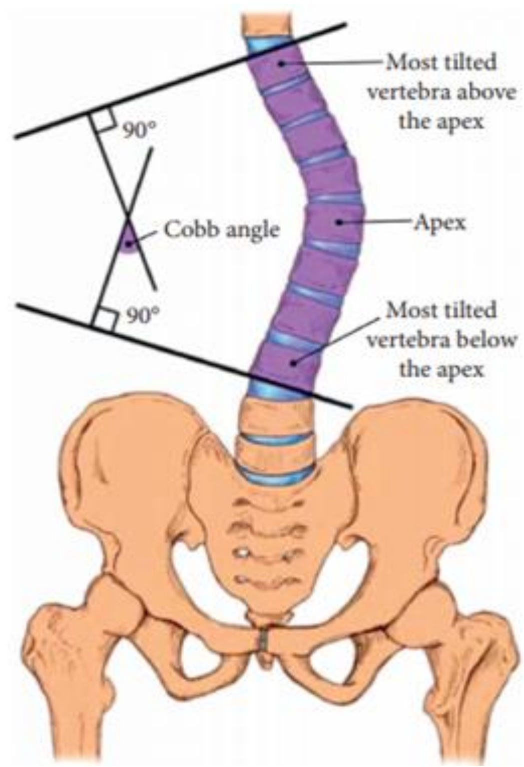

Figure 3: - Schematic representation of Cobb's angle measurement [33]

Table 2: - Inclusion and exclusion criteria

INCLUSION CRITERIAS	EXCLUSION CRITERIAS
Articles related to AIS	Articles related to other spinal pathologies
Articles related to orthotic management of AIS	Articles on orthotic management of other spinal conditions
Articles on the efficiency of bracing in AIS	Case study articles on AIS

Table 3: - Scoliosis classification [1]

Type of classification	Sub-classification	Features
Based on spinal structure	Structural Scoliosis	• Involves vertebral rotation along with curvatures • true scoliosis • based on causes such as idiopathic, congenital, paralytic vertebrae, and other pathologies
	Non-structural Scoliosis	• doesn't involve vertebral rotation • mobile or transient scoliosis • Based on scoliosis varieties such as postural, compensatory, and sciatic.
Based on onset	Early-onset (infantile)	• by an age of 0 to 3 years (infantile)
	Juvenile onset	• by the age of 4-9 years and
	Adolescent onset	• From the age of 10 years until skeletal maturity

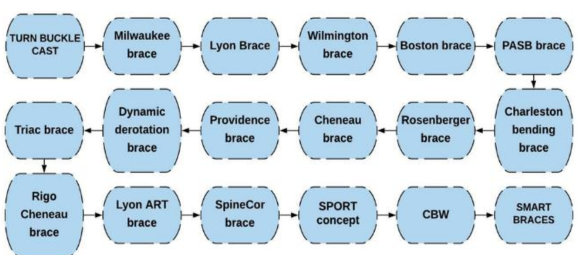

Figure 4: - Path of spinal orthosis

Early beginnings of spinal bracing

Contributions of Ambrose pare' in the field of orthosis are massive and always appreciated. The use of corrective treatments was first described by paring' opened the door towards the developments of spinal bracings. Iron corsets were utilized for corrective treatments and are still recognized as the foundation of modern orthotic braces [3]. The major contributions on orthotic devices were primarily from Europeans which brought various materials such as steel, leather, and plaster into the field of bracing. The Kalibis splint also called the "spiral bandage" was one of the earliest reported orthoses for scoliosis treatment found in the medical literature [11].

The Schroth method

The Schroth method was developed by Katharina Schroth in 1920. The principles of active 3D posture correction, corrective breathing, and correction of postural perception form the foundation for what came to be known as the Schroth method of scoliosis treatment. The Schroth system of classification is derived from the Schroth principle of dividing the body into 'Body Blocks' [5].

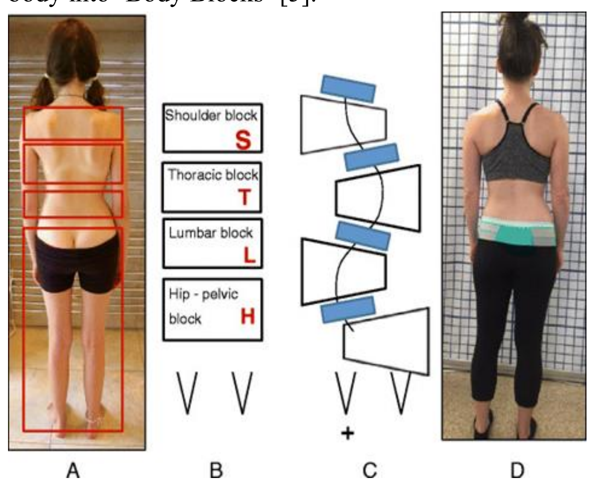

Figure 5: - Schroth system of classification into body blocks showing shoulder block, thoracic block, lumbar block, and hip – pelvic block [5]

Table 4: SRS criteria for bracing [2]

SCOLIOSIS RESEARCH SOCIETY (SRS) CRITERIA FOR BRACING
• Age > 10 years at brace prescription • Growth stage, Risser 0–2 • Cobb angle 25°–40° • No prior treatment • If female, less than 1-year postmenarchal

The path of spinal orthosis

Turnbuckle cast

Preoperative treatments utilizing plaster cast immobilizations have gained massive popularity in the histories. RusselHibbs (1869 - 1932) explained the use of turnbuckle cast to achieve initial curve correction [3]. The design was simple and effective in which a plaster cast is incorporated with a turnbuckle mechanism. Plaster/fiberglass can be utilized for this technique. This initial design of the turnbuckle cast was improved by Lovett and Brewster in 1942[3]. The design of the cast is split into two as superior and inferior parts then joined together with a threaded screw and wing nut in the concave side and the turnbuckle and hinge on the convex side of the curve. The mechanism of correction was the application of lateral and vertical forces by gradually opening the hinge on the convex side and hence slowly correcting the deformity. The major drawback of turnbuckle casts was that they couldn't correct the rotational aspect of the deformity and huge possibilities of developing secondary curves as the application of corrective force are only in one direction [3].

Figure 6: - turnbuckle cast [3]

The Milwaukee brace

Walter Blount described the benefits of CTLSO in 1946 commonly known as Milwaukee brace. A lot of research studies have been done by various scholars aiming to bring the best-improvised design of Milwaukee. By 1970 Moe and Kettleson explained Milwaukee as a non-operative method of treating AIS by refining the early designs [3]. The major drawbacks of initial designs such as increased bulk and orthodontic and facial complications due to chin pad etc. were resolved in the improved design [3].

Milwaukee brace is beneficial for high thoracic curves especially having Cobb’s angle range of 25 to 45 degrees. The concept relies on the connection with flattening of lumbar lordosis to achieve scoliosis correction. Thus a pelvic module is considered as the foundation of the Milwaukee brace which ensures close contact with the iliac crest and lumbar area of the spine.

The increased efficiency of the Milwaukee brace can be explained in terms of better correction and stabilization achieved through the application of longitudinal forces along the long axis of the spine through distraction and corrective pad attachments [3].

Figure 7: - Milwaukee brace- Anterior, sagittal and posterior view

Lyon Brace

Pierre Stagnara in 1947 introduced the first Lyon brace concept in scoliosis bracing. It is known as the first 3D adjustable contention brace used after a plaster cast [5]. The historic Lyon brace involves the combination of Physiotherapeutic scoliosis-specific exercises along with correction through the brace. The brace consists of adjustment facilities to allow the child’s growth up to 7cm and for weight gain up to 7kg. The Lyon management protocol requires curve reduction with a plaster cast for one to four months, after which the brace is molded and fit. Originally made up of steel and leather. The adjustability feature due to the extension between two pelvic and scapular girdles can decrease the pressure on intervertebral discs. The design was symmetrical which provides a much better aesthetic appearance and made fabrication easy as well [6].

Figure 8: - Historical Lyon

Wilmington brace

Dr. G. Dean MacEwen brought the concept of the Wilmington brace in 1969 [3]. Wilmington brace is a total contact TLSO designed to correct scoliotic curves of apices inferior to T7 with Cobb's angle between 25 to 39 degrees. It is a custom-made underarm symmetrical design with an anterior opening provision. Studies prove that treatment using a Wilmington brace can improve spinal decomposition. The domination of thermoplastic designs started with the development of Wilmington. Fabrication of Wilmington started by placing the patient in a Risser localized cast and crafting a new mold afterward. The involvement of longitudinal traction through the head and pelvic straps along with the application of hand pressure for creating lateral forces was one of the most evident features of the design. Scholars describe the efficiency of this brace as a seen maximum when used for 23 hours in a day until skeletal maturity [7].

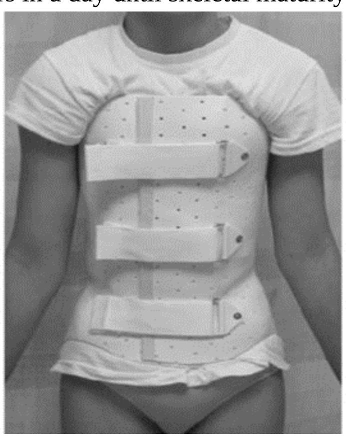

Figure 9: - Wilmington brace, anterior view

Boston brace

Hall and William Miller in 1972 at Boston Children's Hospital created a milestone in spinal bracing through the invention of Boston design [8]. The utilization of both active and passive corrective forces increased the popularity of the design and is widely used to date. The design reflects a symmetrical pattern with a posterior opening facility. The key feature of Boston design wasthat it includes anterior abdominal molding and flattening of posterior columns. Beneficial for a curve having Cobb's angle between 20 to 45 degrees and custom made up of polypropylene materials. The pads

Figure 10: - Boston brace, anterior and posterior view [38]

placed on the apices of the brace, near the axilla, allowed for passive corrective forces, whereas the open areas of the braces near the concavity adjacent to the pads allowed for corrective curve reduction into those openings [9].

Progressive action short brace

Dr. Lorenzo Aulisa (Institute of Orthopedics at the Catholic University of the Sacred Heart, Rome, Italy) introduced progressive action short brace in 1976. The PASB was designed to overcome the limits imposed by the trunk anatomy. Indeed, the particular geometry of the brace can generate internal forces that modify the elastic reaction of the spine10. The mechanism prevents homolateral bending of the scoliotic curve on the convex side. The inferior part of the brace helps to stabilize the brace on the pelvis in the sagittal plane. In transverse, the brace above the grip has an asymmetrical shape which allows the affected spine to rotate only towards the concave side which generates continuous derotation moments.10

Figure 11: - PASB brace – posterior, sagittal, and anterior views [10]

Charleston bending brace

Charleston bending brace is the first side bending brace made especially for nighttime use. It is indicated for Cobb's angle of 20 to 35 degrees for curves at an apex of level T7. The design concept relies on holding the curve in an overcorrected position and unloading the vertebral endplates on the concave side of the curve aids in reducing asymmetric bone growth. The design focuses on the coronal plane deformity and the mechanism involves creating a medially directed force vector on the convex side of the curve at the apex and below that is coupled with a medially directed counterforce on the convex side located above the apex to unbend the curve.

King's classification of scoliosis is utilized to achieve the specific brace design. Duration of wearing is limited to a short period (8 to 10 hrs.) in a day. Even though the wearing time is very minimal, the patient compliance was very poor due to the aggressive stretching and discomfort.11

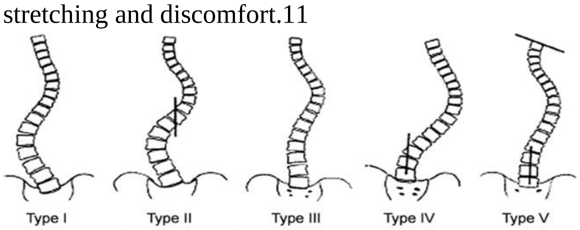

Figure 12: - Diagrammatic representation of King's classification of scoliosis [40]

Rosenberger brace

Rosenberger orthosis is a custom-molded low-density anterior opening TLSO. This orthosis is fabricated from a bivalved plaster impression, performed on an examination table with corrective forces applied during casting.

Figure 13: - Charleston bending brace – anterior view [39]

While casting the transverse force applied on the apex of the curve with counter forces applied to both the contralateral pelvis and axilla. Indicated for curves having an apex level of T6 and Cobb's angle of 29 degrees.

The design incorporates the use of adjustable slings through moveable straps [12].

Cheneau brace

The traditional Cheneau design was initially called Cheneau - Toulouse - Monster orthosis, introduced in 1990 [46]. The Cheneau brace is the most widely used in Europe within the group of rigid TLSO. The major

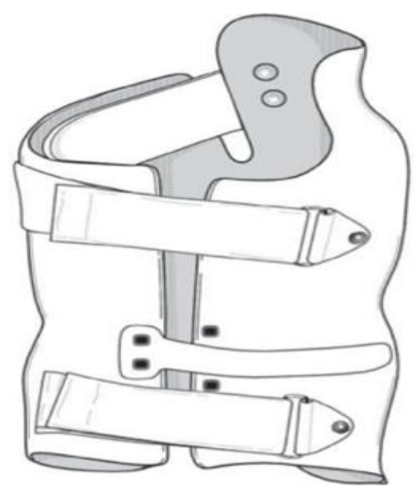

Figure 14:– Rosenberger brace, anterior view [12]

mechanism of this orthosis consists of a three-dimensional correction of the spine deformity by a system of multipoint pressure zones and expansion chambers. It is indicated for a curve level of T5 and a Cobb angle between 250 and 450. The original design includes an anterior opening provision and multiple three-point passive force mechanisms to de-rotate the thorax and to create an elongation and bending effect. Multiple oblique vectors in a dorsolateral to ventromedial direction located at the apex of the curve on the convex side are coupled with opposite oblique vectors to create force couples. Large voids are included in the design opposite to the pressure areas, to facilitate the convex to concave force transfer [46].

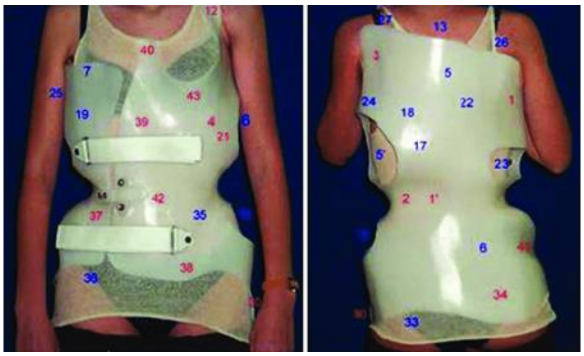

Figure 15: –Traditional Cheneau brace – Anterior and posterior view [41]

Providence brace

Originally named as providence nocturnal scoliosis system but commonly known as the providence brace was introduced in 1992, Charles D'Amato and Barry McCoy [12]. Initially, it was a design of acrylic positioning board capable of providing corrective forces with minimal discomfort to the patient. Later on, the board was developed into a nighttime brace design. The concept of providence brace design resembles the Charleston bending brace in some aspects. But providence brace chooses to apply a medial and oblique force vector to the apical areas rather than overcorrecting it. This method of force application assists in bringing the curve towards the midline. A trochanteric extension part will be provided over the contralateral side of the lumbar pad area to generate a counterforce.

Figure 16 – Charleston bending brace, anterior view [12]

Dynamic derotation brace

Dynamic derotation brace is developed in 1982 as a modified version of the Boston brace [13]. Indicated for curve apices above T5. The Dynamic Derotating Brace (DDB) was designed to create an extra anti rotatory force and block the deforming rotator action of the asymmetrically acting spiral composite muscle trunk rotator. The DDB is useful in double scoliotic curves or curves with compensatory components when deforming rotator force is present. Boston-type TLSO supplied with metallic blades on its posterior surface that act as anti-rotation devices. This can be achieved because it maintains constant correcting forces at the pressure areas and at the same time produces movements in opposite directions of the two side-halves of the brace. The de-rotating metal blades are attached to the rear side of the brace corresponding to the most protruding part of the thorax or the trunk of the patient [13].

Figure 17: - Dynamic derotation brace, sagittal, anterior, and posterior view [13]

Figure 18:- Triac brace – Anterior, posterior views14

Triac Brace

Triac brace is a tension-based dynamic scoliosis orthosis. The name “TRIAC” indicates the three “c” emphasized on the brace design such as comfort, control, and cosmesis [14]. Developed by Dr. Albert Gerrit Veldhuizen. The design incorporates two parts such as lumbar and thoracic parts connected through a flexible coupling which in turn acts as a cantilever that keeps the lumbar and thoracic pads in constant contact with the patient regardless of body position [14]. The design has an improved cosmetic appearance and wearing comfort.

Rigo Cheneau brace

The Rigo system Cheneau brace is a design evolved from the original Cheneau brace. The historical development of Rigo Cheneau evolved from improvements over the last three decades. In 2005, the latest improvised version of Cheneau was evolved offering a 3-dimensional corrective system. The design gives more emphasis on the derotation aspect of curve correction. Biomechanical principles include the application of a three-point force system in all planes. Lumbar and thoracic forces are incorporated into the design and are enhanced at times with additional pads. Vectors are located at the apex of the curve on the convex side providing a resultant oblique vector force in dorsolateral to ventromedial direction. Counter forces are built into the medial with void areas to allow movements [15].

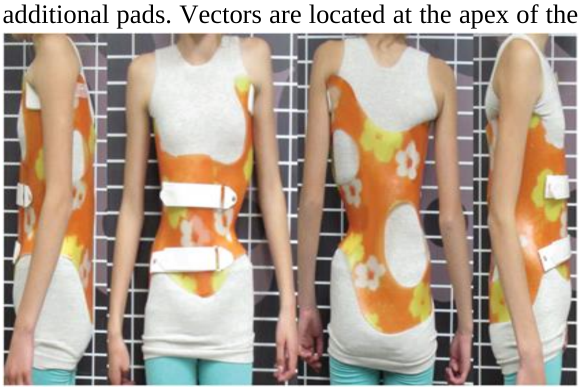

Figure 19: - Rigo Cheneau brace, sagittal, anterior, posterior views [15]

Derivate of cheneau braces such as Scoliologic off-shelf system called cheneau lite (in 2006), Gensingen brace, etc. is available which are evolved from the principles of cheneau [32].

Lyon ART brace

The Lyon ART brace is a design that evolved from the historical Lyon brace design. ART refers to asymmetrical rigid torsion brace, implies the asymmetries in the brace design and the improved rigidity of the design which reproduces a twisted-column shape opposite to scoliosis. The parts include two polycarbonates lateral Hemi shells articulated on a posterior metal bar. The anterior and inferior closures are rigid; the upper third is made up of a velcro strap. The Lyon ART brace is the only asymmetrical brace design having Hemi shells. The major biomechanical concepts are based on elongation along the vertical axis of the spine, lateral flexion in the frontal, and derotation of the spine to obtain curve correction [16].

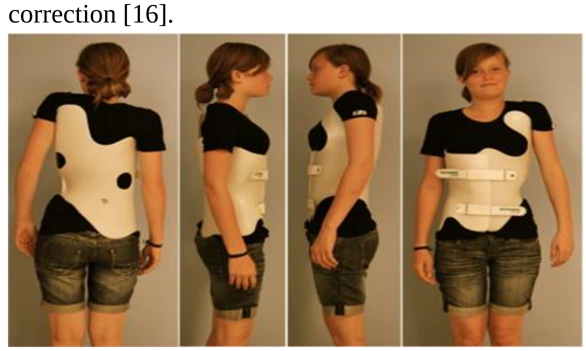

Figure 20: - Gensingen brace – Posterior, Sagittal and anterior views

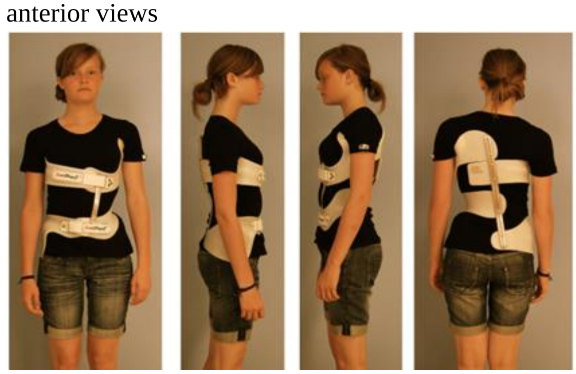

Figure 21: - Cheneau lite brace- Anterior, sagittal and posterior views [45]

Figure 22: - Lyon ART brace, posterior and anterior view [16]

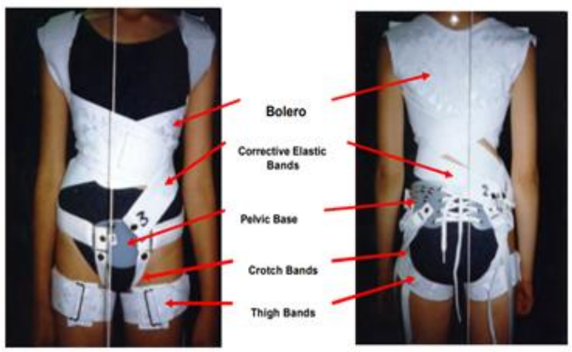

Figure 23: - Parts of SpineCor brace in posterior and anterior view [17]

SpineCor brace

The SpineCor system is a flexible brace that is principally prescribed for AIS patients with a Cobb angle between 15° and 50° and Risser signs 0 to 2 [17]. It is a dynamic corrective brace that is prescribed to wear 20 hrs out of 24 hrs in a day. The first section of components includes a pelvic base, crotch bands, and thigh bands whose role is to act as an anchoring point and support for the actions applied to the patient's trunk by the elastic bands. When the pelvic base is stable, the traction by the elastic bands is provided along with the stable liners. Another set of components such as bolero corrective elastic bands are also included in the design which functions directly to the active dynamic correction through wrapping across the torso [17].

SPORT concept in bracing

SPORT concept implies symmetrical patient-oriented rigid three-dimensional active bracings [18]. It is one of the latest advancements in scoliosis bracing in which the application of CAD-CAM is possible. The concept relies on constructing a brace according to the patient's comfort. Sforzesco brace, Sibilla brace, and Lapadula brace are developed based on the SPORT concept. The mechanisms needed to achieve deflection are Lateral-distal convex push, Lateral-proximal concave push, and Posterior-convex push. The action of derotation includes Posterior-convex push, Anterior-inferior concave push, Posterior-concave escape, Superior-concave push [18].

Figure 24: - Sforzesco brace, anterior, sagittal and posterior view29

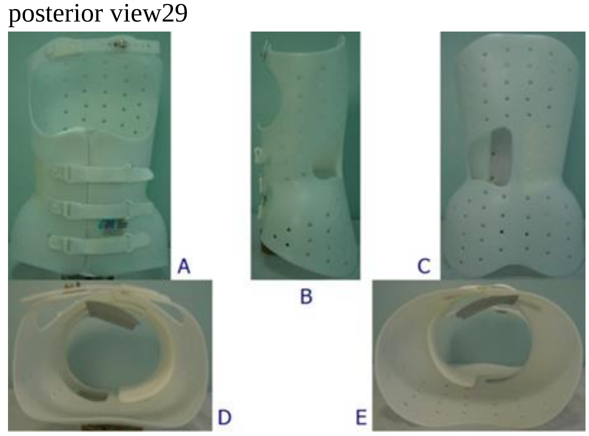

Figure 25: - Sibilla brace (a) anterior view, (b) sagittal view, (c) posterior view, (d) transverse view from inferior (e) transverse view from superior [29]

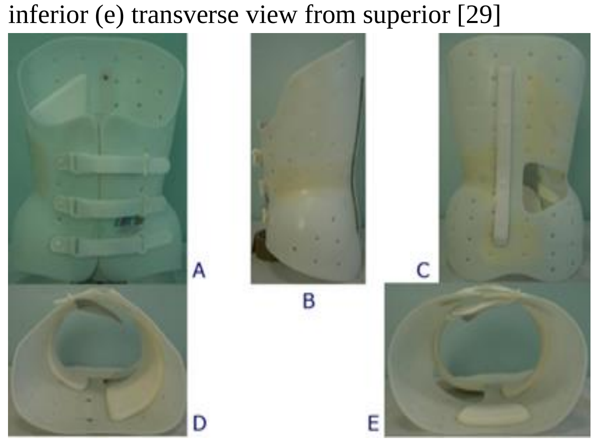

Figure 26: - Lapadula brace – (a) anterior view, (b) sagittal view, (c) posterior view, (d) transverse view from superior, (e) transverse view from inferior [29]

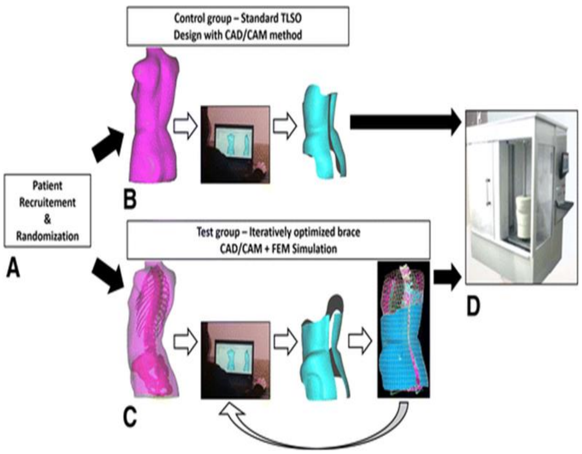

Figure 27: - process of CAD CAM technology of TLSO fabrication [42]

Chêneau-Boston-Wiesbaden braces (CBW)

Chêneau-Boston-Wiesbaden brace (CBW) is not an internationally popular design but has developed as a brace combining the application of some Chêneau pressure areas with the Boston style brace which is being closed dorsally [19].

Figure 28: - Cheneau – Boston – Wiesbaden brace-posterior, sagittal and anterior view [19]

ADVANCED METHODS OF SCOLIOSIS BRACING

CAD/CAM and smart materials

CAD-CAM technology was a revolutionary concept that eliminates the need for traditional fabrication techniques such as plaster casting, modification, etc. The system involves a photogrammetric scanning initially which is capable of capturing the body dimensions accurately and then allowed the fabrication of the CAD/CAM braces using 3D printing. Smart materials have gained substantial consideration in medical applications. In particular, shape memory alloys (SMAs) are most generally employed for their superelasticity (SE) in orthopedic treatment. Among the suitable systems for variable stiffness, jamming-based systems are emerging with a new set of possibilities. Layer-jamming mechanisms have certain advantages, such as compactness, being lightweight, high resistance force, and fast reaction time. Jamming structures also possess the shape-locking capability, which can help to reduce the metabolic cost. They can be fabricated entirely using a 3D printing technique [20].

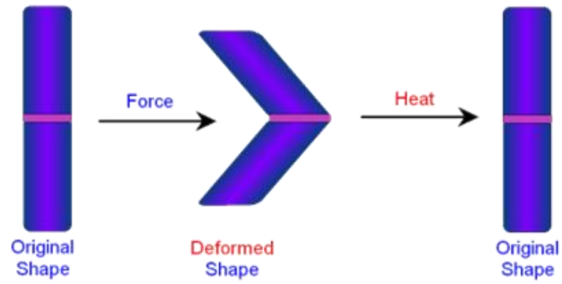

Figure 29: - Schematic representation of shape memory alloy smart material [43]

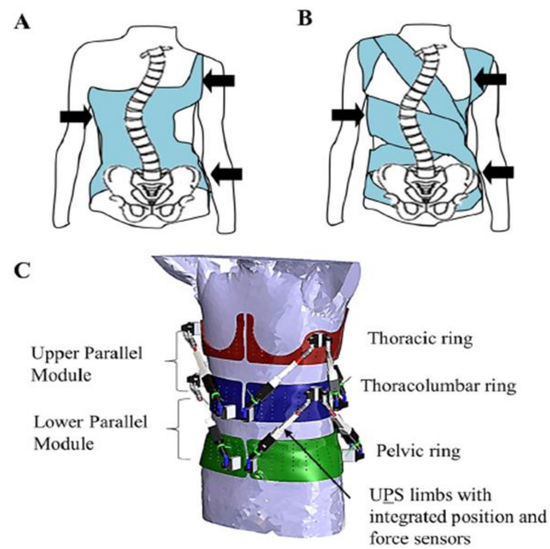

Figure 30: - (A) Illustration of the design and force application of typical rigid spine braces for treating spine deformities. (B) Illustration of the design of non-rigid spine braces using flexible straps. (C) RoSE consists of two 6 DOFs parallel-actuated modules connected in series, each with six actuated limbs. Each module controls the translations/rotations or forces/moments of one ring in three dimensions with respect to the adjacent ring [21].

SMART REHABILITATION ORTHOSIS

Robotic spine exoskeletons brace (RoSE Dynamic brace)

Designed by Columbia Engineers, RoSE is the first device to measure the 3D stiffness of the human torso, with the potential to lead to new treatments for children with spinal deformities such as AIS and kyphosis. It is designed to provide three-dimensional displacements at certain cross-sections of the human torso while simultaneously measuring the forces and moments it exerts on the torso [21]. The RoSE dynamic spinal brace performs the role of an assistive as well as a training device that aims at strategizing advancement in spinal bracing by controlling both position and force control mode through respective sensors and a dynamic torso exoskeleton. It embodies a two-layer Stewart platform, consists of three rings placed on the pelvis, mid-thoracic, and upper-thoracic regions of the spine. The motion of two adjacent rings is controlled by a six-degrees-of-freedom parallel-actuated robot. Overall, the system has 12 degrees of freedom controlled by 12 motors. The system can also apply corrective forces in specific directions while still allowing free motion in other directions [22].

The Green Sun Medical Dynamic Brace (GSM) brace

The Green Sun Medical Dynamic Brace (GSM) brace was developed as an alternative to rigid TLSOs, braces to prevent continued curve progression in patients with AIS. The brace instigates corrective forces to the muscular and bony structures of the spine while securing a range of motion (ROM). A series of semi-rigid segments encircle the patient's torso in close contact and are joined by a structure of flexible elements. These flexible (or elastic) elements generate stabilizing forces, providing the necessary immobilization while allowing relative motion of the semi-rigid segments [23], [24].

Figure 31: - Green Sun Medical Dynamic Brace (GSM), Sagittal view [20]

UNYQ Align Brace

The UNYQ Align Brace distinguishes itself from the traditional braces that lack ventilation and breathability making the patient feels hot and constricted. Through an array of techniques including 3D scanning, printing, and revolutionary digital design, this advanced brace is a custom-fit, lightweight, breathable, and personalized scoliosis brace. Patient compliance is important in bracing success. The innovative design and comfort of the UNYQ Align brace allow for higher patient satisfaction and, ultimately, favorable treatment success [25].

Figure 32: - UNYQ align brace, anterior view [25]

ScoliSMART Activity Suit

The ScoliSMART Activity Suit, an effective, comfortable, and non-restrictive system for users with scoliosis engineered to mimic the effect of resistance training on the spine, works by engaging the natural torque pattern of the body to create new muscle memory. Every step taken activates the muscles in the spine while the suit helps to reprogram the firing and coordination of those muscles. With each step, posture improves and scoliosis becomes more stable. It helps to unwind the spine while stabilizing asymmetrical muscles to reduce spinal curvature without causing direct pressure or pain. This design does not restrict normal activity and wearing the device for just a few hours a day has been shown to improve function and reduce pain [26].

Figure 33: - ScoliSmart activity suit [26]

Table 5: - Brace concepts and it efficacy

BRACE CONCEPT	EFFICACY OF THE BRACES
Rigid braces	• Full-time rigid braces have a high success rate compared to part-time and nighttime wearing[27]. • The efficacy of each brace is different. • Boston (51-83%), Cheneau (86%), PASB (65.6-100%), Lyon (99%). Gensingen (92%) and pressure adjustable orthosis (100%) are the most commonly used full-time braces[27]. • Studies indicate Cheneau brace is most effective for lumbar curves. • Nighttime braces such as Charleston and providence shows 84% and 52-89% of success rate respectively[27]. • Risser sign has a great impact on treatment. Risser sign of 0-1 shows 42%, 0-2 shows 68-74%, 0-3 shows 70-80% and 0-4 shows 60% of success rate[27].
SOFT/ flexible braces	• Soft braces such as SpineCor are successful in 59-73% of patients on full-time use[27]. • When comparing with rigid TLSO, the efficacy of flexible braces is less. But rigid braces cause more heat problems, difficulties with donning and doffing, and flexible braces are difficult to maneuver during toileting[28].
SPORT Concept	• SPoRT concept of bracing is based on an almost symmetric envelope with pushes acting inside the brace to exert higher forces on the trunk and creating a lower degree of asymmetry.[6] • Patients with large curves exceeding 45° but refusing surgical treatment, has improved in more than 50 % of cases.[6] • In large curves (over 40°), that are always rigid, the Sforzesco brace is used. Before puberty, in juveniles or infantile scoliosis patients, the Sibilla brace is prescribed with the very rare exceptions of a very rigid curve; in all other clinical situations, a case-by-case choice is
ART Concept	• Better in-brace correction when compared with SPORT concept braces but not statistically and clinically significant[2]. • Studies have found a significant difference in the score of Thoracic and Lumbar Bunnel Angle of trunk rotation[6].
SMART braces	• The RoSE offers the direct capability to dynamically sense and modulate the three-dimensional forces applied on the torso, which may allow for timely adjustment of the intensity/profile of the correction[21]. • Smart brace group shows the better quality of brace wear, wearing their brace at the prescribed tightness level a higher proportion of time than the standard brace group[30]. • Smart brace group exhibits successful outcomes, Cobb angle change less than 5°[30]. • The smart brace group also reported that the smart brace was more comfortable to wear than the standard rigid brace[30].
CAD/CAM concept	• Studies demonstrated significantly better in-brace correction with CAD/CAM compared to the traditional approach, adding consistent scientific evidence[2]. • CAD/CAM braces could save time, be lighter, and be more comfortable for the patients, which could have a positive impact on compliance and could substitute plaster-cast braces[2]. • By comparing the mean reduction value of the Cobb's angle and apical vertebral rotation between CAD/CAM and manual methods, no significant difference was found. Thus, the CAD/CAM system could provide similar treatment results to the manual method[31].

RESULT

Starting from the history of bracing, a myriad variety of scoliosis braces have emerged to date. The rate of advancements is very abrupt and interestingly many studies are carried out focusing on improving the previous designs. Starting from the history, maximum braces till date are tried to include in this study. The increased demand for braces is arisen due to the best result exhibited by previous designs in the non-operative treatment of scoliosis. Many articles reflect on the increased efficiency of brace treatment compared to other non-operative methods. Bracings are more reliable and provide continuous corrective force vectors while wearing which in turn assist in showing results in a much speedier manner.

DISCUSSION

By evaluating the result, it has been substantiated that there is strong evidence support for the use of braces in the treatment of AIS. Typically curves more than 10° and less than 40° - 45° of Cobb's angle are generally indicated for bracing. The need for this study solely relies on the lack of comprehension about bracing among prosthetic and orthotic students. Many studies ascertain the efficiency of orthotic treatment in AIS. Starting from BC, the era of Hippocrates, the treatment of scoliosis was based only on dieting and longitudinal forces. Later on, as time passed many improvisations in technology and proficiency of bracing came into practice. Ambrose pare, the father of orthopedics initiated the first big step in bracing3. Latter on many pioneers followed his path and crafted brilliant thoughts on scoliosis bracing. Currently, numerous spinal orthosis is available as a non-operative treatment method. Polypropylene designs are more popular among them. The research is still progressing since there is a huge need for braces having better aesthetic appearances, less cumbersome, and easy to fabricate. Presently the status is exhibiting a great possibility of the wide use of CAD-CAM technology in bracing combined with the application of smart materials. Meanwhile, smart rehabilitation orthoses are also winning popularity in this epoch20.

CONCLUSION

Bracing AIS is a vast field enriched with developments and technologies. Currently, a wide variety of braces are available globally but there is a lack of availability of appropriate resources which can help clinicians and students regarding spinal orthosis designs, technology, and materials related to AIS. Braces are indicated mainly based on Cobb's angle, Risser sign, type of curve, and apex level of the curve. Previous braces are mainly focused on the application of various pressure system but currently, the trend has changed into developments using advanced technologies which brings more comfort and better aesthetic appearance with improved efficiency. This literature journey is focused on various design concepts in spinal bracing, aiming to bring awareness about the huge scope of bracing in AIS and its impeccable efficiency as a non-operative method for treating AIS. This article will act as a ready-to-access source of information for clinicians and students to assist in learning as well as in making appropriate orthosis prescriptions for AIS.

SUMMARY

A wide variety of molded dynamic devices are available which can be included in bracing options in developing countries. Also to acquire the skill and knowledge, to implement in the service provision and prosthetic and orthotic education sector.

The interest of Conflict

The authors declare no conflict of interest.

Table 6: - Brace concept summary [3], [20]

Brace design	Year and origin	Rigidity	Cobb's angle/ Apex	Material
Turnbuckle cast	1869-1932 Russell Hibs	Rigid	-	Plaster of Paris
Milwaukee brace	1946 United States Moe and Kettleson	Rigid	Greater than 25	Polyethylene, steel, and aluminum
Lyon brace	1947 Pierre Stagnara, France	Rigid	Apex – T6 – T12	Polymeta-acrylate and radiolucent duralumin
Wilmington brace	1969 Dr. G. Dean MacEwen, United States	Rigid	25-39	Polyethylene, custom-made/handmade
Boston brace	1972 Hall and William Miller United States	Rigid	20 – 45	Polyethylene, prefabricated models
PASB	1976 Dr. Lorenzo Aulisa, Italy	Rigid	25-40	Polyethylene, custom/handmade
Charleston bending brace	1979 Frederick Reed and Ralph Hooper United States	Rigid	20-35	Polyethylene
Dynamic de-rotation brace	1982 Greece	Rigid	Apex above T5	Polypropylene and aluminum, custom made/CAD-CAM,
Rosenberger brace	1983 United States	Rigid	29	Polyethylene
Cheneau brace	1990 France	Rigid	25-45	Polyethylene
Providence brace	1992 Charles d'Amato and Barry McCoy United States	Rigid	35	Polyethylene
Traic	Dr Albert Gerrit Veldhuizen Netherlands	Low rigidity	20-40	Soft plastic and metallic connections, prefabricated envelope/models
Rigo Cheneau	2005 Dr Manuel Rigo Barcelona, Spain	Rigid	35	Polyethylene, custom-made/CAD- CAM, handmade
Lyon ART brace	Jean Claude de Mauroy France	Rigid	>20	Polymer Modified MasterSeal (PMM), radio-transparent duralumin and steel
SpineCor	1993 Canada	Elastic	15-50	Elastic tissue, Prefabricated envelope/models
Sforzesco brace	Stefano Négrini Italy	Rigid	45–50	Copolyester radiolucent duralumin, custom-made/CADCAM, handmade

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