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HISTORY OF MEDICINE – REVIEW – OPEN ACCESS

A Historical Perspective of the Management of Scoliosis

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ABSTRACT

Efforts to treat spinal deformity have a long and fascinating history. The ancient Greek physicians Hippocrates and Galen are credited with early descriptions of the condition, management, and the term scoliosis, though even earlier references are seen in Hindu epics. The first known treatment techniques used axial traction and pressure. Subsequent cast correction required fixation of the pelvis and flattening of lumbar lordosis. Bracing superseded traction as the primary means to treat spinal deformities in the 1900s. The first spinal fusion surgery was performed in the 20th century. Scoliosis treatment was greatly improved with the recognition of the 3-dimensional nature of scoliosis and its symptoms. Advances in nonsurgical treatment alternatives included the Milwaukee brace and the subsequent development of underarm plastic braces, such as the Boston brace, the Wilmington brace, and the Chêneau brace. Today, treatment options include bracing, and scoliosis-specific exercises selected according to the curve type and severity, in addition to surgery.

Keywords: Ancient history, braces, conservative management, history of medicine, scoliosis

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INTRODUCTION

Spinal deformity has been recognized and treated using various techniques in a long and fascinating history dating back millennia. The earliest known written sources describing correction of spinal abnormalities date back to Indian religious mythological books from 3500 BCE. In the ancient world there was an interest in developing the human being as a whole to optimize functional capacity and harmony; medicine, religion, philosophy, athleticism, and other disciplines, values, and beliefs often intersected. Plato believed that a flexible spine was the product of divine intervention. While much progress has been made, knowledge of the development of spinal deformity, progression, and effective management still remains incomplete (1).

Early theories considered the unique structure of the human spine in examinations of altered posture, and spinal deformities were treated with traction, casts, or braces. The definitions of diagnostic physical findings continued to develop, and asymmetries in the shoulder and scapular regions were recognized as signs of scoliosis. The rotational component of scoliosis was introduced in the early 1800s, and in 1865, Adams developed the Forward Bending Test. Scoliosis became easier to diagnose and led to prevalence studies (2). Idiopathic scoliosis is the most commonly seen type (70%–80% of all scoliosis cases) (3). The prevalence of idiopathic scoliosis in the general population has been reported to be 2% to 4% (4).

Due to the 3-dimensional nature of scoliosis deformity, the trunk and the whole body is affected biomechanically. With torsion of the spine, spinal deformation can cause gibbosity and patient anxiety about cosmetic appearance. Notable effects of scoliosis can include postural deviation, body asymmetries, scapular movement impairment, unrealistic body image perception, and functional deviations, which can have a negative effect on health-related quality of life (5, 6).

The management of scoliosis has a long history. Several devices were developed very early in recorded history to correct curvature using traction with pressure or stretching methods (1). These include the ladder treatment technique developed by Hippocrates (7). In more modern times, bracing became the primary treatment method to correct curvature, followed by the introduction of underarm braces (8).

This review presents a historical perspective of developments in scoliosis management.

DEVELOPMENT of the TERM SCOLIOSIS

Treatment of spinal deformities dates back to at least the time of Hippocrates the Koan (9). Hippocrates described the curvatures of the vertebral column very precisely, using the term ithiscolios to refer to a spine

Table 1. Some landmarks in the history of scoliosis management

Year	Scientist	Significance
3500–1800 BCE	Unknown (India) (15)	First record of correction of spinal deformity
460–361 BCE	Hippocrates (11, 16)	First description of scoliosis, spinal manipulation, and corrective device
131–201 BCE	Galen (11)	First use of the term scoliosis
1510–1590	Ambroise Paré (8)	Recognition and definition of congenital scoliosis, metal corset corrective device
1824	Andrew Dods (13)	First to report rotation of the spine in lateral curvature
1869–1932	Russell Hibbs (27)	First spinal fusion for kyphosis and scoliosis
1892–1982	Joseph Risser (28)	Development of Risser sign
1947	Pierre Stagnara (38)	First 3-dimensional adjustable brace made of plaster cast: the Lyon brace
1969	Dean MacEwen (29)	First custom-made plastic thoraco-lumbo-sacral orthosis: the Wilmington brace

that is curved in the sagittal plane but straight in the coronal plane; however, scoliosis was used in a general sense for any spinal curve (9). Hippocrates reported 2 developmental causes of scoliosis: accumulations in the interior of the spine, which was likely a reference to tuberculosis abscesses; and long-term bed rest due to illness. Hippocrates associated scoliosis with chronic pulmonary disease (9).

Galen of Pergamon, some centuries later, studied the texts of Hippocrates and refined the definition (10). Galen added the terms kyphosis, lordosis, and scoliosis to describe types of spinal deformity (11). His work was fundamental to our knowledge of diseases of the spine and anatomy, including the number of vertebrae in each spinal segment (12).

Hodgkin and Adams (13) credited Dods, an English doctor, with drawing attention to rotation of the spine in lateral curvature. Dods published "Pathologic Observations on the Rotated or Contorted Spine, Commonly Called Lateral Curvature" in 1824, and it appears that he reached his conclusions by palpating the transverse processes. Guerin also reported rotation in scoliosis in "On the Treatment of the Deviations of the Spine by Section of the Muscles of the Back" in 1843.

Adams (14) published work on the pathology and treatment of curvature of the spine in 1882. He created the pivotal Forward Bending Test and emphasized trunk asymmetry associated with the rotation of the spine.

Scoliosis is now known to be a 3-dimensional deformity with lateral deviation and axial rotation of the spinal column (3). This definition emerged as a result of many centuries of studies and shapes the choices and content of the treatment offered today. Some landmarks of scoliosis management are shown in Table 1.

TREATMENT of SCOLIOSIS in ANCIENT TIMES

The use of axial traction in scoliosis management is an ancient idea. The earliest known source is Hindu epics (3500–1800 BCE) (15). The first known source to record treatment and correction of spinal deformity is the Srimad Bhagavata Mahapurana, an ancient Indian religious mythological text (15). The treatment of a young hunchback woman was described as "To shower the fruits of his blessings, happy Lord Krishna decided to straighten Kubja, who was deformed in three places. He pressed her feet by his foot, held her chin by two fingers and pulled her up. By the touch and pull of Lord, she became a beautiful straight woman." It seems that Kubja may have had both 3-curve scoliosis and kyphosis.

Hippocrates is recognized as the first to use spinal manipulation and invent and use devices for therapeutic treatment related to the spine (16). He suggested that kyphosis should be treated with body traction and local pressure applied to the apex of the deformity (7). He proposed several methods to address spinal curvature, and included the role of nutrition (9, 17). One device was the Hippocratic ladder that used the weight of the body: The patient was tied to a ladder and shaken. The positioning of the patient was related to the location of the hump. The patient was restrained in an upright position if the hump was in the cervical region, while if the hump was at a lower level, the patient was positioned upside down. The treatment called for an abrupt end to the agitation; the sudden release was believed to be therapeutic as a pulling force that strengthened the spine (18).

The Hippocratic board was another device used to manage scoliosis (9, 18). A preliminary vapor bath was recommended, and the patient was to lie on the board stretched out in the prone position with the arms fastened to the body. Three soft, yet strong, bands were fastened around the chest/shoulders, the knees, and the heels, and attached to a pole to create extension of the spine. A trained individual used their hands, foot, or the whole body to press on the hump area while applying traction to extend the body evenly in a straight line.

Galen further developed the studies of Hippocrates and refined the treatment according to the type of spinal deformity (11). Galen's contributions to the treatment of spinal deformities were a primary influence on medical treatment for centuries. While some of his work is thought to have been lost, his early guidance was exceptional.

Ibn Sina, also known as Avicenna, a Persian physician of the Islamic Golden Age, was another father of medicine. He, too, advocated the use of stretching, pressure, or traction to correct bone and joint deformities brought about by curvature of the spine (such as the Hippocratic ladder or board). He also suggested the use of diet therapy in the management of musculoskeletal deformities (19).

SCOLIOSIS MANAGEMENT in the PREMODERN ERA

Traction, massage and spinal manipulation, electrical stimulation, exercise, and braces have all been prescribed therapies for spinal deformities. They have ancient roots, and alongside recommendations for diet and other therapies, they were the most effective treatment method until the 16th century. However, the degree of spinal correction was limited and the prolonged effect of bracing couldn't be ensured.

The next significant development regarding scoliosis management was Paré's recognition of congenital scoliosis, as well as a female prevalence in the disease, in the mid-1500s. Paré was the first physician to recommend perforated iron corsets for children with various spinal deformities. Paré also recognized other causes and the ineffectiveness of corrective bracing treatment following skeletal maturation. His studies informed the development of modern bracing techniques commonly used today (8).

Venel, another pioneer in the field, established the first known orthopedic clinic, in Switzerland in 1780, which specialized in children's spinal deformities. He emphasized the importance of bracing in the management of skeletal distortions (20). Sometimes referred to as the "father of orthopedics," Venel defined the 3-dimensional balance of the spine acknowledged today by recognizing the need to derotate a scoliotic spine (21).

Chessher is credited as the first British orthopedist and invented several devices designed to support and correct fractures and spinal deformities. Chessher's collar, developed in 1824, was a new apparatus to stretch and support the spine as a means of correction (20) (Fig. 1). The success of the device is uncertain, but it was an important invention that influenced therapeutic technique.

Delpech, a surgeon in France in the early 19th century, emphasized the importance of exercise in the treatment postural deformity and pain. He noted the role of balance and muscle tone on joint stability on posture and he explored different developmental causes of scoliosis, as well as introducing subcutaneous tenotomy (22).

Galeazzi, an Italian orthopedic surgeon now well known for research related to forearm fracture, also studied scoliosis and other skeletal diseases. He invented a device to derotate the spine using 2 metal arches with a chair fixed in between. The patient's body was positioned in the desired posture using clamps and gears to effect correction. Bracing was subsequently applied with plaster of Paris (23).

Sayre, an orthopedic surgeon in the USA, developed a plaster of Paris body cast to correct deformities. Sayre used a combined protocol of operative and nonoperative techniques that included the use of partial suspension and retention with the cast that came to be known as the Sayre jacket. The success rate of the treatment is questionable, due to variation in patient age and deformity type; however, Sayre's (24) studies contributed to modern techniques of bracing for patients with scoliosis.

Also notable in the timeline of developments in the treatment of scoliosis is Roentgen's discovery of the wavelength range known as X-rays in 1895. The imaging tool based on this revelation provided better understanding of the anatomy and has since become a standard tool. It also contributed to the formation of new spinal fusion methods using metal or bone and to better spinal stabilization after surgery (25).

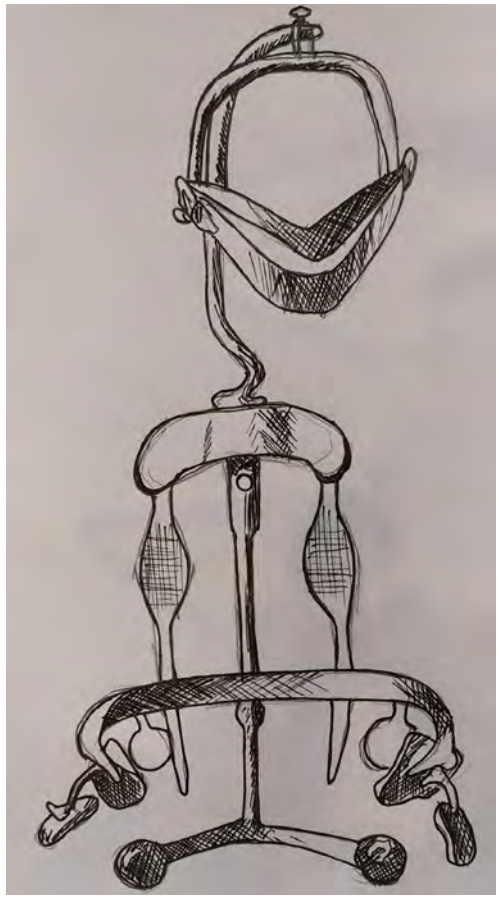

Figure 1. A Chessher's collar
Drawn by the authors

Hadra, an orthopedic surgeon in the USA, was the first to perform spinal fusion surgery for a patient with a dislocated fracture by wrapping wires around the spinal column for stabilization in the treatment of tuberculosis. He recognized his colleague, Wilkins, with inspiring the procedure. It was Lange, a German surgeon, who first used fusion surgeries for patients with scoliosis, in 1909. He used a fusion protocol to correct spinal curvature by supporting the spine with celluloid bars, steel, and silk wiring, which is very similar to today's surgical stabilization approaches (26).

Hibbs, an orthopedic surgeon in the USA, developed an innovative surgical technique to reduce the progression of structural kyphosis and scoliosis in the early 1900s. A plaster cast that incorporated hinges at the apex of the curve to be corrected to adjust tension, known as a turnbuckle jacket, was used for preoperative correction. The cast was divided into upper and lower sections joined with a side-facing hinge on the convex side of the deformity and a turnbuckle screw on the concave side of the curve. The device was designed to straighten the spine by applying laterally bending forces (Fig. 2). The patient then underwent spinal fusion surgery, and was subsequently immobilized in a plaster cast for 2 to 3 months. Although the operation often had complications, such as infection, recurrence of the deformity, or pseudoarthrosis, Hibbs's work on spinal fusion was a significant step in the development of modern surgical techniques (8, 27).

Figure 2. A turnbuckle cast
Drawn by the authors

Figure 3. A Milwaukee brace
Obtained from the Bilim Orthopedics-Orthotic Prosthetics Center, Ankara, Turkey

Key points: Principles of Bracing in the Premodern Era

- The flexibility of the spine was considered to be a good guide in efforts to correct scoliosis. Cast correction required fixation of the pelvis and flattening of lumbar lordosis to achieve the best possible result. Excessive and prolonged lateral pressure applied to the spine by a brace was believed to cause greater rib deformity. Bracing efforts were largely not successful until the 1900s.
- Scoliosis-specific exercise was also recommended in the 1800s (2).

A cornerstone of the evaluation of scoliosis is the use of the Risser sign and staging system based on the attachment of the iliac apophysis as a means to assess skeletal maturity, developed by Risser. Risser and Ferguson (28) developed a radiographic method to assess the progression of scoliosis in the early 1900s. The Risser sign is still widely used to evaluate spinal curvature and in the selection and planning of a treatment approach.

In the 1950s, Risser made a modification to the turnbuckle cast, called the Risser localizer cast. It was much lighter, more contoured, and provided greater focus of lateral forces for correction and easy ambulation. The cast was used to correct scoliosis in the immature skeletons of adolescent patients and to prevent curve progression in the mature skeletons of adults (29).

Harrington (30), an American orthopedic surgeon, is known for scoliosis deformity treatment using internal fixation. His surgical approach is still widely used today, known as the Harrington instrumentation system. It is a minimally invasive implant procedure most suited to single and double thoracic idiopathic curves; however, there is limited derotation and sagittal plane control. Luque, from Mexico, improved on the technique in the 1970s with the Luque (31) implant, which provided more stable fixation with sublaminar wiring rods contoured for correction as needed. This innovation meant that patients were no longer required to wear a brace after surgery. However, an increased risk of neurological damage was reported because the wires passed through the spinal canal.

MODERN CONCEPTS in SCOLIOSIS TREATMENT

Modern choices for nonoperative scoliosis therapy include bracing, exercise, electrical stimulation, manipulation, and biofeedback. Bracing is the conservative method with the greatest evidence of ability to reverse curve progression in individuals with idiopathic scoliosis. The indications for bracing are curves between 20° and 45° and continued growth.

Several scoliosis-specific exercises have been developed and are used to encourage 3-dimensional correction of a spinal deformity and stabilization of correction based on different muscle functions and integration into daily life (4).

Figure 4. (a) A modified Boston brace; (b, c) Another Boston brace with a dynamic antirotatory component seen from the front and side view

Obtained from Bilim Orthopedics-Orthotic Prosthetics Center, Ankara, Turkey

Cotrel and Dubousset, French orthopedic surgeons, improved the approach used for scoliosis surgery and introduced techniques used in the modern era. They first used a multiple hook and contourable rod system in 1984. This system consists of bilateral rods used to bring the spine to a desired position and hooks and/or screws used to fix the vertebrae. The technique offers correction of vertebral rotation and of the associated rib hump, which is the main purpose of today's spinal fusion surgery (32).

In recent years, new implants, such as MAGEC (MAGnetic Expansion Control) growing rods (NuVasive Inc., San Diego, CA, USA), have been introduced as an alternative means to surgically treat children with severe scoliosis. Magnetic rods are implanted and lengthened using an external remote control during the child's growth period. The curvature can usually be corrected by some 50% at the time of the initial surgery. Benefits include the ability to reduce the number of surgical interventions and the associated risks (33).

Modern Bracing Approaches

Blount developed the Milwaukee brace, a cervical-thoracic-lumbar-sacral orthosis (CTLSO) that extends from the pelvis to the skull, in 1946 (Fig. 3). The Milwaukee brace was the first modern brace successfully used as nonoperative treatment of spinal deformities and became the standard. The brace was developed for postoperative care, but was subsequently used to prevent curve progression in adolescents with a curve of 25° to 40°.

The design of the brace used 2 important principles: longitudinal traction and curve correction. Longitudinal traction was provided by the pelvic module in combination with the neck ring. Corrective forces were applied from posterolateral region to the apex of the deformity with lateral pads. Flattening lumbar lordosis was considered critical to maximize the correction of scoliosis. Earlier braces had only used passive forces to correct the curve. The Milwaukee brace applied both passive and active forces to achieve the best possible correction. Passive correction was provided by direct pressure through the pads or by traction based on the brace design. Active correction was thought to be provided with active body movement away from pressure points (29). Non-compliance and complications, such as mandible and teeth deformities due to the chin pad, emerged as limitations to the device (34). However, as a CTLSO, the Milwaukee brace can still be appropriate in some cases, for example, thoracic curves with an apex at or above the T8 level where underarm orthosis is not effective (29, 35, 36).

The advent of a thoraco-lumbo-sacral orthosis (TLSO) brace, a type of underarm brace that fits under the arm and around the rib cage, lower back, and hips, offered more comfort and less conspicuous correction. Originally, a TLSO was prescribed for single lumbar and thoracolumbar curves. Later TLSO braces have been designed for use with different types of curvatures, including double curves and single thoracic curves. The selection of an appropriate brace includes consideration of the patient's age, cosmetic appearance, amount of decompensation, and the stiffness of the curve (35). All TLSOs developed for scoliosis apply external corrective forces to the trunk with different intensities to correct the 3-dimensional nature of spinal deformity (4, 37). SOSORT (The International Scientific Society on Scoliosis Orthopaedic and Rehabilitation Treatment) and other organizations hold regular meetings and publish consensus statements about brace classification, effectiveness, and innovations in the field (37).

The Lyon brace was developed in France in 1947 by Stagnara (1917–1995). It was the first 3-dimensional adjustable brace based on a plaster cast. The Lyon brace was designed to elongate the patient's trunk with equal distribution of forces on the right and left in an attempt to create global spinal detorsion. Precise adjustment of the brace is required during the growth period. The original Lyon brace has been modified and improved in recent decades, including the Lyon ARTbrace (Asymmetrical Rigid Torsion brace) (38).

The first rigid custom-made plastic TLSO was the Wilmington brace, introduced by MacEwen in 1969. Advantages of the brace included a low-profile, lightweight design that was made of thermoplastic material molded to the body. It also offered removability, though full-time wear (23 hours/day) was typically prescribed during the growth period (29).

The Boston brace, developed in the 1970s in Boston, MA, USA, by Hall and his orthotist, Miller, is another TLSO brace that has been widely used (39). It differed from the Wilmington brace in that it was prefabricated in 6 sizes, rather than customized. A Boston brace has a low profile, is made of rigid material, and has symmetric corrective characteristics with interior pads and posterior closures. The brace design includes passive (apical pad pressure on the convexity) and active corrective forces (open areas of the superstructure on the concavity provides curve reduction by the forces acting from pads to these open areas). Two important design characteristics are derotation of the deformity and flattening of lumbar lordosis. In the early 1990s, the original brace design was modified to incorporate 15° of lumbar lordosis into the pelvic module to achieve derotation correction of the curve. The Boston bracing system was designed for full-time wear (18–23 hours a day, every day) with the exception of time spent bathing, swimming, physical education, and engaged in sports (29, 39).

The Providence brace and Charleston nighttime brace were subsequent alternatives developed to address some concerns, including the need for continuous wear (40). The Boston brace has also been modified and remains in use (Fig. 4). Modifications include production based on individual measurements and the addition of an anterior opening. Other improvements provide greater protection of lumbar lordosis and increased derotational effect (41).

The Chêneau brace was developed in France in 1979 (Fig. 5). It is a rigid TLSO that provides 3-dimensional correction of a spinal deformity, yet is dynamic because it uses a system of multipoint pressure zones and expansion chambers. The brace provides both active and passive correction. The passive correction mechanism of the brace is based on pressure on the convexity of a curve and wide expansion chambers in the frontal, sagittal, and horizontal planes on the opposite side. The active correction mechanism uses pressure zones, asymmetrically guided expansion according to respiratory movements, repositioning of the trunk muscles, and the antigravity effect (42).

Today, computer-assisted design/computer assisted manufacturing (CAD/CAM) technologies are used to design and manufacture the Chêneau brace. Foort (43) was the first use CAD-CAM technology in the prosthetics and orthotics industry in the 1970s. A CAD-CAM system uses 3 units: a milling machine, a computer station, and a digitizer. The digitizer unit records 3-dimensional data of body shape in digital format, computer software provides the design of the brace in terms of shape, upper and lower borders, pressure areas, expansion chambers etc., and molding according to the patient's body profile. The milling machine is used to create a 3-dimensional model of the trunk (44).

Figure 5. A Chêneau brace
Digital image, Shutterstock, September 2018. Web ID: 497453587

Modern Exercise Approaches

The most commonly used method of exercise for scoliosis treatment today is the Schroth approach, which was developed in Germany by Schroth, who herself suffered from scoliosis and had unsuccessful results with bracing. In the early 1900s, Schroth developed a personalized, functional, evidence-based, nonsurgical option to treat scoliosis. Mirror monitoring to synchronize corrective movement, breathing, and functional correction were key elements of the therapy. (45).

Other scoliosis-specific exercise methods originating in Europe are the SEAS (Scientific Exercise Approach to Scoliosis) method from Italy, and the DoboMed (Dobosiewicz) and the FITS (Functional Individual Therapy of Scoliosis) methods from Poland, Lyon therapy from France, and Side-shift therapy (Mehta) from England (46, 47).

CONCLUSION

The history of efforts to manage scoliosis begins in ancient times. Early methods used traction and local pressure as corrective principles, and the devices and treatments could be aggressive and painful. Over time, developments in casting and bracing, as well as surgical techniques have led to greater success correcting or reducing the progression of structural kyphosis and scoliosis. Significant advancement was achieved with the recognition and accommoda-

tion of the 3-dimensional nature of scoliosis, rather than relying on traction. Advancements in science and technology have led to more effective and more practical plastic underarm braces as well as exercise approaches to remedy curve progression. Modern braces are less obtrusive and more comfortable, and scoliosis-specific exercises can improve quality of life by improving posture while correcting the spine. The benefits of physical activity, recognized by the early Greeks, are acknowledged to be valuable at every stage of scoliosis rehabilitation, both in the pre- and post-surgical period, or as an accompaniment to bracing. When conservative treatment is not sufficient, today's surgical techniques provide an important and beneficial option.

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REFERENCES

1. Heary RF, Madhavan K. The history of spinal deformity. Neurosurgery 2008; 63(3 Suppl): 5–15. [CrossRef]
2. Tolo VT. Progression in scoliosis. A 360 degrees change in 75 years. Spine (Phila Pa 1976) 1983; 8(4): 373–7. [CrossRef]
3. Lonstein JE. Idiopathic Scoliosis. In: Moe's Textbook of scoliosis and other spinal deformities. Lonstein JE, Bradford DS, Winter RB, Ogilvie JW, editors. 3rd edition. Philedelphia: W.B. Saunders; 1995.p.219–56.
4. Costa L, Schlosser TPC, Jimale H, Homans JF, Kruyt MC, Castelein RM. The effectiveness of different concepts of bracing in Adolescent Idiopathic Scoliosis (AIS): A systematic review and meta-analysis. J Clin Med 2021; 10(10): 2145. [CrossRef]
5. Weinstein SL, Dolan LA, Cheng JC, Danielsson A, Morcuende JA. Adolescent idiopathic scoliosis. Lancet 2008; 371(9623): 1527–37.
6. Shakil H, Iqbal ZA, Al-Ghadir AH. Scoliosis: review of types of curves, etiological theories and conservative treatment. J Back Musculoskelet Rehabil 2014; 27(2): 111–5. [CrossRef]
7. Hippocrates, Adams F. The Genuine Works of Hippocrates; Translated from the Greek by Francis Adams. Bailliere: Tindall & Cox; 1939.
8. Khan MJ, Srinivasan VM, Jea AH. The history of bracing for scoliosis. Clin Pediatr (Phila) 2016; 55(4): 320–5. [CrossRef]
9. Marketos SG, Skiadas P. Hippocrates. The father of spine surgery. Spine (Phila Pa 1976) 1999; 24(13): 1381–7. [CrossRef]
10. Marketos SG, Skiadas PK. Galen: a pioneer of spine research. Spine (Phila Pa 1976) 1999; 24(22): 2358–62. [CrossRef]
11. Siegel RE. Galen on the Affected Parts: Translation from the Greek text with explanatory notes. Karger 1976.p.224–33.
12. Shapiro R. Talmudic and other ancient concepts of the number of vertebrae in the human spine. Spine (Phila Pa 1976) 1990; 15(3): 246–7.
13. Hodgkin T, Adams W. Case of distortion of the spine, with observations on rotation of the vertebræ as a complication of lateral curvature. Med Chir Trans 1854; 37: 167–80.5. [CrossRef]
14. Adams W. Lectures on the pathology and treatment of lateral and other forms of curvature of the spine. J. & A. Churchill, 1882.
15. Subramaniam K. Srimad Bhagavatam.1st Edition. Bharatiya Vidya Bhavan, 1979.
16. Kumar K. Spinal deformity and axial traction. Spine (Phila Pa 1976) 1996; 21(5): 653–5. [CrossRef]
17. Sanan A, Rengachary SS. The history of spinal biomechanics. Neurosurgery 1996; 39(4): 657–69. [CrossRef]
18. Marketos SG. Hippocratic medicine and nephrology. Am J Nephrol 1994; 14(4-6): 264–9. [CrossRef]
19. Markatos K, Androutsos G, Karamanou M, Kaseta M, Korres D, Mavrogenis A. Spine deformities and trauma in Avicenna's Canon of Medicine. Int Orthop 2019; 43(5): 1271–4. [CrossRef]
20. Ohry A. Spinal therapeutics before our times. Prog Health Sci 2011; 1(2): 196–9.
21. Rüttimann B, Schreiber A. Before the word was coined and ahead of his time -- the orthopedics of Ambroise Paré (1510-1590). [Article in German]. Z Orthop Ihre Grenzgeb 1985; 123(6): 981–6. [CrossRef]
22. Cho SK, Kim YJ. History of spinal deformity surgery part I: The Pre-modern Era. Korean J Spine 2011; 8(8): 1–8. [CrossRef]
23. Sava G. A surgeon's destiny. London: Faber & Faber; 1934.
24. Sayre LA. The history of the treatment of spondylitis and scoloisis: By partial suspension and retention by means of plaster-of-Paris bandages (1895). Kessinger Publishing; 2009.
25. Kärrholm J. Roentgen stereophotogrammetry. Review of orthopedic applications. Acta Orthop Scand 1989; 60(4): 491–503. [CrossRef]
26. Tarpada SP, Morris MT, Burton DA. Spinal fusion surgery: a historical perspective. J Orthop 2017; 14(1): 134–6. [CrossRef]
27. Falcone D. The Hibbs Society: Russell A. Hibbs, MD. Scoliosis Research Society. Available from: URL: https://www.srs.org/professionals/conferences-and-meetings/the-hibbs-society.
28. Risser JC. Scoliosis: Past and Present. J Bone Joint Surg Am 1964; 46: 167–99. [CrossRef]
29. Fayssoux RS, Cho RH, Herman MJ. A history of bracing for idiopathic scoliosis in North America. Clin Orthop Relat Res 2010; 468(3): 654–64. [CrossRef]
30. Harrington PR. The history and development of Harrington instrumentation. Clin Orthop Relat Res 1973; (93): 110–2. [CrossRef]
31. Luque ER. Interpeduncular segmental fixation. Clin Orthop Relat Res 1986; (203): 54–7. [CrossRef]
32. Hopf CG, Eysel P, Dubousset J. Operative treatment of scoliosis with Cotrel-Dubousset-Hopf instrumentation. New anterior spinal device. Spine (Phila Pa 1976) 1997; 22(6): 618–28. [CrossRef]
33. Doany ME, Olgun ZD, Kinikli GI, Bekmez S, Kocyigit A, Demirkiran G, et al. Health-related quality of life in early-onset scoliosis patients treated surgically: EOSQ scores in traditional growing rod versus magnetically controlled growing rods. Spine (Phila Pa 1976) 2018; 43(2): 148–53. [CrossRef]
34. Blount WP, Schmidt AC, Keever ED, Leonard ET. The Milwaukee brace in the operative treatment of scoliosis. J Bone Joint Surg Am 1958; 40-A(3): 511–25. [CrossRef]
35. Lonstein JE. Milwaukee brace treatment of scoliosis. Scoliosis Research Society Bracing Manual. Available from: URL: https://www.srs.org/UserFiles/file/bracing-manual/section4.pdf.
36. Jiang J, Qiu Y, Mao S, Zhao Q, Qian B, Zhu F. The influence of elastic orthotic belt on sagittal profile in adolescent idiopathic thoracic scoliosis: a comparative radiographic study with Milwaukee brace. BMC Musculoskelet Disord 2010; 11: 219. [CrossRef]
37. Negrini S, Aulisa AG, Cerny P, de Mauroy JC, McAviney J, Mills A, et al. The classification of scoliosis braces developed by SOSORT with SRS, ISPO, and POSNA and approved by ESPRM. Eur Spine J 2022; 31(4): 980–9. [CrossRef]
38. de Mauroy JC, Lecante C, Barral F. "Brace Technology" Thematic Series - The Lyon approach to the conservative treatment of scoliosis. Scoliosis 2011; 6: 4. [CrossRef]

39. Emans JB, Hedequist D, Miller R, Cassella MC, Hresko MT, Karlin L. Reference manual for the boston scoliosis brace. Scoliosis Research Society: Boston Brace International, INC, 2003.
40. Howard A, Wright JG, Hedden D. A comparative study of TLSO, Charleston, and Milwaukee braces for idiopathic scoliosis. Spine (Phila Pa 1976) 1998; 23(22): 2404–11. [CrossRef]
41. Grivas TB, Kaspiris A. The classical and a modified Boston brace: description and results. Physiother Theory Pract 2011; 27(1): 47–53.
42. Rigo M, Weiss HR. The Chêneau concept of bracing--biomechanical aspects. Stud Health Technol Inform 2008; 135: 303–9.
43. Foort J. Socket design for the above-knee amputee. Prosthet Orthot Int 1979; 3(2): 73–81. [CrossRef]
44. Bidari S, Kamyab M, Ghandhari H, Komeili A. Efficacy of computer-aided design and manufacturing versus computer-aided design and finite element modeling technologies in brace management of idiopathic scoliosis: A narrative review. Asian Spine J 2021; 15(2): 271–82.
45. Lehnert-Schroth C. Three-dimensional treatment for scoliosis: Physiotherapeutic method for deformities of the spine.California: The Martindale Press Palo Alto, 2007.
46. Berdishevsky H, Lebel VA, Bettany-Saltikov J, Rigo M, Lebel A, Hennes A, et al. Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools. Scoliosis Spinal Disord 2016; 11: 20. [CrossRef]
47. Negrini S, Antonini G, Carabalona R, Minozzi S. Physical exercises as a treatment for adolescent idiopathic scoliosis. A systematic review. Pediatr Rehabil 2003; 6(3-4): 227–35. [CrossRef]