SCIENCE SET
OPEN ACCESS PUBLISHERS

Research Article

Science Set Journal of Medical & Clinical Case Studies

Scoliosis is the Most Common Deformity of the Spine

Siniša Franjić

Independent Researcher

***Corresponding author:** Siniša Franjić, Independent Researcher, E-mail: sinisa.franjic@gmail.com

Submitted: 03 Dec 2022 **Accepted:** 05 Dec 2022 **Published:** 31 Dec 2022

***Citation:** Siniša Franjić (2022).Scoliosis is the Most Common Deformity of the Spine. Sci Set J of Med Cli Case Stu 1(1), 01-05.*

Abstract
Scoliosis is the most common deformity of the spine and comes from the Greek word „scoliosis", which means bending. The spine consists of many small rectangular bones located in the central part of the body so that they connect the head to the pelvis. Scoliosis occurs when the spine bends to the side and can look like the letter "C" or "S". In addition, the vertebrae rotate or twist and pull the ribs so that a complex deformity occurs in three planes.

Keywords: Scoliosis, Signs, Conditions, Curves, Bone Healing

Introduction

A reverse engineering methodology based on digitization by means of a threedimensional (3D) optical scanner was employed to develop the geometric model [1]. The force flow lines characterizing the brace and indicating the general working method of the orthosis's structure were determined using the FEM (finite element method) model. Identification of the main areas of the orthosis, carrying loads correcting the spine and of the positions of sites exerting little effort, from the perspective of their participation in the orthosis's essential therapeutic application, was carried out. Methods for mechanical optimization of the brace's design can be proposed based on the results obtained. As the conducted analysis is universal in character, it can be adapted to other types of orthopedic braces.

Ill·fitting clothing, shoulder drop, curving spine, or a rib hump are signs ofidio· pathic scoliosis [2]. Patients with neurogenic scoliosis may also have weakness. loss of balance, joint contracture, and urinary or fecal incontinence. Back pain is rare with idiopathic scoliosis but may be present in scoliosis caused by slIch lesions as spinal cord tumor. Patients with severe scoliosis may have respiratory insufficiency.

SCI

Nearly all patients in whom SCI (Spinal Cord Injury) occurs before the adolescent growth spurt develop progressive scoliosis [3]. Therefore, young children with SCI should be monitored very closely for development of spinal deformity. Orthotic treatment should be started as soon as the spinal deformity is identified. Although there is no strong literature support for the use of bracing in patients with SCI, if bracing is started in curves less than 10 degrees, potential fusion can be avoided and if bracing is started after 20 degrees, some slowing of curve progression can occur. Bracing can impair daily activities and independence, but the potential benefits clearly outweigh the risks and complications.

The potential causative factors for the development of progressive spinal deformity in pediatric SCI are: residual fracture deformities after the initial injury, truncal muscle imbalance, development of spasticity secondary to incomplete SCI, progressive cord apoptosis, and development of syringomyelia. Progressive deformity and poor sitting balance in the wheelchair are some of the indications for surgical intervention. Spinal deformities should be treated in a similar manner as neuromuscular scoliosis with modern corrective surgical techniques when bracing fails to prevent progression.

Surgical correction and fusion in this population have a high complication rate. The incidence of pseudarthrosis requiring revision surgery may be as high as 29%, and infection rates are also elevated compared to other causes of scoliosis with our data indicating an infection rate of 16%. Potential reasons for the high complication rate include poor wound healing due to the lack of protective sensation, incontinence resulting in wound contamination, and confinement to bed or a wheelchair which predisposes the child to pressure ulcers. Management of spinal deformity related to SCI is fraught with complications, and revision surgery is common.

History

The natural history of scoliosis is dependent on the curve severity, curve pattern, and skeletal maturity of the patient [4]. Patients who present with large curves and significant growth potential are likely to have curve progression. Sixty-eight percent of patients presenting with curves measuring 20–29 and Risser grade 0–1 will have curve progression. Indications for bracing include curves between 30 and 40 on initial presentation or curves greater than 20 that exhibit progression skeletally immature patients. The success of brace wear is dose dependent, with better results reported for so-called full-time bracing versus part-time bracing. This results in a high rate of noncompliance among adolescents. Furthermore, bracing does not typically result in curve correction; rather, its goal is to halt curve progression and it is effective approximately 70 % of the time.

Fusionless techniques using minimally invasive approaches to the anterior thoracic spine have been developed in an effort to obtain curve correction and avoid brace wear. These techniques are often referred to as anterior thoracoscopic vertebral stapling, convex tethering, mechanical growth modulation, or internal bracing. Utilizing the Hueter-Volkmann principle, these techniques inhibit progression and may correct scoliotic deformities while preserving growth, motion, and function of the spine and do not rely on patient compliance for efficacy. Additionally, they may prevent adjacent segment degeneration seen with more traditional fusion technology. A number of centers are evaluating these concepts. Early applications of vertebral stapling had disappointing results and were complicated by staple dislodgement or failure.

Signs

The earliest sign is prominence of the paravetebral muscles on the convex side of the curve, seen when the patient bends over at the waist [2]. This occurs because the spine not only curves but also rotates into the convexity of the curve, elevating lumbar muscles or ribs. The shoulder may be depressed, with truncal shift and head balance decompensation. Neurologic signs are present in scoliosis because of cerebral palsy. muscular dystrophy. and other neurologic conditions and often include muscle weakness, spasticity. abnonnal deep tendon reflexes. and ankle clonus. In scoliosis due to spinal cord tumor, abnonnal abdominal reflexes and tight hamstrings may be present.

A standing anteroposterior and lateral radiograph of the entire spine is taken to assess location and magnitude of the curve and to detect congenital scoliosis abnormalities such as hemivertebrae, fused vertebrae. or unilateral WlSegmented bars. The Cobb angle is used to measure curves: lines are placed on the endplates of the end vertebrae at the proximal and distal end of the curve; lines perpendicular to those lines inscribe the angle of the curve. A Cobb angle greater than 10° is defined as scoliosis. An increase in the Cobb angle by 5° or more defines the scoliosis as a progressive curve. Rotation of the vertebrae is assessed by pedicle position. Skeletal maturity is estimated by the extent of ossification of the iliac apophysis (ie. the Risser sign). Other congenital lesions associated with scoliosis include diastematomyelia and posterior element dysraphism. Intradural spinal cord tumor may cause medial flattening of the pedicIes and increased inlerpedicular distance. Vertebral tumors may obliterate the pedicles or erode vertebral bodies. Computed tomography scans can be done to assess congenital deformity of the spine and bony tumors. Magnetic resonance imaging scans are useful for ruling out spinal cord cysts and tumors.

Conditions

A variety of conditions may cause or be associated with scoliosis [5]. The most common type of scoliosis is referred to as idiopathic, meaning that the cause of the disorder is unknown. Hereditary factors have been implicated, and research is ongoing as to other possible causes of idiopathic scoliosis. While it is likely that the development of idiopathic scoliosis is multifactorial, genetic, hormonal, biochemical, biomechanical, and neuromuscular abnormalities continue to be investigated. Idiopathic scoliosis can be broken down by age at diagnosis: curvature of the spine diagnosed up to age 3 years is defined as infantile idiopathic scoliosis, a diagnosis between the ages of 4 and 10 is juvenile idiopathic scoliosis, and curves diagnosed after the age of 10, or the onset of adolescence, is referred to as adolescent idiopathic scoliosis. Most cases of idiopathic scoliosis are identified during the adolescent growth spurt and are therefore considered adolescent curves.

Numerous other conditions either cause or are associated with scoliosis and must be considered when evaluating an individual for scoliosis. Congenital abnormalities of the vertebrae, resulting in congenital scoliosis or congenital kyphosis, represent some of the more common etiologies of spinal deformity. Neuromuscular disorders such as polio, cerebral palsy, muscular dystrophy, spinal muscular atrophy, or myelomeningocele are frequently associated with spinal deformity. Other conditions, such as neurofibromatosis or Marfan's syndrome, may result in spinal deformity and scoliosis is also seen secondary to intraspinal anomalies such as syringomyelia (cystic degeneration of the central aspect of the spinal canal) or a tethered spinal cord. There is also a known association between scoliosis and certain congenital conditions, such as congenital heart disease.

Estimates of the prevalence of scoliosis depend on the threshold for definition. While 1.5–3% of the population are believed to have curves over 10o, only 0.2–0.3% of the normal population have curves over 30o, a magnitude where treatment is typically instituted. The natural history of idiopathic scoliosis has been well established. Most curves are identified in early adolescence. Progression is variable and is more likely in younger patients, in skeletally immature patients (in particular, premenarchal girls), and in larger curves. Finally, while mild curves are as common in boys as in girls, progressive curves and curves requiring treatment are far more common in girls.

The implication of scoliosis in adulthood entails consideration of curve progression, pain, disability, and mortality. It has been established that an idiopathic curve of greater than 50o, in particular a right thoracic curve (which is the most common type of idiopathic curve), is at significant risk for progression even in adulthood. While curve progression is a possibility, the presence of scoliosis does not necessarily place the patient at risk for back pain. Some patients with scoliosis appear to have pain related to the curve, but it has been demonstrated that patients with idiopathic scoliosis are not at any increased risk, when compared to the general population, for the development of disabling low back symptoms. Similarly, pulmonary dysfunction and significant functional disability are relatively rare occurrences.

The mortality rate of individuals with idiopathic scoliosis does not differ significantly, with the possible exception of severe (greater than 100o) curves present since childhood, from that of the general population. Finally, scoliosis does not have an adverse impact on a woman's ability to bear children, nor is the curve more likely to progress during pregnancy than at other times.

Curves

Scoliosis is a curvature of the spine in the coronal plane [6]. Axial rotation, translational deformity and excessive kyphosis and lordosis of the spine may combine with scoliosis to produce complex spinal deformities. The changes may be of unknown cause (idiopathic), as with many adolescent cases or may be attributed to malformation of a vertebra as an embryo, muscle tone imbalance, such as in cerebral palsy or lack of muscle strength against gravity as in muscular dystrophy.

Many deformities deteriorate with growth but some spontaneously improve. Untreated, severe spinal deformity can lead to pain, difficulty with sitting balance, respiratory problems and even spinal cord impingement as well as cosmetic distortion which can have a significant psychological impact on adolescents and young adults.

Curves are described by their aetiology, direction, apex and Cobb's angle (formed between the top of the uppermost tilted vertebra in a curve and the bottom of the lowermost tilted vertebra) as these elements will inform treatment decisions. Curves will tend to progress quickest during a growth spurt, which starts about a year after menarche or voice breaking, and children will be closely monitored from this time until they reach skeletal maturity to choose the best time for surgery. Thoraco - lumbar spinal orthoses (TLSOs) may be used to slow down progression of mild curves and support but have limited effectiveness depending on the size, shape and compliance of the wearer and have little corrective effect on fixed curves.

If the curve is causing significant functional problems, spinal fusion surgery is likely to be indicated and the occupational therapy should use compensatory strategies.

Degenerative Disc

Currently, neither the reason for the high rates of degenerative disk disease in asymptomatic individuals nor the relationship between degenerative disk disease and back pain is known [7]. The pathogenesis of degenerative disk disease is elusive. Some authors advocate nutritional pathways that lead to disk degeneration; for example, atherosclerosis involving the arteries that supply the vertebral body together with endplate calcification may cause loss of cellular activity and cell death in the disk. Others advocate a mechanical pathway, in which abnormal mechanical loads are thought to provide a pathway to disk degeneration. Heavy forces imposed on the intervertebral disk may cause initial structural damage that leads to disk degeneration, annular tears, nuclear desiccation, and loss of proteoglycan content. When these changes occur, mild loss of disk space height may be observed on plain radiographs, while MRI demonstrates decreased signal intensity on T2-weighted images. In this condition, the disk fails to sustain loads and thus overloads the posterior facet joints, causing articular degeneration. Moreover, the pain generators in degenerative disk disease are not well defined: nociceptive innervation of the posterior aspect of the annulus, anterior aspect of the annulus, and facet joints have all been implicated.

The patient with degenerative disk disease generally presents with persistent low back pain over the lumbosacral region, occasionally with pain radiation to the sacroiliac joints, buttocks, and posterior thighs. The sitting position and prolonged walking worsen the pain. No radicular symptoms are evident, unless disk herniation or foraminal stenosis (noted in end-stage degenerative disk disease) is present. There may be point tenderness over the lumbar spine; the ROM of the lumbar spine is usually limited, particularly in flexion so that returning to an upright position is often painful while extension may relieve pain. Radicular signs are negative (straight leg rise test negative, normal neurological findings).

Imaging studies are mandatory. On plain radiographs, narrowing of the disk space, endplate sclerosis, osteophytes, degenerative spondylolisthesis, and degenerative scoliosis may be present. On MRI, common findings are: loss of water (dark disk), high-intensity zone lesions (common finding for annular tears), and endplate changes.

Brace

Scoliosis is a severe, three-dimensional (3D) deformation of the spine [1]. Non-surgical treatment involving bracing, using the Boston brace, is the most commonly applied method of treatment. A brace can be described as a customized thoracic orthosis. Typically, it is relatively heavy and rigid. For treatment to achieve results, the brace must be worn for over 23h every day, practically from diagnosis to physical maturity of the body. The apex of the spinal curve and support sites at two points on the opposite side are the sites of load application in the case of the simplest corrective action. It is called the three-point pressure system. Multiple three-point corrective systems, applied onto a 3D space, are present in more advanced designs, e.g. the Cheneau brace.

Experiments associated with the determination of forces arising in components of the brace during corrective work, e.g. in brace tightening straps, or pressures acting on the brace, play a significant role in research concerning the structure of braces. For example, large numbers of pressure sensors can be placed as arrays on the interior side of the brace. Two directions of research can be distinguished. The first of them involves tests conducted with the involvement of the patient. In the second direction, stationary stands for testing of forces with three-point brace loading are employed.

One can see that the progress made until now in the field of rigid braces concerns a better understanding of their corrective functions, described by, among others, the spatial field of forces applied to the torso required for correction, and, to a lesser extent, by the mechanical properties of braces needed for the performance of these functions. There are examples of FEM applications in the literature that describe individual braces as an additional option accompanying FEM modelling of the torso, but these orthosis models are simplified and do not represent the geometry of the actual orthosis sufficiently well.

Computer Model

Computer modelling of the brace's mechanical structure seems to be a difficult task due to its nature [1]. It is thin-walled, has an open cross-section, and a spatial distribution of loads is applied to it. Attention has been paid in the literature to the relationship between the mechanical properties of the brace's material and the pressures exerted by the orthosis. More flexible braces are more comfortable to wear, but at the same time, more rigid orthoses are better at exerting corrective forces. There is literature concerning determination of corrective force distributions, but there is little information about the mechanical properties of the brace's structure, required for effecting these forces. Literature analysis shows that the values and directions of an orthopedic brace's corrective forces are critical factors in the efficacy of treatment by its means. Therefore, it is important to identify the conditions that the brace's mechanical structure must fulfill in order to ensure its capacity to implement the required field of forces.

One may hypothesize that the proper starting point for analysis of the mechanical features of existing brace designs is to develop a credible numerical model of an actual orthosis whose efficacy has already been confirmed in practice. In-depth modelling results of such structures are absent in the literature. The numerical simulations presented in this article were aimed at developing a reliable FEM model of a sample brace. Indepth analysis of the model will serve for definition of the working scheme of the brace's structure, which will then enable indication of the possibilities of optimizing the brace's design.

Surgery

Surgery for scoliosis correction is one of the most common operations performed on healthy teenagers [8]. Anesthetic implications unique to this procedure include spinal cord monitoring and positioning. In general, teenagers have higher anesthetic and narcotic requirements in the operating room than adults undergoing this procedure. Some children presenting for scoliosis correction have underlying medical syndromes that add complexity to the patient's care.

It is important to elicit a complete history, including the patient's exercise tolerance. Healthy teenagers are usually still able to exercise with mild restrictive pulmonary disease and may only have respiratory symptoms at full exertion.

Identifying the location of the spinal deformity, the age of onset, and the direction and severity of the curve will provide valuable information about the patient's pulmonary function and potential associated congenital anomalies. Most curves in adolescent idiopathic scoliosis are convex to the right. A left thoracic convexity should raise ones index of suspicion to look for other underlying conditions and congenital anomalies.

Knowing the type or etiology of the scoliosis is essential. In many teenagers the etiology of scoliosis is unknown, or idiopathic. However, neuromuscular scoliosis may occur as a result of diseases such as cerebral palsy and muscular dystrophy. This type of scoliosis is associated with significantly increased intraoperative blood loss compared with idiopathic scoliosis. These patients are also at higher risk for perioperative neurological and respiratory complications.

The two monitoring techniques most commonly used to monitor spinal cord function are somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs). The functional integrity of the somatosensory pathways in the posterior column of the spinal cord can be continually assessed by SSEPs. Normal intraoperative SSEPs are good predictors of normal postoperative sensory function. MEPs assess the integrity of the spinal motor pathways in the anterior columns. It is important to monitor these signals for thoracic spine surgery. The routine use of MEPs intraoperatively has virtually replaced the "wake-up test" previously relied upon to assess spinal cord insult during surgery.

Bone Healing

Bone healing is a complex physiological process [9]. The striking feature of bone healing, compared to healing in other tissues, is that repair is by the original tissue, not scar tissue. Regeneration is perhaps a better descriptor than repair. This is linked to the capacity for remodeling that intact bone possesses. Like other forms of healing, the repair of bone fracture includes the processes of inflammation, repair, and remodeling; however, the type of healing varies depending on the method of treatment. According to Wolff law, bone remodels along lines of stress. Bone is constantly being resorbed and replaced as the resorption of circumferential lamellar bone is accomplished by osteoclasts, and replaced with dense osteonal bone by osteoblasts.

In classic histological terms, fracture healing has been divided into two broad phases: primary fracture healing and secondary fracture healing.

• Primary healing, or primary cortical healing, involves a direct attempt by the cortex to reestablish itself once it has become interrupted. In primary cortical healing, bone on one side of the cortex must unite with bone on the other side of the cortex to reestablish mechanical continuity.

• Secondary healing involves responses in the periosteum and external soft tissues with the subsequent formation of a callus. The majority of fractures heal by secondary fracture healing.

Within these broader phases, the process of bone healing involves a combination of intramembranous and endochondral ossification. These two processes participate in the fracture repair sequence by at least four discrete stages of healing: the hematoma formation (inflammation or granulation) phase, the soft callus formation (proliferative) phase, the hard callus formation (maturing or modeling) phase, and the remodeling phase.

Conclusion

Scoliosis is a lateral curvature of the spine with simultaneous rotation of the vertebrae. Scoliosis represents one of the most complex forms of pathological postural adaptation, and denotes a structural three-dimensional deformation of the spine and trunk, which means that there is curvature of the spine in all three body planes (frontal, sagittal and transverse levels). It is estimated that 3-5% of the population has scoliosis, from the smallest degrees to severe forms. It occurs more often in girls and 7 times more often than in boys. Girls may be more sensitive to changes in central control during the development of the central nervous system due to shorter and faster growth and development during puberty and adolescence compared to boys. Scoliosis most often forms during the phase of intensive growth - between the ages of 10 and 12. There are various causes of scoliosis, but in almost 80-90% of cases, they are unknown. It is assumed that the triggers for the development of scoliosis can be hormonal, nervous and muscular disorders. Hereditary predisposition is also one of the causes of the phenomenon.

References

1. Grycuk S, Mrozek P (2022) Numerical Analysis of Scoliosis Brace" in Hadamus, A.; Piszczatowski, S.; Syczewska, M.; Błażkiewicz, M. (eds): „Biomechanics in Medicine, Sport and Biology", Springer Nature Switzerland AG, Cham, Switzerland 44-45.
2. Campbell jr, RM Scoliosis Heckman JD, Schenck jr RC Agarwal A (2000): „Current Orthopedic Diagnosis & Treatment", Current Medicine, Inc., Philadelphia, USA 164.
3. Garg H, Pahys J, Cahill PJ (2012) Thoracic and Lumbar Spine Injuries" in Abzug, J. M.; Herman, M. J. (eds): „Pediatric Orthopedic Surgical Emergencies", Springer Science+Business Media, New York, USA 83-85.
4. Zarro CM, Lonner BS (2016) Minimally Invasive Treatment of Spinal Deformity" in Scuderi, G. R.; Tria, A. J. (eds): „Minimally Invasive Surgery in Orthopedics, Second Edition", Springer International Publishing AG, Cham, Switzerland, pp. 1125. - 1126.
5. Delahay JN, Lauerman WC (2010) Children's Orthopedics" in Wiesel, S. W.; Delahay, J. N. (eds): „Essentials of Orthopedic Surgery, Fourth Edition", Springer Science+Business Media, New York, USA 239-240.
6. McDowell H (2009) Spinal conditions: management and o ccupational therapy" in Mooney, M.; Ireson, C. (eds): „Occupational Therapy in Orthopaedics and Trauma", Wiley-Blackwell, John Wiley & Sons, Chichester, UK 104-105.
7. Maiello A, Smucker JD (2011) Spinal Disorders in Sports Medicine" in Margheritini, F.; Rossi, R. (eds): „Orthopedic Sports Medicine - Principles and Practice", Springer-Verlag Italia, Milan, Italy 513-514.
8. DelPizzo KR, Dong N, Guheen CR (2014) Pediatric Anesthesia for Orthopedic Surgery" in MacKenzie, C. R.; Cornell, C. N.; Memtsoudis, S. G. (eds): „Perioperative Care of the Orthopedic Patient", Springer Science+Business Media, New York, USA, pp. 74.
9. Dutton M (2011) Dutton's Orthopedic Survival Guide - Managing Common Conditions", The McGraw-Hill Companies, Inc., New York, USA 32.