SCOLIOSIS: COMPARATIVE ANALYSIS OF SURGERY VS. BRACE TREATMENT

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INTRODUCTION

The spine, or spinal column, as it is also called, is a complex structure made up of 33 vertebrae (bone segments) arranged vertically in succession from just below the skull to the tailbone. The entire column is broken up into various classes of vertebrae named, from superior to inferior, as cervical, thoracic, lumbar, sacral, and coccygeal. Different forms of spinal deformities that can occur include kyphosis, lordosis and scoliosis (Neuwirth and Osborn 2001).

Scoliosis is defined simply in medical terms as a lateral three-dimensional irregular curvature of the spine. The curvature as seen from the back of the person can be described as an "s" shaped bend or a "c" shaped bend. The spinal curves are measured by degrees of curvature and depending on the severity of the degree of curvature, an appropriate treatment method will be determined. Scoliosis curvatures do not retain a status quo over time. If not treated properly, the curves tend to progressively worsen, causing pain and discomfort to the diseased party. In this paper, different methods that are used in treating scoliosis are discussed including the different types of braces that are used and the various forms of surgeries that are performed in such cases.

Figure 1:
Normal spine compared to scoliosis.
Source:
http://www.inspireyourbodymt.com/home/2009/9/3/injury-of-the-week-scoliosis.html

CAUSES OF SCOLIOSIS

Although the causes of scoliosis aren't fully understood, most scientists believe that its causes are multifactorial and dependent on the form of scoliosis. Contributing factors may be genetic inheritance or the laxity of ligaments and the deformation of the vertebral bones. The factor contributing to the disease would place it into one of two categories, either structural or functional scoliosis (Wikipedia.org 2010).

If the cause of the disorder is not genetic, it will fall under the grouping called functional scoliosis. This form of scoliosis, which usually appears in people with weak vertebral muscles, may be caused by the patient sitting for long periods of time in a slouched position or from carrying a heavy backpack on the same shoulder too often. Fortunately, functional scoliosis can more often than not be easily treated by toning the back muscles or by making a conscious effort to sit and stand erect with proper posture (Lyons et al. 1999).

Although there may be many factors contributing to functional scoliosis, structural scoliosis is unanimously agreed upon to be caused by direct genetic inheritance. Structural scoliosis, the more common form of the disorder, is the natural progression of the spine adapting a curved position and is the more severe form of the ailment. This mode of scoliosis cannot be treated through good posture and toning the back; rather, a proactive step must be taken to stop the progression and straighten the spinal column (Lyons et al. 1999). While certain types of scoliosis have different ratios of men to women (and some

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forms may even be more prevalent in males than females) due to the genetic factors involved, scoliosis is more commonly found in females than in males. In fact, the more severe the vertebral curve is, the larger the female to male ratio gets.

SCOLIOSIS DIAGNOSIS

There are various ways in which scoliosis can be diagnosed. To a physician, there are certain bodily indications that are easily seen that signify that the patient may have scoliosis. Some examples are asymmetric hips, an elevation of a shoulder, a protrusion of one shoulder blade or a visibly curved spine. These are all indications of a spinal deformity that to any person (not only doctors) are visible to the naked eye. There are a couple of more specific tests that a physician will use to diagnose the patient. The Adams forward bend test is the simplest and most common scoliosis test used by physicians. The patient bends forward with their arms pointed straight down to their toes and the physician examines the spine for any curvatures. If the curve is not clearly visible, using a device called a scoliometer, the physician can look for elevated muscles or a spinal curvature by placing the scoliometer on the back of the patient and measuring the discrepancy between different elevations of the back.

Today, technology has advanced and a more accurate method of diagnosis is used. A combination of X-rays and/or radiographs is used in conjunction with the Cobb angle, which is the angle two right angles make with the curved spine, to diagnose an exact degree of curvature. There are four different types of X-rays that physicians will use along with the Cobb angle to determine the severity the bend. The various X-ray forms range from the classic and simple front/back X-ray to the complicated bending X-ray. Bending X-rays are often used to determine the flexibility of the spine, which could affect the style of treatment that is utilized. Visits and X-rays are taken every couple of months to watch for progression of the curve so that the proper form of treatment can be determined.

TYPES OF SCOLIOSIS

Scoliosis is more much more common in our society than most people imagine. Statistics show that an astounding 1/ 40th of the population have a scoliosis curvature of at least ten degrees. As the severity of the curve increases the ratio decreases but still maintains a high percentage of people, with five people out of every thousand having vertebral curves of over 20 degrees (Dotsky and Lipp 2002). The reason scoliosis is so common is because there is such a wide variety of different types of scoliosis that people can have. No single description of scoliosis can encompass the wide range of curvatures that exist. Origin, time of onset and location of curvature are all variables in classifying what type of scoliosis affects the patient. Categorization, i.e. the shape of the curve and severity, are important because that will determine the form of treatment that a doctor will advise. Some curves exhibit considerable lateral curvature and little rotation while others have extreme rotation and insignificant lateral curvature.

All structural scoliosis deformities can fit into one of two more specific categories, the idiopathic cases and those cases that have an identifiable cause. Non-idiopathic cases can be further subdivided into congenital and neuromuscular scoliosis.

IDIOPATHIC

Idiopathic scoliosis is loosely defined as scoliosis that progressed for apparently no cause. This means that although extensive research has been done, the cause for the onset and progression of the scoliosis still evades scientists and it appears that the deformity is

unrelated to anything else. Approximately 75-85% of people with scoliosis have idiopathic scoliosis in a ratio of 1:8, men to women (Lonstein 2002).

Idiopathic scoliosis is different than congenital scoliosis in that its onset can occur at any point during person's lifetime. In order to discern between the numerous types of situations, specific names are given to each case based on when the onset occurred. Infantile idiopathic scoliosis has its onset between infancy and age 3. While scoliosis in general is more common in women than men, infantile idiopathic scoliosis is more common in boys than girls. Most often, this type of scoliosis will manifest itself as a thoracic curve with left convexity (Lyons et al.1999). If the condition appears between age 4 and 10, it is labeled as juvenile idiopathic scoliosis, while if it occurs from age 11 till the end of the teen years, it is called adolescent idiopathic scoliosis (AIS).

The majority of idiopathic scoliosis cases are considered adolescent idiopathic scoliosis. This may be because even though the onset of the condition began when the person was a juvenile patient, since it only became noticeable at adolescence, it will still be considered adolescent idiopathic scoliosis (Dotsky and Lipp 2002). Logically, it's understandable that AIS is the most common form of scoliosis, because the adolescent growth spurt is the most opportune time for the spine to curve or increase the degree of a curve dramatically. Interestingly, AIS tends to follow a series of specific patterns in forming scoliosis curves; a) thoracic curves which show a right convexity b) thoracolumbar curves which also show right convexity c) lumbar curves which show a left convexity and d) double major curves which show a and c together forming an "S" shaped deformity of the vertebral column (Lyons et al. 1999).

Adult idiopathic scoliosis (onset over 20 years of age), although uncommon, is a possibility. In fact most adult scoliosis cases are idiopathic and structural as opposed to a logical functional cause (due to weaker muscles etc.). This structural deformity is usually a consequence of osteoporosis, degenerative arthritis or another condition that causes deterioration of vertebrae (Arthritis-Symptom.com).

CONGENITAL

Non-idiopathic scoliosis is usually the result of a neuromuscular disease or a congenital abnormality (Lonstein 2002). Congenital scoliosis normally forms when there is an abnormal or warped formation in the spinal cord during embryonic development. "A key feature of congenital scoliosis is the presence of one or more abnormally formed vertebrae. When these anomalies are identified the curve should be classified as congenital, even if the deformity is not apparent until adolescence" (Erol et al. 2002). There are two main causes of congenital scoliosis; cases are classified based on failure of formation, failure of segmentation or a combination of the two (Erol et al. 2002).

Segmentation defects refer to an abnormal separation of the embryo's different spinal segments, called somites, formed during development of the spine in a process called somitogenesis. In this process, segments of tissue called somites are formed in pairs surrounding what will eventually become the spinal cord. When somitogenesis is disrupted even slightly, congenital vertebral defects result.

The second classification of congenital vertebral anomalies are those that occur due to a failure of formation. The most common type of formation anomaly is a hemi vertebra. This is where a portion of the vertebra is missing resulting in a small, triangular shaped "half vertebra" or hemi vertebra. Hemi vertebrae can be sub-classified based on their relationship to the adjacent spine, segmented, semi-segmented and non-segmented. When

several vertebral segments fail to separate bilaterally, a block vertebra results producing fused vertebral bones. Simple hemi vertebrae cause a progression of spinal column curvature of 1-3.5° per year (Harms 2010). These forms of abnormalities in the spine are usually associated with deformities in other organs and organ systems including the heart, kidney and lungs. In fact, a study showed that more than half the congenital scoliosis cases are related to associate health problems (Harms 2010). Congenital scoliosis is rare, but it may require early surgery due to the severity of the spinal deformity involved.

NEUROMUSCULAR

Neuromuscular scoliosis is the other form of the deformity with an identifiable cause. Neuromuscular scoliosis is classified based on two possible origins; neuropathic and myopathic. Neuropathic diseases involve either the upper or lower motor neurons. Both upper motor neuron diseases, such as cerebral palsy, spinal-cord trauma and tumors, and spinal muscular atrophy, and lower motor neuron diseases, such as polio, can lead to scoliosis. Myopathic diseases include arthrogryposis (joint contractures) and muscular dystrophy. Despite the differences, the common factor in these conditions is an inability to provide muscular support to the spinal column or an imbalance of the muscular control of the spine. Realistically, patients who contracted neuromuscular disease before age 10, have a 100% chance of developing neuromuscular scoliosis (Lonstein 2002). Treating neuromuscular scoliosis is more challenging due to all the additional problems in the other systems that come along with the specific disease of the patient. Bracing is a possible approach, but it will only slow the progression, not stop it, while surgery can be complicated due to numerous factors (e.g. most of these individuals have to be on medications which can affect blood clotting). Sometimes, in wheelchair bound patients, surgeons for neuromuscular scoliosis patients will form a base-like structure unlike the regular rods and wire system that are put in for normal standing patients (Lonstein 2002).

TREATMENT OF SCOLIOSIS

The question arises, what is the best method in treating scoliosis? Unfortunately, there is no one correct answer. When the doctor examines a patient for scoliosis, he performs a comprehensive physical examination to get a perception of the patient's health, preferred activities and lifestyle. Only by knowing all these things can a doctor recommend a treatment that is beneficial for the patient. Of course, the specific type of scoliosis that the patient has been diagnosed as having will also affect the form of treatment.

The first step in the treatment process is diagnosing whether there is a need for a remedy at all. There are two routes of activity that a scoliosis curve can take; it could be a resolving curve or a progressive curve. A resolving curve is a form of scoliosis that like its name will probably resolve on its own. These curves that straighten themselves without any action done upon them are commonly found in infantile idiopathic scoliosis. Progressive scoliosis, obviously the more dangerous of the two varieties, is a curve that progressively gets worse unless treated effectively. Treatment of progressive scoliosis can take the form of a brace progression (or body casting in very young patients) for lesser degree curve or surgical stabilization for those curves that bracing alone won't be an adequate solution. Determining the specific treatment for a patient is based on the patient's age, curve flexibility or curve magnitude.

BRACES

TYPES OF BRACES

There are many different types of braces which all serve their own designated functions. Regardless of their categorization they all are meant to achieve the same purpose: to improve scoliosis related deformities, to prevent curvature from progressing and to provide postural comfort and stability. Although braces cannot correct scoliosis curvatures, they can slow or stop the progression, eliminating or at least delaying the need for a surgical remedy. There are four general categories of rigid scoliosis braces known to physicians by their acronyms cervical thoracolumbar sacral orthosis (CTLSO), thoracolumbar sacral orthosis (TLSO), lumbosacral orthosis (LSO), and the bending brace. These braces are more commonly known to the patients by the name of their city of origin (e.g. Milwaukee brace and Boston brace). In each general category of bracing, over the years, technology has advanced and many new braces have come out. All these newer scoliosis braces follow the direction of one of the four general categories but each has their own little nuances that make them different from each other. For example, under the category of the Boston brace we have other braces that follow the Boston brace prototype but are known by other names (i.e. the Wilmington brace and the Miami brace). Regarding treatment, there is no brace that is considered better than the others; all the different forms of braces cater to different people with different curvatures. Each model has a distinct style that will benefit some patients and not others. Sometimes, two brace

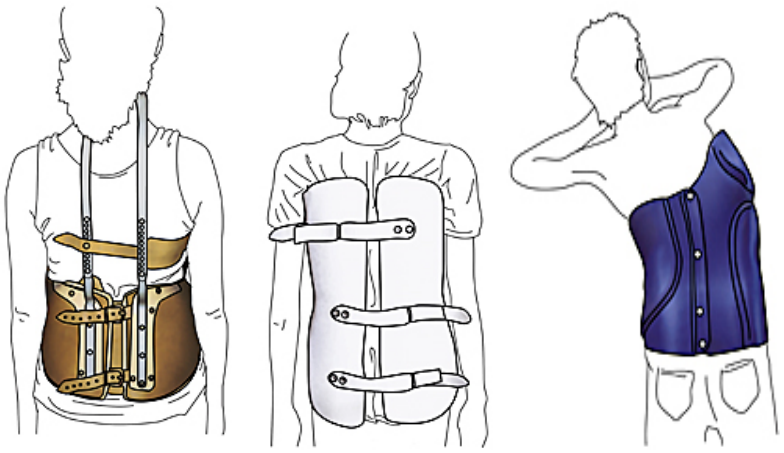

Figure 2: Posterior Views in order from Left to Right: The Milwaukee Brace, The Boston Brace, and The Charleston Bending Brace.
Source: http://www.iscoliosis.com/articles-brace_types.html

models may be recommended for the treatment of a specific patient and the only reason to choose one over the other would be personal preference.

The Milwaukee brace (Figure 3) was introduced in 1946 and first designed by Blount and Schmidt to be worn by patients to "provide comfortable and efficient passive correction and fixation following patients post-surgery". They discovered soon after that this brace was very effective in patients who had not yet gone for surgical procedures. This became the first form of non-operative treatment for scoliosis patients. This brace is a CTLSO brace that is usually given to patients who have high thoracic curves with apexes above T7 vertebrae or patients who have double major curves. It is normally used with

growing adolescents to hold a 25° to 40° advancing curve (Chow 1997). The brace is intended to minimize the progression to an acceptable level, not to correct the curvature.

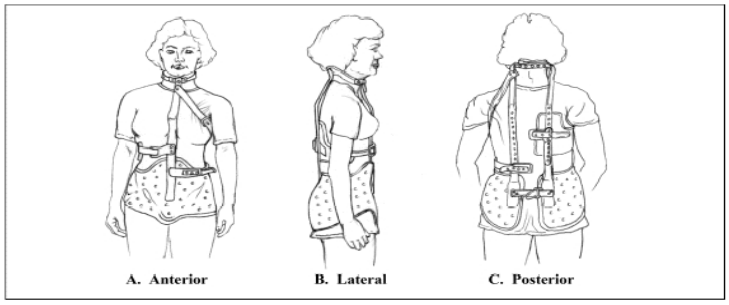

Figure 3: Milwaukee Brace
Source: http://www.ncbi.nlm.nih.gov/books/NBK27217

The Milwaukee brace is commonly worn 23 hours a day and is a full torso brace that is made to custom fit the patient's torso. It extends from the neck to the pelvis and consists of a specially contoured plastic pelvic girdle and a neck ring connected by metal bars in the front and the back of the brace. The metal bars help extend the length of the torso and the neck ring keeps the head centered over the pelvis. Pressure pads, strategically placed according to the patient's curve pattern, are attached to the metal bars with straps. The Milwaukee brace is often characterized by a chin piece that the patient can rest his/her head on. Although the extension of the brace up to the neck is uncomfortable and unfavorable, it is the distinguishing feature that makes this brace useful and effective (Chow 1997). While wearing the Milwaukee brace, patients found it difficult to perform the simple activities of daily living such as putting on socks, tying shoe laces, brushing their teeth and eating spaghetti from a plate, due to the immobility of the spine. Although the brace is difficult to deal with on a daily basis, studies found that the Milwaukee brace is very effective when the patient complies with the proper treatment.

The Boston brace and its sub types are the most commonly used braces in the United States. This brace is usually used by patients with lumbar or thoracolumbar curvatures (apexes lower than T7). Like the Milwaukee brace, the Boston brace has various pads that are placed around the brace to provide specific forces to effectively maintain the curve in the corrected position. The Boston Brace extends from below the breast to the beginning of the pelvic area in front and just below the scapulae to the middle of the buttocks in the back. It is designed to keep the lumbar area of the body in a flexed position by pushing the abdomen in and flattening the posterior lumbar contour.

There are two main varieties of the Boston brace, TLSO and LSO. The difference between the two types and the reason why a patient would wear one over the other is determined by the location of the scoliosis curvature. Curves in the upper lumbar and/or accompanied by minor thoracic curves will wear the TLSO version of the Boston brace. This version extends up to one or both underarms, while the LSO extends only to the lower region of the patient's back. Therefore, patients with curves strictly in the lower lumbar region that show little or no thoracic component will use the LSO version of the Boston brace. Cosmetically, the Boston brace is usually preferred over the Milwaukee brace because it is easily concealed under normal clothes. Like the Milwaukee brace, the Boston is generally worn 20-23 hours a day.

The Charleston bending brace is different from both the Milwaukee (CTLSO) and the (TLSO/LSO) Boston braces in many of its aspects. While the Boston and Milwaukee braces are worn most of the day, the Charleston bending braces are only worn at night. The Charleston brace is meant to be worn at night as it was originally designed for the purpose of increasing compliance in kids and young adults (Hooper et al. 2003). The design of the Charleston brace is similar to the Boston brace but its redeeming

characteristic is that its shape is molded around the patient's body. The brace is bent in the opposite direction of the curve, thereby "over correcting" the spinal deformity, so while the patient is wearing the brace his/her torso is physically being pushed to bend in the opposite direction of the natural curve of the spine. Another reason why the brace is only used at night is because it forces the patient into a bent over position, which would be awkward and prohibitive in daily life. There are many benefits to the Charleston bending brace over the other two, nearly all of which are related to the nightwear component. It allows full, unrestricted musculoskeletal development and opportunity for athletic participation, if desired. Also, it causes fewer and less severe complications. Results can be assessed without the customary long-term follow-up, and decision-making regarding success or failure of the program can be made earlier (Hooper et al. 2003). Patients with single lumbar or thoracolumbar curves are the best candidates for the Charleston bending brace and have the greatest chance of a positive outcome because inadvertently increasing a secondary curve through bracing is not a concern.

The previous three braces discussed were all forms of rigid bracing. Recently, technology has advanced and there is a new system of flexible bracing that is now being used to treat scoliosis patients. Researchers at the St. Justine Children's hospital in Montreal Canada have developed corrective movements for all types of idiopathic scoliosis to "open up" or correct the curves. The patient is braced in that corrective movement and held there 20 hours per day by the elastic bands that make up the brace. The real action in the brace is in the elastic bands. As the patient goes through the movements of the day, they stretch the elastic bands and the bands then resist and pull them back into the corrective movement. This stretch and resist system stimulates the growth centers in the deformed vertebrae and in the neuromuscular system and over time the gentle resistance of the brace and the reprogramming of the body's neuromuscular pattern results in a relatively permanent stabilization or correction of the scoliosis in almost all patients. Unlike rigid braces where patients walk around like a robot, SpineCor allows patients to do virtually any physical activity they want. In fact, exercise and activity are absolutely essential for the SpineCor brace to work.

The brace has a pelvic unit from which strong elastic bands wrap around the body, including the thigh and pelvis, pulling against curves, rotations, and imbalances. The Bolero is the component that wraps around the torso and provides an anchoring point above the pelvis. Attached between the Pelvic Base and the Bolero, the corrective bands, the most important part of the SpineCor, cause the body to be held in the corrective movement. Some of the bands will have high tension on them and others will have virtually no tension but together they work synergistically to bring about the slow but steady stabilization or correction of the scoliosis (Coillard et al. 2010). The SpineCor system is very effective; in fact, a study performed by Coillard et al. (2010) concluded that "the SpineCor orthosis is a very effective method of treatment of juvenile idiopathic scoliosis. Most encouraging perhaps is the fact that the positive outcome appears to be maintained in the long term, and that surgery can be avoided or at least postponed." The SpineCor system was actually the 2010 SOSORT winner and in a study done for the award, 75% of SpineCor users had their curves stabilized and straightened by at least 5 degrees.

Side Effects

In comparison to surgery, bracing causes fewer complications and poses little risk from its treatment but may have an effect on the patient's daily activities and lifestyle. Some side effects include affected pulmonary function, skin complaints, and general impact on daily activities. Studies show that back bracing can affect the pulmonary function and breathing patterns. Shortness of breath is commonly experienced by patients with a brace when climbing stairs or going for a walk or run. This may be caused by the brace being so tight around the body that the lungs have little room to expand and take in air. Obviously, if the patient finds it difficult to breathe, the patient should remove the brace immediately until normal breathing returns. Braced scoliosis patients are usually taught breathing techniques to prevent a decline in lung function. Ironically, some people have found that bracing actually increases their ability to breathe. Scoliosis curvatures may cause the rotation of the spine that will push the ribs to press on the lungs. Bracing, which straightens the rotated spine, will actually decrease the pressure of the ribs on the lungs and make it easier for the patient to breathe (Lyons et al. 1999).

Another common side effect of bracing is that the patient can break out with different skin rashes, sores, blisters or other skin infections. This can be caused by the brace's constant rubbing against the skin during regular daily activities (Scoliosisadvice.com 2010).

Braces may interfere significantly with daily activities, as wearing a brace is often a full-day affair. Although doctors do give patients specific directions on when and how long to wear the brace, generally most physicians instruct the patient to wear it between 18-23 hours a day (depending also on the type of brace). The brace needs to be worn for the full number of hours prescribed by the doctor until the patient finishes growing, although it may be removed for activities such as showering, swimming, and sports. Some braces are only worn at night and do not affect the patient's day at all. Young children with braces often have an intense physical exercise program they go through to improve compliance with treatment and keep the muscles in tone so that the transition period after brace removal is easier (Blackman 2009). Ignoring all the physical effects that bracing can have on a person, there is still an enormous amount of emotional stress that a person can go through in brace treatment.

Surgical Treatment

Some curves are too severe for bracing to be effective and surgery is the only remaining option. In most cases surgery is an elective procedure and very rarely is the surgery a matter of urgency, especially in adolescent idiopathic curves. Urgent surgery is only called for when the spinal rotation is so severe that it is affecting the lungs and breathing capacity or any another organ's functionality. So what is the goal of surgery? "Scoliosis reconstruction is undertaken to improve the curve from a cosmetic standpoint as well as to prevent further progression of the curve. The purpose of scoliosis surgery is not to fully straighten a curve, but rather to obtain reasonable correction of the curve, and to restore balanced posture for the patient" (Walker 2010). In adults, surgery is often used to reduce chronic back pain and discomfort in a progressing curve.

Types of Surgery

Once surgery is agreed upon by the doctor and the patient, there are a couple of different surgical approaches that the doctor may take. The first and most common style of surgery is spinal fusion surgery. In spinal fusion there are still two subcategories, posterior

spinal fusion and anterior spinal fusion. Both use a combination of hooks, screws, wires and rods. The hooks are screwed in and attached together by wires that are anchored in place along the vertebral column. The rods are placed in the anchors and fixed there, so that when tightened or rotated they can straighten the spine. The surgeon then fuses part of the spine using bone grafts, in posterior fusion taken from the top of the pelvis or taken from a rib in the anterior fusion and spread it out along the vertebrae and joints. The bone graft pieces ossify and fuse with the spine creating one solid piece of vertebrae permanently corrected in the straightened position. Although the rods are no longer needed in the patient, removing them would require an added surgery so they are usually left in place (Dotsky and Lipp 2002).

The posterior form of spinal fusion is done through an incision that approaches the spine from the back and runs down the length of the body; a long posterior incision can go

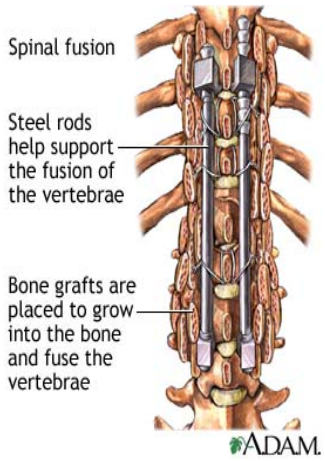

Figure 4: Harrington rods Post-op. Source: http://healthguide.howstuffworks.com/scoliosis-in-depth9.html

Figure 5: Pre and post-surgery X-Rays. Source:http://www.scoliosis.org/forum/showthread.php?4254-Live-Broadcast-of-Scoliosis-Surgery

from the shoulder blades down to the waist. The original posterior fusion surgeries used Harrington rods (now outdated) which worked by "distraction and compression" to straighten the curve. The issues that arose with the Harrington rods (Figure 4) are that they tended to make the entire spine abnormally flat from the side plane known as "flat back effect". It did not allow a posture where the head and pelvis were perfectly aligned and it did not account for rotational deformity (Figure 5). The more modern systems address these problems of sagittal imbalance and rotational deformities (Modi 2009).

The anterior spinal fusion method approaches the deformity from the front and in recent times has become more common. This method of surgery is a more invasive operation because it entails moving around internal organs in order to reach the spinal column. The incision runs along one side of the abdomen below the ribcage, as opposed to the posterior method, which runs along the length of the back. The anterior method is mostly used in the scoliosis cases that have a curvature in the thoracolumbar or lumbar vertebrae. The discs between the vertebrae are removed, screws are placed into the vertebral bodies, and a rod is attached to the screws like a posterior spinal fusion. The advantage of the anterior spinal fusion is that a smaller segment of the vertebrae is fused leaving more "freely movable" components of the spine. Some people are actually

candidates for an extremely complex surgery in a combination procedure involving both posterior and anterior surgeries.

The newest approach to scoliosis surgery is the thoracoscopic method. This new

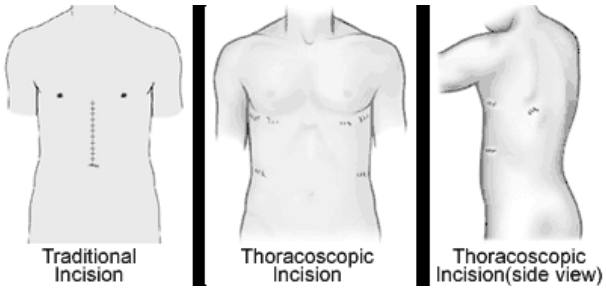

Figure 6 : Thoracoscopic Incision
Source:
http://my.clevelandclinic.org/thoracic/services/video_assisted.aspx

technologically advanced method uses cameras attached to the surgical instruments, inserted into small "peephole" incisions (replacing the long incision and inevitable scar) (Figure 6) on the side of the body by the surgeons. The cameras produce an image that is projected onto the screen in the operating room so the doctor can perform the surgery without exposing the spine. This procedure is not to be confused with thoracoplasty, which is another scoliosis related procedure. Sometimes combined with spinal fusion, this process involves the removal of 4-6 adjacent rib segments that protrude in a 'hump". This is caused by scoliosis related rotation of the rib cage, resulting in a visible protrusion of specific rib segments. This removal of rib will many times serve as the rib graft needed in posterior fusion surgery (Lyons et al. 1999)

SURGICAL SIDE EFFECTS

According to the article "Scoliosis" on the Health Scout web site, for people undergoing scoliosis surgery "complication rates are high, nearly 10%, with any surgical procedure. In fact, 7% of patients require reoperations within 5 years after surgery" (Health Scout 2009). Since the risks of surgery are manifold, people don't really know what to expect post-surgery. Risks and potential complications include the following (Lyons et al. 1999):

- allergic reactions to anesthesia
- bleeding (patients are encouraged to donate blood before the operation for use in possible transfusions)
- postoperative infection of the wound/incision site
- nerve damage (neurologic injury can occur in 1% of patients, which can lead to motor weakness and, in rare cases, paralysis)
- pseudoarthrosis (or failure of the fusion to take place)
- disc degeneration
- lower back pain
- loss of trunk mobility, balance, and muscle strength
- leg and back pain
- dislodging of hooks or broken or loosened rods
- fracture of a fused vertebra

Surgery, like every other method of treatment, has its pros and cons. Advantages of surgery include a stop to the progression, a better cosmetic outcome, and an immediate decrease in the curvature. However, there are many cons to surgery: Once fused, the "arthritis time clock" begins, recovery period is lengthy and painful, many activities become unsafe for the new spinal addition, and like any surgery, it comes with many possible post and perioperative complications.

In comparing the long-term effects of bracing and surgery, we find a landslide of a difference between the two. While bracing has little potential of long-term complications, surgery has many. In every case of spinal surgery there is an irreversible loss of the normal active range of movement in the spinal column. Furthermore, the rigid post-surgical spine puts a lot of strain on the un-fused portion of the vertebral column, which often causes post-surgical degenerative changes and may be a cause for re-operation. Severe back pain after surgery is usually an indicator that a re-operation is needed. Infections and inflammations have been known to appear as early as days to as late as eight years after a spinal surgery. The causes for these infections range from instruments being left in the body (which can be a cause for a second surgery to remove the instruments) to transmission during a blood transfusion and many other reasons in between. Although a rarity, there have been reports showing that the patients received HIV (or other diseases) from blood transfusions because of negligent surgeons. It is possible that rods or anchors can break or loosen, initiating the onset of curvature progression. Although the bulk of surgeries do not have complications that are severe enough to call for a follow up operation, nevertheless, the risks are high.

CRITERIA FOR TREATMENT

Determining the specific treatment for a patient is based on the patient's age, curve flexibility or curve magnitude. The first factor mentioned, age, is really a reference as to whether or not the patient has reached a level of skeletal maturity. Factually, scoliosis increases rapidly during general skeletal growth and most rapidly during the adolescent growth spurt (Lyons et al. 1999). Therefore, doctors must determine in younger patients how far they are from skeletal maturity. Young children, naturally, are significantly far from full skeletal maturity and are therefore almost always braced if their curves call for non-operative treatment. Adolescents must be carefully analyzed as to whether they would be a candidate for bracing based on their skeletal growth. Actual age can also be a factor when it becomes a health issue like being too old to tolerate surgery; most often, though, it is considered for younger patients.

Skeletal maturity is based on a scale called the Risser Sign named after Dr. Joseph Risser. In 1958 Dr. Joseph Risser made an important observation while looking at X-rays of the pelvis of an adolescent with scoliosis. He recognized that as the growth plate on top of the pelvis completed growing, it changed from cartilage to bone. Bone would first appear at the outer border of the growth plate and then

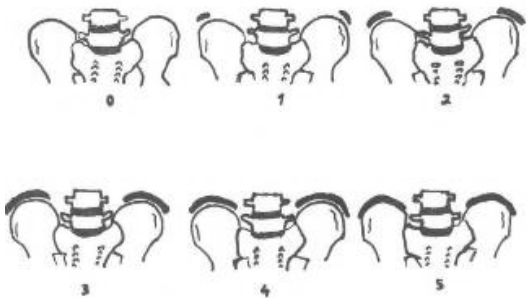

Figure 7:
Risser Signs.
Source:http://journals.tums.ac.ir/upload_files/pdf/11901.pdf

progress inwards as growth neared completion. After two years the X-ray showed that this bone had become like a "cap" on top of the pelvis. This signified that when a bone first appears a prediction can be made that an average growth of 2 years remains. The cap can then be followed like the hands of a clock from the outer aspect of the pelvis inward (Figure 7). Risser divided the appearance of this bony cap into 4 sections; when 25% of the bony cap can be seen on X-ray it is described as Risser 1, 50% is Risser 2, 75% is Risser 3and 100% is Risser 4. The final stage, Risser 5, is when the space between the cap and the pelvis fills in completely with bone (Skeletal Age 2010).

Most physicians agree that by the time "Risser 3" has occurred, the patient has passed the peak of his/her "growth spurt", a period of rapid spinal growth during which scoliosis curves can increase rapidly. To recap, during development, the iliac apophysis first appears laterally and grows medially. The stages are Risser 1 through Risser 5, where Risser 5 denotes that the apophysis has completely fused with the iliac crest and therefore skeletal maturity can be assumed (Skeletal Age 2010).

Curve magnitude is a factor that is equally, if not more, important than determining skeletal maturity. Measured in degrees, the curve magnitude combined with the Risser sign aids doctors in determining the proper treatment for patients. For curves of 20-29 degrees, some doctors will continue observation and if the curve progresses they will then recommend a brace. Bracing cannot totally fix a vertebral curve but only slow down the progression of one (Lange et al. 2009). Occasionally, bracing is used by adults with scoliosis to ward off back pain or just for straightening posture, since surgery may not be recommended for these older patients due to osteoporosis, arthritis or other health reasons. Additionally, younger patients with scoliosis whose conditions are not severe enough to require bracing will sometime turn to back bracing to reduce poor posture or to relieve muscle pain (Aulisa et al. 2010).

When determining whether a patient is a candidate for surgery, the same criteria that are used in bracing are examined, namely the age (skeletal maturity), flexibility of spine and degree of curvature. Age and skeletal maturity can affect a scoliosis surgery done at too young of an age. If a patient goes through a fusion at a young age, the vertebrae might "weld," causing it to no longer grow in length with the rest of the body. That is why surgery is reserved for older teens with progressive curvature degrees over 40 and pre-teens with even more severe curves.

CONCLUSION

In conclusion, determining the proper from of treatment for any scoliosis patient is a multistep process. First, the specific type of scoliosis must be determined by a physician and then the potential treatment options can be discussed based on factors like age and health. Next, in making a decision to begin orthotic treatment for any scoliosis case (juvenile or adolescent), a family has to consider the psychosocial effects, body image concerns and lifestyle changes that may affect the patient. Depending on all these factors, the family and physician will together decide on the proper form of brace treatment that will benefit the patient best. Not all forms of bracing can be used for any patient (although there is overlap) and not all have an equal success rate. If the curvature of the patient is too severe for bracing to be an option, there are still many different surgeries that can be performed. The family also must be aware of all of the concerns and complications that can come with any surgical procedure. Both bracing and surgical procedures in general

have positive effects on correcting the scoliosis curvature and complications are not commonly found in either.

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