Scoliosis

Introduction

A spine with scoliosis has abnormal curves with a rotational deformity. This means that the spine turns on its axis like a corkscrew. Compare the more subtle curve of the normal spine to the severe curvature of the scoliotic spine.

Scoliosis is a curvature of the spine which may have its onset in infancy but is most frequently seen in adolescence. It is more common in females by a 2:1 ratio. However, when curves in excess of 30 degrees are evaluated, females are more frequently affected by a ration of approximately 8-10:1.

Anatomy

Scoliosis is a three-dimensional curvature of the spine. It may develop as a single primary curve (resembling the letter C) or as two curves (a primary and compensating secondary curve that form an S shape). Scoliosis may occur only in the upper back (the thoracic area) or lower back (lumbar), but most commonly it develops in the area between the thoracic and lumbar area (thoracolumbar area).

Scoliosis is often categorized as structural or nonstructural. In structural scoliosis, the spine not only curves from side to side, but the vertebrae also rotate, twisting the spine. As it twists, one side of the rib cage is pushed outward so that the spaces between the ribs widen and the shoulder blade protrudes (producing the rib-cage deformity, or hump); the other half of the rib cage is twisted inward, compressing the ribs. A nonstructural curve does not twist but is a simple side-to-side curve. Other abnormalities of the spine that may occur alone or in combination with scoliosis include kyphosis (an exaggerated backward rounding of the spine, the so-called hunchback) and hyperlordosis (an exaggerated forward curving of the lower spine, also called swayback).

The physician attempts to define scoliosis by the location, direction, and magnitude of the curve, and, if possible, its cause. The location of a structural curve is determined by the particular apical vertebra, the bone at the apex, or highest point, in the rib cage hump; this particular vertebra will also have undergone the most severe rotation. Direction of the curve in structural scoliosis is

determined by whether the convex (rounded) side of the curve bends to the right or left. For example, a physician defines a certain case as right thoracic scoliosis if the apical vertebra is in the thoracic (upper back) region of the spin and the curve bends to the right. The magnitude of the curve is determined by taking measurements of the length and angle of the curve on an x-ray view.

The severity of scoliosis is diagnosed according to the curve and by the angle of the trunk rotation (ATR). The two factors are usually related, so that, for example, in a person with a curve of 20 degrees the trunk usually has rotated at an ATR of 5 degrees. Scoliosis is diagnosed when the curve measures 11 degrees or more, but treatment is not usually required until the curve reaches 30 degrees and the ATR is 7 degrees.

Causes In 80% of patients, the cause of scoliosis is unknown. Such cases are called idiopathic scoliosis, and they account for about 65% of the structural form of scoliosis. Most cases of idiopathic scoliosis have a genetic basis, but researchers have still not identified the gene or genes responsible for them. Some experts are looking at inherited imbalances in perception or coordination that may relate to asymmetrical growth in the spine of some children with scoliosis. Other researchers are investigating a possible defective gene responsible for production of fibrillin, an important component of connective tissue, which makes up bones and muscles. A very rare genetic disease called familial dysautonomia has been identified as a cause of scoliosis in Jewish children of Ashkenazi descent. (It should be noted that only 500 cases have been reported.) One study showed a higher incidence of abnormally high arches in the feet in people with idiopathic scoliosis, suggesting that altered balance may be a factor in certain cases.

Investigators are also looking at enzymes known as matrix metalloproteinase, which is involved in repair and remodeling of collagen, the critical structural protein found in muscles and bones. In high levels, however, the enzymes can cause abnormalities in components in the spinal discs, contributing to disc degeneration. Some researchers have found high levels of the enzymes in the discs of patients with scoliosis, which suggests that the enzymes may contribute to curve progression.

Birth defects are known to cause scoliosis, including spinal bifida or myelomeningocele (a hernia of the central nervous system that can also cause hydrocephalus). Scoliosis may also be a result of muscle paralysis or deterioration from diseases such as muscular dystrophy, polio, or cerebral palsy. Other diseases that can cause scoliosis are Marfan's syndrome, rheumatoid arthritis, and osteogenesis imperfecta. Injury to the spinal cord may also cause scoliosis.

Nonstructural scoliosis is sometimes caused by poor posture, differences in leg length, and muscle spasms. Tumors, growths or small abnormalities on the spinal column may play a larger role than previously thought in the causes of scoliosis in small children. Back surgery, known as laminectomy, for removal of benign tumors increases the risk for spinal deformity.

Symptoms

Scoliosis is usually painless. Often the curvature itself may be too subtle to be noticed by even observant parents. Some may notice abnormal posture in their growing child that includes a tilted head, protruding shoulder blade, and one hip or shoulder that is higher than the other, causing an

uneven hem or shirt line. The child may lean more to one side than another. With more advanced scoliosis, fatigue may occur after prolonged sitting or standing. Curves caused by muscle spasms or growths on the spine can sometimes cause pain. Nearly always, however, there are no symptoms for mild scoliosis, and the condition is usually detected by the pediatrician or during a school screening test

Diagnosis

Screening

Screening programs for scoliosis, which began in the 1940s, are now mandatory in middle or high schools in many states. The American Academy of Orthopaedic Surgeons recommends that girls be screened twice, at ages 10 and 12, and that boys be screened once at 13 or 14. Older teenagers may need to have repeat screening tests; one study showed that over 40% of sophomores with newly diagnosed scoliosis had shown no signs of the disorder in earlier screening tests. The American Academy of Pediatrics recommends scoliosis screening at ages 10, 12, 14 and 16 years. In 1993, however, the U.S. Preventive Services Task Force issued a recommendation against routine screening to detect adolescent scoliosis. Experts on the task force argued that screening tests are not accurate and depend too much on the skill of the examiner. An Irish study reported that early diagnosis and treatment did not reduce the severity of scoliosis or surgeries. Schools often refer to physicians children with minor curves who are not at any risk for a progressive or serious condition, and such over-referrals add considerably to the costs of the health system. It also led to early treatment, usually braces, which at the time of the recommendation had not yet been proven effective.

Other experts argue that universal screening is useful for producing information on scoliosis that may eventually lead to knowledge of its cause and ways to prevent it. They maintain, further, that such wide-spread screening would be cost effective if schools had reasonable guidelines to use for determining which children should see a physician for further testing. A diagnosis of scoliosis is based on the degree of the curve and the angle of the trunk rotation (ATR). A 20 degree curve with a 5 degree trunk rotation used to be the criteria for recommending treatment, although it is now known that up to 80% of 20-degree curves do not get worse. Some experts recommend that reasonable guidelines would be to refer to a physician only children with a 30-degree curve; those with curves between 20 and 30 degrees would be screened every six months. Such guidelines would detect about 95% of all genuinely serious cases while referring only 3% of all children tested, thereby cutting costs without jeopardizing children. The final argument for universal screening is that braces have been proven to be effective since the task force's recommendation, and early treatment can be important.

Forward Bend Test

The screening test most often used in schools and in the offices of pediatricians or primary care physicians is called the forward bend test, in which the child bends forward dangling the arms, with the feet together and knees straight. The curve of structural scoliosis is more apparent when bending over, and the examiner may observe an imbalanced rib cage, with one side being higher than the other, or other deformities. The forward-bend test is not sensitive to abnormalities that occur in the lower back, which is a very common site for scoliosis.

Other Physical Tests

The patient is usually requested to walk on the toes, then the heels, and then is asked to jump up and down on one foot. Such activities indicate leg strength and balance. The physician will also check for tight tendons in the back of the leg, which is usual in adolescence but may also indicate nerve root irritation or spondylolisthesis, a condition in which one vertebra has slipped forward over the other. The physician will also check for neurologic impairment by testing reflexes, nerve sensation, and muscle function.

Inclinometer (Scoliometer)

An inclinometer (Scoliometer) measures distortions of the torso. The patient is asked to bend over, with arms dangling and palms pressed together, until a curve can be observed in the thoracic area (the upper back). The Scoliometer is placed on the back and used to measure the apex (the highest point) of the curve. The patient is then asked to continue bending until the curve in the lower back can be seen; the apex of this curve is then measured. The measurements are repeated twice, with the patient returning to a standing position between repetitions. The results of the Scoliometer can indicate problems, and some experts believe it would make a useful device for widespread screening. Scoliometers, however, measure rib cage distortions in more than half of children who turn out to have very minor or no sideways curves. Scoliometers are not accurate enough to guide treatment, and, if results show a deformity, x-rays need to be performed.

Diagnosing Scoliosis

Proper diagnosis is important, since a misjudgment can lead to unnecessary x-rays and stressful treatments in children not actually at risk for progression. Unfortunately, although measurements of curves and rotation are useful, no test exists yet to determine whether a curve will progress.

X-Rays

If screening indicates scoliosis, the child may be sent to a specialist who takes an initial x-ray and monitors the child every few months using repeated x-rays. X-rays are essential for an accurate diagnosis of scoliosis. They reveal the degree and severity of scoliosis and also identify any other spinal abnormalities, including kyphosis (hunchback) and hyperlordosis (swayback). By showing certain features of the bones, they also help the physician determine whether or not skeletal growth has reached maturity. X-rays of forward-bending patients can also help differentiate between structural and nonstructural scoliosis. Structural curves persist when a person bends over, and nonstructural curves tend to disappear (although nonstructural scoliosis caused by muscle spasm or spinal growths may sometimes reveal an exaggerated curve). In children and young adolescents who have mild curves or in older adolescents who have more severe curvatures but whose growth has stopped or slowed down, x-rays should be performed every few months in order to detect increasing severity. Because frequent x-rays may be required on young children, parents should see that x-ray technicians take all necessary protective methods. Studies have reported an increased risk for cancer in women and men who, because of scoliosis, had been exposed to diagnostic x-rays in their childhood and adolescence. It should be noted that such women were diagnosed before 1965, and since then x-ray techniques have become safer, although experts are still concerned about the long-term effects of radiation on sensitive young

organs, particularly about a possible increase in the risk for cancer. Some experts believe the risk can be reduced considerably if the x-ray beams are directed through the patient from back to front, rather than the reverse. Some protective measures include a filter for the x-ray tube that absorbs some of the beam, and the use of fast film, which can reduce exposure by two to six times. Lead aprons or shields should always be worn over parts of the body that are not being examined.

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is an advanced imaging procedure that does not use radiation, as x-rays do, but it is expensive and many experts believe it is not needed for diagnosing scoliosis. Some studies indicate, however, that there may be a higher than normal percentage of spinal cord and brain stem abnormalities in children thought to have idiopathic scoliosis. Such abnormalities can only be identified using MRI. It also may be particularly useful before surgery for detecting potential complications.

Calculating the Curve

The degree of the curve is nearly always calculated using a technique known as the Cobb method. On an x-ray of the spine, the examiner draws one line extending out and up from the edge of the top vertebrae of the curve and another extending out and down from the bottom. A perpendicular line is then drawn between the two lines, and the intersecting angle is measured to determine the degree of curvature. The Cobb method cannot fully determine the three-dimensional aspect of the spine and so is not as effective in defining spinal rotation or kyphosis. It also tends to over-estimate the curve and so should be used with other diagnostic tools to make a more accurate diagnosis. A new technique using calculations based on geometric principles of the apex of the curve as well as the top and bottom of the curve may prove to be accurate in determining all the dimensions of the curve. Even if the curve is accurately calculated, however, it still remains difficult to predict whether the scoliosis will progress.

Determining Skeletal Maturity

It is important to determine how much more the child will grow in order to predict the curve's progression. In addition to the child's age, certain predictive methods have been developed. One method is called the Risser sign, which grades the amount of bone growth in the area at the top of the hipbone. A low grade indicates that the skeleton still has considerable growth; a high grade means that the child has nearly stopped growing and the curve is unlikely to progress much further. The Risser scale differs between genders and in boys a high grade does not always signify the end of progression.

Alternative Noninvasive Diagnostic Techniques

Researchers are investigating many noninvasive diagnostic methods that can be used as alternatives to costly and potentially hazardous x-rays. These techniques are designed to measure the rotation of the rib cage hump, or deformity. The severity of this three-dimensional rotation is presumed to relate to the severity of the two-dimensional side-ways curve as calculated using the Cobb method. If one or more of these noninvasive diagnostic techniques prove to be as accurate as standard methods in determining the disease stage, they may eventually replace some of the x-

rays used currently to monitor the progression of scoliosis. To date, these techniques appear to be fairly accurate for detecting scoliosis in the upper back (the thoracic region) but not scoliosis in the lower back (the lumber region).
One such technique uses an instrument called the back contour device, which is a level frame that is placed on the back of a forward-bending patient. Rods, inserted through the frame, pass close to points on the hump of the back. Measurements are recorded of the apex (the highest point) of the curve and the point of severest rotation. They are then entered into a computer program that calculates the degree of trunk rotation. The procedure may prove accurate for thoracic scoliosis, but it does not seem beneficial for lumbar scoliosis. It also appears to provide results similar to a Scoliometer, a simpler screening tool.

Treatment

Surgical Treatments for Scoliosis
Surgery is almost always recommended for anyone whose curve exceeds 50 degrees and for growing children whose curve has gone beyond 40 degrees. For children whose scoliosis is due to inborn abnormalities, the younger they are when surgery is performed, the better their chances for success. It should also be performed as early as possible for children with multiple physical handicaps; older children who have surgery tend to experience improved well being from the changes in their appearance, even if they have no actual improved physical functioning.

General Description
The goals of scoliosis surgery are to straighten the spine as much and as safely as possible, to balance the torso and pelvic areas, and to maintain correction. These goals are accomplished by fusing (joining together) the vertebrae along the curve and supporting these fused bones with instrumentation -- steel rod, hooks, and other devices attached to the spine. Many variations exist. One Minnesota study reported that for some children instrumentation without fusion may be effective, but more research is needed to determine which patient would be appropriate for this more limited operation. All of the operations require meticulous skill. A number of variations on scoliosis surgery exist, using different instruments and procedures; in most cases, however, success depends less on the type of operation than on the skill and experience of the surgeon. Parents of patients or adult patients should not be shy in asking the surgeon and hospital about their experience with specific procedures being considered.

Preoperative Care
Before the operation, a complete physical examination is conducted to determine leg lengths, muscle strength, lung function, and any postural abnormalities. The patient is trained in deep breathing and effective coughing to avoid lung congestion after the operation. Patients are encouraged to donate blood before the operation for use in possible transfusions. In one study, erythropoietin (rhEPO) was given to patients before the procedure. RhEPO is a hormone that acts in the bone marrow to increase the production of red blood cells. Patients who were given this hormone, particularly those with idiopathic scoliosis, needed fewer transfusions and spent less time in the hospital than those who did not receive rhEPO.

Fusion
All scoliosis operations involve fusing the vertebrae, but the instruments and devices used to

support the fusion vary (see Instrumentation below). Fusion is done by first slicing flaps to expose the backs of the vertebrae that lie along the curve and then removing the processes -- the bony outgrowths along the vertebrae that allow the spine to twist and bend. The surgeon lays matchstick sized bone grafts vertically across the exposed surface of each vertebra, being careful that they touch the adjoining vertebrae. The flaps are then folded back to their original position, covering the bone grafts. These grafts will regenerate and fuse the vertebrae together.

Bone grafts are usually "autografts" that is, they are taken from the patient's hip, spine, or other bones; researchers are also investigating "allografts", which are bone grafts taken from another person. Because autografts are taken from the patient, the operation is longer and the patient may experience more pain afterward than if allografts are used. Allografts, however, pose an increased risk for infection from the donor. Longer studies are needed to determine the seriousness of this risk. Investigators have been testing a ceramic material made of tricalcium phosphate (Biosorb) for grafts; in one comparative French study, these synthetic grafts were resorbed by the original bone in two years, while x-rays still showed evidence of the donated bone graft. Correction loss was also better with the synthetic materials, which also eliminate the risk for viral infections.

The healed fusions harden in a straightened position to prevent further curvature, leaving the rest of the spine flexible. It takes about three months for the vertebrae to fuse substantially, although one to two years are required before fusion is complete. At that point, the steel rod is not really necessary, but it is almost always left in place unless infection or other complications occur. Fusion stops growth in the spine, but most growth occurs in the long bones of the body, so the patient will most likely gain height from growth in the legs as well as from the straightened spine.

Instrumentation

Harrington Procedure
Until ten years ago, the standard instruments used in fusion procedures were those of the Harrington procedure, first developed in the 1960s. To support the impending fusion of the vertebrae, the surgeon uses a steel rod, extending from the bottom to the top of the curve. (More than one rod may be used depending on the type of curve and whether kyphosis is present.) The rod is attached by hooks that are suspended from pegs inserted into the bone. Similar to changing a tire, the steel rod is jacked up and then locked into place to support the spine securely. The surgeon is then ready to fuse the vertebrae together.

After this operation, patients are required to wear a full body cast and lie in bed for three to six months until fusion is complete enough to stabilize the spine. The Harrington procedure is very difficult to undergo, particularly for young people, and although the operation can achieve a correction of the curve of over 50%, studies have reported a loss in this correction of between 10% to 25% over time. The procedure does not correct the rotation of the spine and, therefore, does not improve an existing rib hump that was caused by the rotation. The operation does not interfere with normal pregnancies and deliveries later in life. Because the procedure has only been used since the 1960s, however, it is not known whether the rods will last for an individual's lifetime.

About 40% of Harrington patients have a condition called the flat back syndrome, because the procedure eliminates normal lordosis (the inward curving of the lower back). Flat back syndrome does not cause any pain, but in later life the discs may collapse below the fusion and cause

difficulty in standing erect. In some cases corrective surgery called closing wedge osteotomy may be needed, in which wedges of bone from the fused mass are removed and spaces are closed to restore a curve. In children under eleven whose skeleton is immature and who have the Harrington procedure, there is a fairly high risk for curve progression called the crankshaft phenomenon. In one study that followed patients for between five and 16 years, progression was moderate, however, with the Cobb angle averaging 9* and rotation averaging is 7*.

Cotrel-Dubousset Procedure

The Cotrel-Dubousset procedure not only corrects the curve but may also help to correct rotation, and it does not cause flat back syndrome. With this procedure, parallel rods are cross-linked for better stability in holding the fused vertebrae. Improvement in correction averaged 66% in one study, with a later correction loss reported to be 5%. (Other studies have reported loss of curvature correction at less than 2%.) Over 95% of patients reported the results to be good or very good (only 86% of patients who had the Harrington procedure experienced the same levels of satisfaction.) Patients often go home in five days and may be back in school in three weeks. Operation time and blood loss are greater than with Harrington procedure, but complication rates are similar. Cotrel-Dubousset and other procedures that are designed to reverse the rotation of the spine have less risk for flat back syndrome but they have a higher risk for spinal imbalance than the Harrington procedure. Studies have reported that five to seven years after their surgery between 20% and a third of patients have low back pain. (In one study only 3% had experienced back pain before surgery). In such cases, however, the pain was not severe enough to interfere with normal activities and did not require additional surgery. The procedure does not eliminate the risk for disc deterioration later on; in one study follow-up study, indications of disc deterioration occurred in nearly a quarter of the patients. New implants that use a locking wedge to improve stabilization of the spine are being tested.

Other Instrumentations

Other instrumentation procedures have refined the hardware used in the Harrington and Cotrel-Dubousset operations. The Texas Scottish-Rite instrumentation (TSRH) is similar to the Cotrel-Dubousset procedure in that it uses parallel rods and other devices that reverse rotation as well as improve curvature. The instruments, however, use smooth rods and hooks that are designed to make removal or adjustment easier later on if complications arise. Complications are similar to the Cotrel-Dubousset procedure. Another technique to prevent rotation is the Wisconsin segmental spine instrumentation (WSSI). Luque instrumentation was developed to help maintain normal lordosis and experts hoped that bracing would not be needed afterward with this device. A number of studies showed, however, that without braces correction was lost after this operation, and there also may be a higher risk for spinal cord injury than with standard procedures. Luque instrumentation is used primarily in people whose scoliosis is due to problems of nerves and muscles.

The use of a device called a pedicle screw to stabilize the fused spine is now being used and, after early high complication rates, is now proving to be reliable and effective. A 1997 European study reported that complication rates were now acceptable and there is a very low risk for neurologic injury.

Approaching the Patient through the Back or Chest

Posterior versus Anterior

Generally, surgeons who operate have used a posterior approach for scoliosis; that is, they reach the area by opening the back of the patient. An alternative is the anterior approach, meaning that the surgeon operates through the chest wall, rather than entering through the back. The surgeon makes an incision in the chest, deflates the lung, and removes a rib in order to reach the spine. (This rib may be used during the operation as a strut to support the spine.) A two-stage procedure uses both posterior and anterior approaches. Because the frontal approach allows the procedure to be performed higher up in the spine than with standard procedures, the patient may have less risk for lower-back injury later on. Studies are showing better correction and function with the anterior approach than with posterior approaches alone. Transfusion rates are also much lower with the anterior approach. A 1997 study reported that the anterior approach was safe and serious complications were rare, although about 46% of patients experienced minor problems. The risk for such problems was significantly increased in smokers. Another study reported that the procedure using both the posterior and anterior approach was associated with a higher risk for neurological complications, which, however, improved over time.

Anterior Endoscopy

A promising, but still very experimental procedures, uses endoscopic techniques. Endoscopy is far less invasive than the standard approaches because it employs only a few small incisions. The surgeon inserts tubes through the incisions that contain tiny instruments and cameras by which to view the procedure. In most cases, endoscopy is used during a two-stage procedure. Endoscopy is employed first with an anterior approach to remove disc material and loosen the spine. In a second stage, a posterior approach is made for fusion and instrumentation. Researchers are now investigating whether anterior endoscopy can be used to perform the complete operation. To do this, researchers have had to design new instrumentation that can be inserted through the small incisions. One center reported that correction was good and that its patients had a much earlier and easier recovery than with the more invasive approaches. The procedure also fuses fewer spinal segments so that spinal mobility is better than with the posterior approach. The endoscopic procedure is complicated, however, and it is not yet known if fusion with this procedure or other long-term effects are comparable to standard procedures. At this time, endoscopy is being used generally for curves in the upper back because it is easiest, but researchers are also devising endoscopic techniques to use on the lower back.

Nonsurgical Treatments for Scoliosis

Treatment for scoliosis has undergone major changes over the past decade and a number of options are available. The general rule of thumb for treating scoliosis is to monitor the condition if the curve is less than 20 degrees and to consider treating curves greater than 25 degrees or those that progress by 10 degrees while being monitored. Whether scoliosis is treated immediately or simply monitored depends on many factors, including the age, gender, and general health of the patient, and the severity and location of the curvature. For example, a young man of 18 who has a curvature of 30 degrees may require no treatment because his growth has probably almost stopped and his gender puts him at lower risk. A young girl of 10, however, with the same curvature requires immediate treatment. Although braces are recommended for moderate curves and surgery for more severe ones, the decision may not be so straightforward.

Braces

For moderate curves of 24 to 40 degrees, a brace is often used to prevent further curvature. A full torso brace called the Milwaukee brace was standard treatment until a decade ago and is still used. The device uses a wide flat bar in front and two smaller ones in back that attach to a ring around the neck that has rests for the chin and back of the head. One study determined that lying on the chest when the brace is worn is the best position for correcting the curve; researchers then suggested that increasing the tension on the chest straps might add benefit. The brace is periodically adjusted for growth. The brace needs to be worn 23 hours a day with relief only during bathing and exercise. Newer, molded braces called thoracolumbar-sacral orthoses (TLSOs or the Boston brace) come up to beneath the underarms and can be fitted to be worn close to the skin so that they don't show under clothes. Patients are still urged to wear these braces 20 hours a day; although wearing them for 16 hours a day may still be beneficial, the risk for curve progression is significantly higher when patients wear braces for less time. The Charleston Bending Brace is worn only at night, although some physicians question its value. In one study, 66% of patients improved and 17% progressed to the point where they needed surgery.

Compliance is a major problem. In one study, only 15% of patients wore the Milwaukee brace as directed. This brace is particularly difficult to endure. One woman who had worn it for seven years during adolescence remembered herself as being invisible at school, ignored and shunned by other children. Young people often refuse to wear even the newer braces, and emotional support from the family and professionals is extremely important to help a child accept the process and sustain compliance. Even TLSOs can cause difficulties; they are hot, reduce lung capacity by 18%, and cause mild, temporary changes in kidney function.

A team approach, with several health professionals involved, is usually beneficial and often necessary to support the patient through the bracing process. An orthopedic surgeon interprets the x-rays, assesses the potential progression of the scoliosis, and plans the treatment with the patient and family. If a brace is used, an orthotist measures and fits the patient with the device. A physical therapist plans the exercise program best suited for the patient. A nurse may also be involved to coordinate the treatment plans and provide physical and emotional support.

It is important to note that a brace will almost never reverse an existing curve. It is only used to stop its progression, and many experts have questioned whether a brace is any better than nature in halting the progress of a curve. Early studies found braces successful in only half the cases. A major analysis of studies, however, reported no significant curve progression for the following groups: in 93% of patients who wore braces for 23 hours a day; in about 60% who wore them for eight or 16 hours a day; in half of patients who had no treatment; and in only 40% of patients receiving electrical stimulation (see below). Those who wore the Milwaukee brace had the best outlook; 99% of these patients had no significant progression. A 1996 study that followed 111 young patients who had stopped wearing the Milwaukee brace found that scoliosis progressed by an average of 4 degrees after six years in those who did not have surgery, and almost half of these patients had curvatures that progressed by over 5 degrees. The brace appears to be helpful in correcting a side-to-side curve but has little effect on rotation. Some experts believe that braces work only because the young patients self-correct their curves by retraining their posture to avoid the discomfort of the brace (see Biofeedback below).

Exercise

Although previous studies have not found that exercise straightens existing curves or prevents

progression, German researchers have suggested that such studies were done before specific exercises were developed that might be helpful. In their study, patients with an average curvature of 27% and Risser sign of 1.4 showed less progression after physiotherapy than that expected in patients with no treatment. Exercising the torso to build muscle strength is important, in any case, in conjunction with braces. Stretching exercises may be beneficial in children whose scoliosis is due to uneven leg lengths or a shortened tendon. For anyone, exercise has many health benefits and is important for maintaining strength and muscle tone and stabilizing weight.

For children who require braces, however, an exercise program helps their sense of well being, improves compliance with treatment, and keeps muscles in tone so that the transition period after the brace is removed is easier. Patients tend to comply with the exercise program in the period when the brace is first being used, to stop exercising when they have gotten used to the brace, and to resume exercising around the time the brace is being removed. If they have not continued this program, their backs will feel weak. One small study showed that patients who performed exercises that improved flexibility in the torso experienced less spinal twisting and had improved curvature. Exercise is important for chest mobility and proper breathing, to maintain muscle strength, especially in the abdominal muscles, and to maintain flexibility in the spine. Patients must also be taught to conduct daily activities while wearing the brace. Practicing correct posture, especially in front of a mirror, is an extremely important part of the physical therapy program. A patient who is accustomed to a curved spine may have the sensation of being crooked when first taught to properly align the spine; practicing in front of a mirror provides a reality check.
In adults with a history of scoliosis and previous surgery, moderate exercise is not harmful and is as important as it is for any person. The only cautionary note is for people with only one or two mobile lumbar vertebrae below the area that was fused during surgery. These people should avoid any activity or exercise that causes excessive twisting or heavy loads on the spine; some experts believe this may accelerate degeneration in the spine.

Other Noninvasive Treatments

Electrostimulation

Electrostimulation has been used in some cases of mild scoliosis. Electrodes are placed on the skin along the convex (rounded) side of the spine at bedtime; they send small jolts of electricity for five seconds every 30 seconds to stimulate muscles while the patient is sleeping. Although the procedure is painless, it causes the shoulder to jerk, and patients have complained about sleeplessness and irritability. A number of studies have found that electrostimulation does no better than observation in stopping progression. In one study, over half of patients needed surgery for curves, which progressed beyond 10 degrees despite electrostimulation, and a major 1994 study found that progression occurred in 70% of patients who had used this method.

Biofeedback

A so-called microstraight device uses biofeedback principles. The premise is that braces work not by pushing or pulling the spine back into place but by encouraging children to self-correct their own deformity by adjusting their body away from uncomfortable pressure. The palm-sized device hangs from a cord around the neck and is attached to two elastic cords that encircle the chest and run down the leg. If the child starts to slump, an alarm sounds, signaling the child to sit up straight.

If the sound is ignored, a louder alarm goes off. In early trials of a small group of children, some reduction in deformity was observed, but long term benefits, if any, are unknown.

Heel Lifts

In one study where scoliosis was caused by differences in leg lengths, adding lifts to the heels decreased curvature by an average of 5.3 to 7.5 degrees. (It should be noted that curvature was very mild in these cases, all under 20 degrees.) Patients with the greatest curvature experienced some muscle pain, fatigue, and even nausea during the first few days they were using the lifts, but these symptoms lessened within 10 days.