Anterior Vertebral Body Tethering for Idiopathic Scoliosis

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Scoliosis is a term used to describe an abnormal curvature of the spine which can affect approximately 2%-4% of the population. It is a complex three-dimensional deformity that is diagnosed when there is a lateral deformity of the spine of 10° or greater. The term idiopathic refers to the fact that there is no single known cause for this condition.

Idiopathic scoliosis is a progressive disease with a rapid onset and the most common form of scoliosis seen by orthopedic surgeons. How idiopathic scoliosis evolves is usually determined by the site of the primary curve. Significantly, the thoracic area is the most common site for primary curvature. It is also one of the most severe forms.

Dr. J. I. James, in his article; "Idiopathic Scoliosis; the Prognosis, and Operative Indications Related to Curve Patterns and the Age of Onset," developed a system for classifying the disease by age. "The true understanding of any disease is based upon a knowledge of the etiology and natural history."[1] His study also considered not only the site of the primary curvature but also the age at onset of the curve presented. He stated that though scoliosis can begin at all ages of childhood, he determined that there were three peak periods of onset. Children three years of age or younger had what he called infantile idiopathic scoliosis. Children who were 3-10

LEARNING OBJECTIVES

- List the indications for surgical intervention in the treatment of scoliosis
- Review the anatomy affected by Anterior Vertebral Body Tethering
- Compare and contrast a spinal fusion and the tethering techniques used to treat scoliosis
- Identify the considerations given when determining to treat this condition
- Recall the procedural steps for performing an AVBT

years old had juvenile idiopathic scoliosis. And finally, children who were 10 years or older had adolescent idiopathic scoliosis.[1]

ETIOLOGY

The exact etiology of idiopathic scoliosis has yet to be determined, however, there are a few common theories. One says it may be the result of a primary muscle disorder. Another theory states that an abnormal fibrillin (a protein in connective tissue) metabolism could be a cause.

And yet a third theory says that the skeletal growth in the patient has been disorganized, leading to a cascading Hueter-Volkmann effect. The Hueter-Volkmann Law is generally used to explain the mechanism of scoliosis. Due to the physiologic curvature of the normal thoracic spine, compressive force is delivered on the ventrally located part of the vertebral column, whereas distractive force is delivered on the dorsally located portion of the spine. This process, leading to an abnormal spinal curvature, is thought to be initiated by the rotation of vertebral bodies in the axial plane. This can cause discrepant axial loading between the ventrally and dorsally located portions of the involved vertebrae. Over time, the discrepancy manifests as a change in the directionality of spinal curvature; that is, the ventrally located part of the vertebral column becomes the concave side and the dorsally located part becomes the convex side of a lateral curve.[3] As a result, compression exerted on the vertebral growth plates at the predetermined concave side of curvature causes growth to slow, while traction exerted on the growth plates at the predetermined convex side of curvature causes growth to accelerate.

CLINICAL PRESENTATION

Patients with idiopathic scoliosis have a marked deformity and an obvious asymmetry of the shoulders, waist and/or rib cage. Typically painless, some patients have experienced scoliosis-related pain.

One of the most common screening methods for determining the presence of scoliosis is having the patient perform the Adams Forward Bending Test. This is a simple, painless screening test where the patient stands with his or her hands at their side. They are instructed to bend forward at the waist with their hands reaching towards the floor. In this position the spine is more visible, making it easier to identify and locate any abnormalities. The surgeon will also place a scoliometer on the patient's back to measure the degree of tilt in the area of the curvature.

TREATMENT

The most conservative nonoperative approach in the treatment of scoliosis is for the patient to wear a brace. The brace, which is made of plastic, is worn under clothing. It sits under the arms, around the rib cage and lower back, and hips. Bracing will not cure or reduce the curves, but it does prevent the curves from becoming more severe.[4]

SURGICAL INTERVENTIONS

The indications for surgical intervention in the treatment of scoliosis are:

- Correcting severe curvature
- Cosmesis
- Associated thoracic lordosis (excessive inward curvature)
- Associated pain development

Surgery becomes an option in patients whose curvature is 45° or higher. The most common procedure for scoliosis involves a large incision with extensive soft tissue damage and the placement of dual rods along the spinal column along with a spinal fusion.

Prior to surgery, the surgeon will explain the procedure and will comment on the risks associated with spinal surgery and general anesthesia. They will discuss the advantages and any disadvantages of using the tether to allow an informed consent to be granted.

Anesthesia is administered while the patient is on a stretcher in the OR. Once an endotracheal tube has been placed and secured, the patient is rolled onto the operating

INSTRUMENTATION AND SUPPLIES

The instrumentation used for this procedure consist of:

- Basic orthopedic instrument set
- Laparoscopic instruments
- Thoracic kit (on standby)
- Tethering instrument sets
- Retractor kit (on standby)
- Omni retractor (used with lumbar curvatures)
- Electrocautery surgical unit
- Bipolar sealer using radiofrequency with saline irrigation

X-ray: Provided by Dr. J. Braun

room table in the prone position. A midline incision is performed with exposure of the spinal column. Screws and dual cobalt steel rods are placed.

A new approach to scoliosis surgery is the Anterior Vertebral Body Tethering (AVBT). AVBT is a fusion-less surgical option where, instead of dual rods, a flexible cord is placed along the convex side of the curvature. It is indicated for skeletally immature patients that require surgical treatment to obtain and maintain correction. This cord, known as a tether, is seated in anchors which have been placed on the outside portion of the curve. Tension is placed on the tether thereby initially straightening the curvature of the spine, allowing the inner portion of the curve to grow. The tether continues to correct the curvature as the adolescent grows.[5] The spine is still able to bend and flex, rather than being fixed in place with the metal rods needed for spinal fusion.

This new technique is a minimally invasive procedure aimed at decreasing operative mortality, optimizing a patient's recovery time, and maintaining spinal motion, as it does not involve any fusion of the spine.

The comparison between a spinal fusion and the tethering procedure can be seen in the following chart.

Fusion	Tether
• Immobile	• Flexible
• Late adolescence	• Done at earlier age
• Does not grow with patient	• Patient's growth increases straightening of curve
• Large incision	• 3-4 small incisions
• May require further surgery	• Allows for future fusion, if needed
• Possible spinal/nerve damage	• No long-term data available
• Long recovery period	• Shorter recovery time

The tethering system used in this procedure has been granted a Humanitarian Device Exemption by the Food and Drug Administration (FDA) in 2019. This system has been authorized by federal law for use in the treatment of skeletally immature patients that require surgical treatment to obtain and maintain correction of progressive idiopathic scoliosis.

For surgical placement of the tether, patients are brought into the operating room and anesthetized while on the stretcher. The anesthesiologist will introduce a double lumen endotracheal tube to provide single lung ventilation in order to adequately expose the operative site. Once safely intubated, the patient is placed in a lateral decubitus position with the thoracic curve facing upwards to expose the convex side of the deformity. Once padded and secured in place, the patient is prepped and draped in a sterile manner.

Radiographic imaging is used to confirm the levels of the spine included in the procedure. Local anesthetic of 0.25% bupivacaine with a concentration of epinephrine of 1:100,000 units is administered to the operative site. Three to four 11-mm thoracic trocars is routinely used for this procedure.

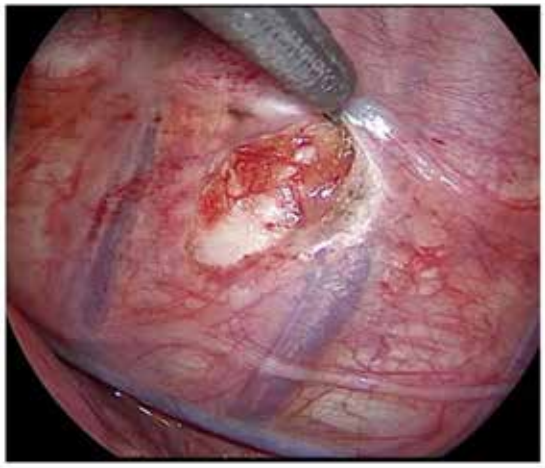

Image A

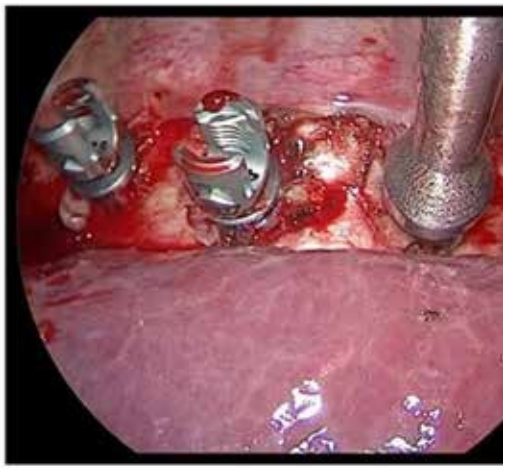

Image B

Using video-assisted thoracoscopy, the parietal pleura of the lateral spine is dissected to make sure to identify the segmental blood vessels along the way. Proper identification and visualization of the intercostal vein (Image A) is a necessary step to orient the surgeon to the anatomy. The entry points for the anchors are located using radiographic imaging. Using a 17-mm spiked awl, the exact placement of the anchors is pinpointed (Image B). A graduated pedicle probe is then used to create the insertion point and to determine the length of the anchor to be used. The hole is tapped to the 5.5-mm to fit the appropriate size anchor.

Once all the anchors are placed, the tethering cord is measured and cut to size. The body of the cord is divided into three segments. The introduction zone on either end of the cord is designed to help thread the cord to the extension spring tube and the tensioner. The working zone is for the capturing, manipulating, and tensioning of the cord. The final portion is the functional zone which is implanted in the patient.

The cord is made of polyethylene terephthalate (PET) – a chemically stable polyester that has been approved for use in medical applications.[6] Laparoscopic blunt graspers are used to seat the cord within the head of the anchor. It is secured in place with titanium alloy set screws using a T-handle screwdriver to lock the tether cord in place. Tension to the cord supplies the initial correction of the curvature. It also allows for growth modulation as the patient grows.

There are two methods used for tensioning the tethering cord. One is a sequential, or segmental tension where tension is placed on only one segment at a time. The other method is multi-segmental tensioning where tension is placed on more than one segment at a time.[7]

To apply tension to the cord, the surgeon uses the tensioner. Tension is applied to the cord by repeated pressure on the forward clip of the tensioner. The tensioner features a gauge that indicates the achieved proximal tension which varies with each patient. Once this has been reached, the excess cord can be cut using a portable cautery unit.

During the procedure neuro monitoring is routinely performed to insure there has been no nerve damage. A final radiographic image is performed to ensure the antici-

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pated results have been achieved.

A 24 Fr. chest tube is placed prior to closing. The lung on the affected side is reinflated and the incisions are closed, in layers, using braided polyester sutures, polyglactin 910 sutures and monofilament subcuticular suture. The chest tube is removed at the completion of the closure of the portals. Once a sterile dressing has been applied, the patient is rolled back onto their stretcher for extubation and reversal of anesthetic agents.

CONTRAINDICATIONS

An AVBT procedure should not be performed in patients with any of the following conditions:

- Presence of any systemic infection or skin compromise at the surgical site
- Prior spinal surgery at the level(s) to be treated
- Known poor bone quality
- Skeletal maturity
- Any other medical or surgical condition which would preclude to potential benefits of spinal surgery such as coagulation disorders, allergies to the implant materials, and patients unwilling or unable to complete the post-operative care instructions

ABOUT THE AUTHORS

Tony Forgione, CST, LPN, FAST, has over 50 years of experience as a surgical technologist. His career has spanned from the U.S. Navy where he received his operating room training, to the Massachusetts General Hospital where he continues to work. In the course of his career, he has written articles for *The Surgical Technologist*, the Journal of the Association of Operating Room Nurses and is a contributing author for *Advanced Disaster Medical Response, Manual for Providers.* Tony has also spoken at numerous AST annual conferences, as well as at conferences of the National Association of Orthopedic Nurses. He was also a surgical technology instructor for many years at Quincy College. As a member of the trauma and critical care team, Tony has been deployed to many disaster scenes around the world. He has a degree in history from the University of Massachusetts. He also remains active in AST's Massachusetts State Assembly.

Laura Anthony, CST, has been a pediatric surgical technologist at the Massachusetts General Hospital for four years. She received her training at Massachusetts Bay Community College. In addition, Laura received dual Bachelor of Art degrees in biology and dance - body science and motion.

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1. **One of the most common screening methods for determining the presence of scoliosis is:**
   a. MRI
   b. X-rays
   c. Adams Forward Bending Test
   d. CT scan

2. **The ____ area is the most common site for primary curvature when determining** idiopathic scoliosis.
   a. Thoracic
   b. Cervical
   c. Lumbar
   d. Sacrum

3. **The indications for surgical intervention in the treatment of scoliosis are:**
   a. Correcting severe curvature
   b. Cosmesis
   c. Associated thoracic lordosis
   d. All of the above

4. **Surgery becomes an option for treating idiopathic scoliosis in patients whose curvature is ___ or higher.**
   a. 15°
   b. 30°
   c. 45°
   d. 60°

5. **AVBT is a fusion-less surgical option where, instead of dual rods, a flexible ____ is placed along the convex side of the curvature.**
   a. Suture
   b. Cord
   c. Rope
   d. Plastic

6. **What is used to confirm the levels of the spine during the procedure?**
   a. X-rays
   b. MRI
   c. CT scan
   d. Radiographic imaging

7. **What are some of the benefits to using the tether option during this procedure?**
   a. It's flexible.
   b. It uses small incisions.
   c. It has a longer recovery time.
   d. Only a and b

8. **True or false: Since this new technique is a minimally invasive procedure aimed at decreasing operative mortality, optimizing a patient's recovery time, and maintaining spinal motion, it does not involve any fusion of the spine.**
   a. True
   b. False

9. **Once safely intubated, the patient is placed in a ____ position with the thoracic curve facing upwards to expose the convex side of the deformity.**
   a. Prone
   b. Lateral decubitus
   c. Supine
   d. Medial decubitus

10. **The proper identification of the _____ helps orient the surgeon to the anatomy of this procedure.**
    a. Azygos vein
    b. Parietal pleura
    c. Intercostal veins
    d. Lumbar veins

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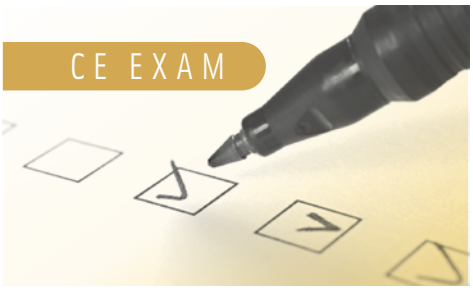

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