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Casting and Traction Treatment Methods for Scoliosis

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Casting for infantile or early-onset scoliosis

Casting for scoliosis was common until Paul Harrington introduced effective spinal instrumentation. Since then, casting largely has been relegated to history books along with racks, corsets, and other medieval implements. As its role diminished, knowledge of casting techniques disappeared, experienced surgeons passed on, and the remaining historic relics—casting tables—fell into disuse and were discarded.

To a large degree, the abandonment of casting is justified. Instrumentation is now solid and secure, provides excellent curve correction, and allows rapid mobilization and return to activity. A rigid cast can create pressure sores, significant rib or mandibular deformities, and constrict the chest. The historical term for superior mesenteric artery syndrome is "cast syndrome." Many of these problems seem to be the result of indiscriminate casting of all types of scoliosis and improper technique combined with a limited understanding of spinal, and, particularly, chest wall deformities.

We have used serial casting in a small group of our patients for several years, and our early results indicate that in selected patients and with proper technique, casting plays a useful role in our treatment armamentarium for early-onset scoliosis.

With few exceptions, we have confined scoliosis casting to patients who had infantile scoliosis and do not believe it has a role in adolescent, neuromuscular, or congenital scoliosis with the rare indications for postoperative stabilization, temporary correction, or immobilization to assess pain relief.

Scoliosis casting comes in several varieties. The most commonly used method in the United States is that of Risser [1]. Indeed, body casting in this country often is called Risser casting. Risser developed two types of casts. The initial method used turnbuckles, whereas the latter, termed a localizer cast, used a three-point mold and a pusher. Although it is possible to obtain significant curve correction with this technique, it does not account sufficiently for rotational abnormality, and, especially in younger children with flexible bones, it can cause significant rib deformities and chest constriction.

Scoliosis in young children has two classifications. The traditional classification used by the Scoliosis Research Society divides these curves into infantile and juvenile, based on whether the curve was diagnosed before or after the age of 3 years. The classification of Dickson [2] divides curves into early onset (diagnosed before age 5 years) and late onset (diagnosed after age 5 years). Dickson's logic was that curves occurring after age 5 years were less likely to result in pulmonary failure. We prefer the former classification because of Pehrsson and colleagues' [3] work showing increased mortality in the infantile and juvenile curves and because younger age of treatment, in our experience, seems to improve the results.

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Infantile idiopathic scoliosis occurs in two basic types: resolving and progressive. Mehta [4] was able to distinguish resolving scoliosis from progressive scoliosis by using the rib vertebral angle difference (RVAD) on an early supine radiograph. The RVAD nearly follows the 80/20 rule: 80% of curves with an RVAD of 20 or more continue to progress, whereas only 20% of those with lesser angles progress. This was confirmed by other investigators [5–7].

More recently, Mehta [8] described her results of casting in 136 patients who had infantile scoliosis using the technique of Cotrel and Morel [9] with the philosophy that early rapid growth, if guided by the cast, would assist an initially curved spine to straighten. She grouped her patients into four physiologic patterns: a "sturdy phenotype" with good muscle mass and tone; a "slender phenotype" with more delicate features, ligamentous laxity, and more rapidly progressive curves; those with known syndromes; and those with unknown syndromes. Her program consisted of cast changes under anesthesia in younger patients every 8 to 16 weeks until the curve was nearly resolved followed by an underarm brace that may be weaned if the patient's curve correction continues. Treatment was related to the patient's phenotype; the sturdy patients responded the best, followed by the slender phenotype, and patients with unknown syndromes responded the worst. Even more important was the age at treatment onset. Casting resulted in full correction in 94 patients, whereas 42 had only partial correction. Treatment was much more likely to be successful if started before the age of 2 years.

Dr. James Sanders learned the basic Cotrel technique from Dr. Albert Sanders and began using it on several patients presenting with progressive infantile scoliosis. The technique was developed further in conjunction with Dr. Jacques D'Astous at the Salt Lake City Shriners Hospital through study and personal instruction by Min Mehta. At the Erie Shriners Hospital, working with Dr. Joe Khoury and an excellent casting team, the technique has become effective and reproducible.

The first requirement is a proper casting table. Some hospitals still have vintage Risser or Cotrel tables, although they are a rarity. Although we initially worked on a Risser frame, the Risser frame is large for a small child. We are indebted to Min Mehta for her design of a smaller, practical frame that leaves the head, arms, and legs supported but the body free.

We have identified a few principles that we believe help to create a better cast (Box 1).

We have a routine of doing the initial casts at 2-month intervals with a schedule based upon how fast the child is growing. Typically, casts are changed every 2 months for those aged 2 years and younger, every 3 months for those aged 3 years, and every 4 months for those aged 4 years and older. It is particularly helpful to be accommodating for the families's busy schedules when booking a date for the casting. We do not know when to stop casting, but have aimed for curves nearing 10° and then proceed with brace fitting. Occasionally, children are given a brace during the summer months with resumption of casting in the fall.

Our early results show significant promise with the typical left thoracic infantile curve being the most likely to respond; however, we lack comparison with other treatment modalities (eg, bracing, growing rods, or the Vertical Expandable Prosthetic Titanium Rib [VEPTR, SYNTHES Spine, Paoli, PA]), and still requires longer follow-up prior to arriving at any definitive conclusions. As Fig. 5 shows, most patients have a significant response, particularly younger ones. The most significant failure is a girl who has Prader-Willi syndrome and a stiff double thoracic curve. Until we have further follow-up, we cannot distinguish those patients who are most likely to respond from those who are likely to fail serial casting, although Mehta's finding that younger children respond better corresponds with our experience. (Fig. 6)

Traction in early-onset scoliosis

"Despite the fact that traction is rarely used today, it does remain an important option for the treatment of children with spinal disorders" [10].

Halo-gravity traction can restore coronal and sagittal balance in severely decompensated curves and may decrease the neurologic risks associated with the surgical correction of these severe deformities, be it by casting, subcutaneous rods, VEPTR, or definitive instrumentation and fusion. Patients who have severe spinal deformities and secondary cor pulmonale may benefit from a period of preoperative traction to allow aggressive pulmonary toilet. Improvements in vital capacity, arterial blood gases, and right heart failure may decrease postoperative complications and can help with patient selection in difficult cases [11–13].

Historical background

Traction is one of the oldest methods for correction of spinal deformity, going back to

Box 1. Guidelines for applying an effective cast

One must have a casting table that stabilizes the body for the anesthesiologist while positioning the trunk and extremities for effective casting.
Light head halter and pelvic traction assist in stabilizing the patient and in narrowing the body (Fig. 1).
A mirror slanted under the table is useful for visualizing the gibbus, the posterior cast, and the molds (Fig. 2).
Traction should not be large. Although traction can correct the curve while applied, the position cannot be retained in the cast once traction is released and the body recoils. The purpose of traction is to align the trunk and narrow the torso slightly for good cast fitting.
Proper casting requires an excellent purchase on the pelvis. Without this basic foundation, the cast will slip, create sores, and fail to support the curve.
Only a small amount of padding is necessary with a well-fitting cast. Mehta uses direct plaster over crepe paper on the skin with occasional felt pads for significant bony prominences, but we use a thin layer of webril over a silver-impregnated body shirt in addition to thin layers of felt on significant bony prominences.
If there is a lumbar curve, we believe that flexion of the hips to decrease lumbar lordosis facilitates curve correction.
The cast must not push the ribs toward the spine and narrow the space available for the lung. Rather, the posteriorly rotated ribs must be moved anteriorly to create a more normal chest configuration (Fig. 3). Counterrotation is applied through the pelvic mold and upper torso or shoulders.
The original Cotrel/Morel technique uses rotational straps to obtain correction. In most young children, using one's hands works well, but we use the straps in more difficult curves, particularly of the lumbar spine.
Although the Cotrel/Morel technique and Mehta's modifications use an over-the-shoulder cast, we have had excellent success staying below the shoulders because most infantile curves have low apices, typically at T10 to T11.
Finally, well-positioned anterior and posterior windows are helpful in dynamic curve correction and cast comfort (Fig. 4).

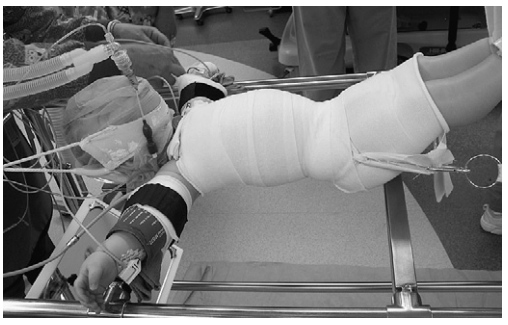

Fig. 1. A proper casting table provides good patient stability with support of the head and lower extremities, full access to the torso, and the ability to provide light traction.

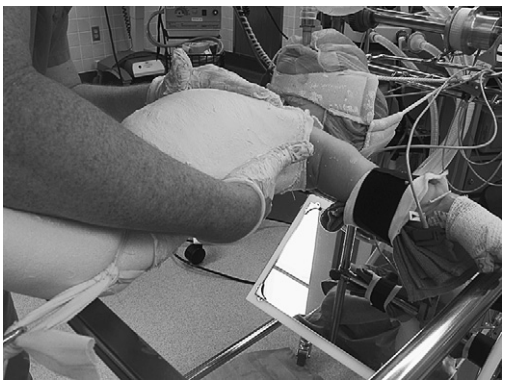

Fig. 2. Rotational correction occurs by rotating the rib or lumbar prominence anteriorly while providing counterrotation through the pelvis and upper torso or shoulders. A slanted mirror is helpful in applying correct molds.

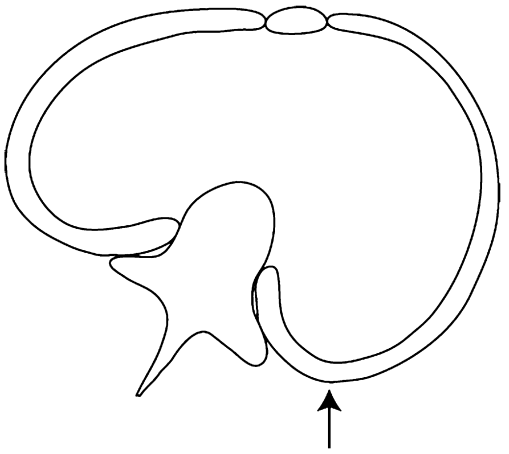

Fig. 3. The correct anterior rotation done manually or with wide straps over the prominence. Forces applied laterally will cause significant rib and chest deformity and must be avoided.

Hippocrates and possibly even earlier. Sayre described gravity-assisted traction before application of a corrective plaster cast for scoliosis in 1876. Harrington, in the 1950s, devised a form of "internal traction," the Harrington rod to obtain and maintain correction of the scoliosis. In 1959, Nickel and Perry designed the halo device to stabilize the cervical spine in patients undergoing cervical spine fusion. Cotrel introduced the concept of dynamic traction in 1960 to treat adolescent idiopathic scoliosis and loosen up rigid curves before surgery. Kane devised halo-femoral traction in 1967, whereas Stagnara is credited for the introduction of halo-gravity traction in 1969. In the early 1990s, Dubousset combined Stagnara's elongation turnbuckle cast with halo-gravity traction. He believed that this was the best way of obtaining correction in a rigid early-onset scoliosis; to maintain the correction, he used a custom-fabricated modular, hard plastic adjustable cervicothoracolumbosacral orthosis called "corset Garchois" (Jean Dubousset, MD, personal communication, 1999).

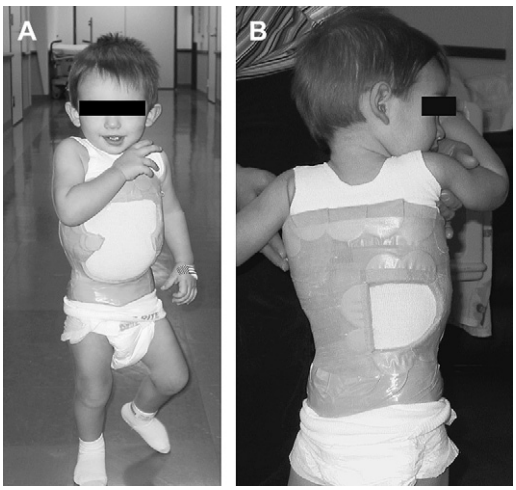

Fig. 4. (*A*) The anterior window allows chest and abdominal space while capturing the anterior ribs to prevent their deformity. (*B*) The posterior window on the concavity allows the curve to settle into the defect and improve the rotation. The window does not cross the midline.

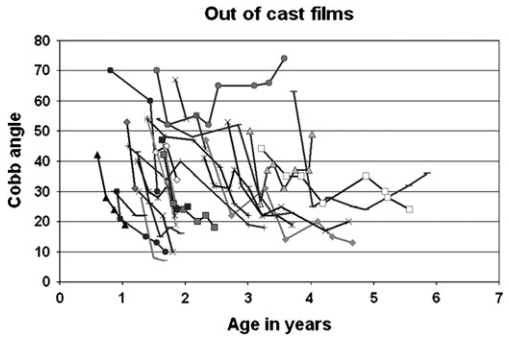

Fig. 5. Early results with cast treatment.

Biomechanics

The spine is a complex structure composed of vertebrae, ligaments, and intervertebral discs; biomechanically, it behaves as a viscoelastic material with a reproducible stress/strain curve. The soft tissues undergo "creep" deformation when continuous traction is applied, and this leads to gradual correction of the spinal deformity with realignment of the coronal and sagittal balance [12]. From the work of White and Panjabi, we know that transverses forces are effective for curves less than 50°, whereas traction forces are more effective for curves greater than 50°. A combination of axial traction and transverse forces was the most effective means of correction for small and large curves [14]. Casting, bracing, or surgery is required to maintain the correction.

Techniques

Halo-femoral and halo-pelvic traction have been used for the treatment of severe scoliosis. Head halter–pelvic traction is used for the initial traction radiograph to assess the flexibility of the

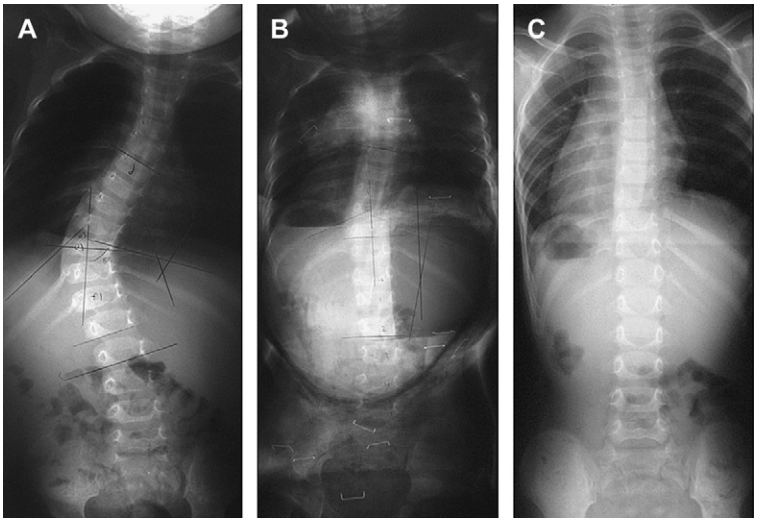

Fig. 6. Younger patients seem to have a better response than older children. (*A*) Eight-month-old girl who has infantile idiopathic scoliosis just before the start of casting, T6–L1 51°, rib phase 2, RVAD 40°. (*B*) Radiograph showing the correction in the second cast. (*C*) The same patient at age 3 years with scoliosis completely corrected; careful follow-up is still required.

scoliosis/kyphosis and again during the application of the Risser cast. The discussion is limited to halo-gravity traction because this is the most common type of traction used in our patients who have early-onset scoliosis.

Axial skeletal traction to the spine may be applied by a halo. In children younger than 2 years of age, because of their thin calvarium, 10 to 12 pins should be used, and the torque should not exceed 2 inch-pounds or finger tightness [15]. Multiple pins (6–8 pins) should be used in older children, and 6 to 8 inch-pounds of torque are applied. The pins are placed under general anesthesia if the child's overall condition allows. It is not necessary to shave the scalp or make a skin incision. The skin and subcutaneous tissues are infiltrated with 1% xylocaine with epinephrine. The anterior pin is placed 1 cm above the eyebrows or between the supraciliary ridge and the frontal prominence. It is important to avoid the anterior frontal sinus with the most medial pin. Placement too medially also can cause supraorbital or supratrochlear nerve damage. Placement too far laterally (behind the hairline) impinges on the temporalis and masseter muscles, leading to possible skull penetration and difficulty with mastication. The posterior pin is placed 1 cm above and posterior to the pinna, below the equator of the skull. The proper ring size allows 1 to 2 cm of clearance between the skin and halo. This alleviates problems caused by edema and facilitates proper pin care. The screws should be 180° opposite from each other whenever possible. The pins should be retightened once at 24 hours after halo application. Further tightening is dangerous, possibly leading to skull penetration. The exact method of pin care is less important than meticulous daily attention, taking care to remove all encrusted material and to examine for erythema or drainage. The pins are cleansed once a day with half-strength hydrogen peroxide or plain soap and water. Pins should be replaced if erythema and drainage do not improve with meticulous pin care or oral antibiotics. The hair and scalp should be washed at least once a week.

Stagnara [16] is credited with the development of halo-gravity traction; it is the mostly widely used method of halo traction. This method uses the patient's own body weight as countertraction. Depending on the child's size, 3 to 5 pounds is applied, with daily additions of 1 to 2 pounds to a maximum of 30% to 50% of body weight. During the day, countertraction may be obtained by the use of a wheelchair or walker. At night, we use a bed in maximum reverse Trendelenburg position, with blocks to elevate the head of the bed, which provides a 45° incline (Fig. 7). Alternatively, a pelvic sling or a Circoelectric bed can be used. This method allows the child to be upright during the day, preventing decubiti and

Fig. 7. Bed in maximum reverse Trendelenburg position.

osteopenia and promoting renal drainage. It has been used safely in children younger than 2 years of age. If a wheelchair is used, it may be necessary to place counterweights on the footrests to prevent tipping backward (Fig. 8). Halo-walker traction is used to allow ambulation in traction (Fig. 9). We have not found it necessary to use a spring scale for traction as described by Sink and colleagues [12], although it may act as a safety mechanism against excessive traction forces.

Fig. 8. Halo wheelchair.

Fig. 9. Halo-walker traction is used to allow ambulation in traction.

Indications

Our indications for the use of halo-gravity traction in early-onset scoliosis are early-onset scoliosis greater than 80°, scoliosis associated with kyphosis, and to "loosen up" the scoliosis and kyphosis before VEPTR or subcutaneous rod implantation, because both of these methods are kyphogenic and are mechanically disadvantaged in the presence of kyphosis.

Contraindications

Relative contraindications to halo-gravity traction include short sharp rigid kyphosis, C-spine abnormalities or instability because of their obvious neurologic implications, cranial defects or thin skull, and age younger than 18 months because of pin penetration problems.

Complications

Several complications have been associated with the use of halo-gravity traction; the most common one in our series is pain and weakness of neck musculature. Other complications include pin tract infections, pin loosening, and cranial nerve palsy (abducens, oculomotor, glossopharyngeal, hypoglossal). It is important to ask about double vision, difficulty swallowing, voice hoarseness, and tongue weakness. The cause of cranial nerve symptoms is believed to be the result of stretching or kinking of the nerve. Alternatively, an interference with the blood supply to the nerves

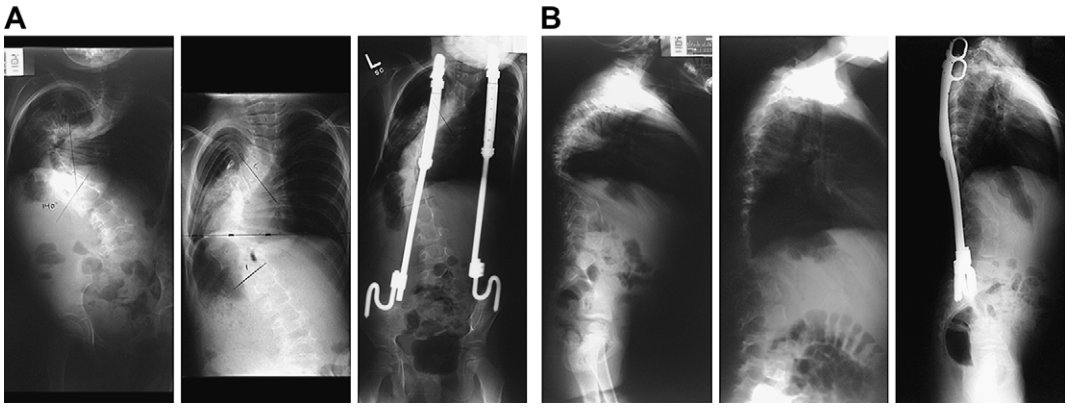

Fig. 10. A 3-year-old girl who had severe early-onset kyphoscoliosis. Halo-gravity traction improved the coronal and sagittal balance and decreased the kyphosis, allowing the use of a VEPTR device to maintain the correction.

secondary to traction may lead to cranial nerve palsy. Other reported complications include skull penetration and brain or epidural abscess, paraplegia, paraparesis, brachial plexus palsy, superior mesenteric artery syndrome, and avascular necrosis of the odontoid [17–20].

Practical advice

A thorough hair wash with shampoo is done the night before surgery. If the patient has long hair, it should be braided. Keep a chart at the bedside to document the patient's weight; chart the amount of weight on bed traction and chair traction, and note all increases in weight. Perform a quick neurologic examination and repeat at 2, 4, and 8 hours after increasing the traction weights.

Case example

A 3-year-old girl presented with severe early-onset kyphoscoliosis. Halo-gravity traction improved the coronal and sagittal balance and decreased the kyphosis, allowing the use of a VEPTR device to maintain the correction (Fig. 10) until the definitive fusion and instrumentation are undertaken.

Summary

The presence of a significant spinal deformity in an infant or toddler with several years of growth remaining has the potential to produce a severe deformity with significant cardiopulmonary consequences. We present alternative, albeit labor-intensive, modalities to bracing, subcutaneous rods, and VEPTR instrumentation. In milder cases and if started before 2 years of age, casting may correct the deformity completely, whereas in more severe cases, it allows the child to grow, minimizing spinal and chest wall deformities, until he/she is old enough to undergo definitive treatment of the spinal deformity.

Acknowledgments

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