Pathway for Implementation of Halo-Gravity Traction for the Treatment of Severe Spinal Deformities at a New Institution

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Abstract: Halo-Gravity Traction (HGT) is an adjunct technique for treating severe spinal deformity that has received increasing interest. Hospitals unfamiliar with these techniques may find implementation difficult due to the need for specialized equipment and coordination involving many healthcare providers. We aim to discuss critical steps for the implementation of HGT technique at new hospitals. HGT initiation first requires equipment purchasing and modification. While surgeon knowledge drives clinical protocols, they must be developed in coordination with a multidisciplinary team. A sustainable HGT program requires plans for equipment maintenance as well as regular review and improvement of clinical protocols. Total institutional costs will vary but should generally be affordable to interested centers. With this information, we believe that safe and efficient implementation of HGT is achievable for orthopaedists across most practice settings.

Introduction

Correcting severe spinal deformities in pediatric patients remains a challenging task tailored to each patient. Axial traction is an ancient technique, with references in Hindu texts dating back to 3500 BC.[1-3] In the 1970s, while practicing at Rancho Los Amigos hospital in southern California, Pierre Stagnara developed modern halo gravity traction (HGT) utilizing a surgically-applied halo apparatus[4] and a wheelchair.[5] Hospital-wide protocols and implementation were not seen until Stagnara's process was adopted by the Texas Scottish Rite Hospital for Children in 1987.[6]

Since then, preoperative HGT has seen greater use amongst pediatric orthopaedists at quaternary spinal deformity treatment hospitals using similar methodologies.[7] Keeping patients in preoperative traction, on average, corrects initial Cobb angles by 24.1% and 19.3% in the coronal and sagittal planes, respectively, with some institutions reporting correction of upwards of 35%.[8,9] It is believed to lead to safer spinal surgeries, a reduced need for three-column osteotomies, and comparatively less blood loss.[10] HGT can be utilized while optimizing pulmonary function and nutritional status prior to "definitive" operative repair of deformities, further minimizing patient risk for particularly compromised patients.[11,12] Current evidence and best-practices are nicely reviewed in other publications,[13,14] and it is not the focus of this article to perform an in-depth summary. The purpose of this QSVI paper is to describe our experience with the implementation process of a novel HGT program at a tertiary academic center in the hopes of providing guidance and reducing effort for others interested in bringing HGT to their own institutions for treatment of severe spinal deformities.

Methods

Indications

Shared decision-making is critical between patient families and the medical team, but clear guidelines will provide a framework for other stakeholders to understand HGT's purpose and potential problems. Our indications for considering HGT are coronal or sagittal deformity over 90 degrees, excessive spinal stiffness from either etiology or prior instrumentation, a need for preoperative nutritional or pulmonary optimization, or to minimize the use of a three-column osteotomy.[14] Thoracic curves and higher Deformity Angular Ratio (calculated as the Cobb angle of the maximum deformity divided by the number of vertebral levels of the involved spine segment) are known correlates with high-risk operative candidates[15-17] and merit stronger consideration for HGT. Absolute contraindications include spine instability, severe skull deformities, or open skull lesions precluding pin placement, significant intra or extradural lesions, or severe canal stenosis.

Perioperative Procedure

Patients should be scheduled simultaneously for halo application and the appropriate second procedure (removal of halo with casting, growing rod placement, or fusion), typically 1-3 months later. Scheduling should notify all relevant providers involved in patient care of this timeline. Intraoperatively, halo application is achieved via the placement of 6-8 pins, each ranging between 2-8 pounds of pressure and informed by patient age, co-morbid conditions and osteopenia, skull morphology, and target traction weight.

After halo placement, patients are transferred to the floor for postoperative management and traction initiation. Upon arrival, traction is typically started at 5-10 pounds, with surgeon-directed safe daily incremental increases to reach goal weight by about 2 weeks. Generally, this is 50% of total bodyweight, though can approach 100% when appropriate. Clinically, minor neck pain is often indicative of the upper limit of tolerable traction. Area-of-interest radiographs and cervical spine radiographs are routinely obtained while adding traction (see appendix for full clinical protocol).

Length of time in traction is up to the discretion of the care team and is generally determined by patient tolerance, radiographic evidence of correction, the surgeon's assessment of the operative course for the second procedure, and the need for pulmonary or nutritional optimization. After full traction is reached, patients may continue HGT treatment as inpatient or outpatient (taking traction equipment home until next procedure). The decision to allow home traction for the patient and family is dependent on family comfort with HGT processes and depends on medical literacy, parental support, the ability to travel often for necessary follow-ups and specialist visits, and cost considerations. With the appropriate clearance, home traction is effective for both patient and the healthcare system, with patients living in the comfort of their own homes, avoiding contact with infectious sources inherent to healthcare settings, and a reduction in hospital resource utilization.

Avoiding Complications

Major complications of HGT include pin site infections (abscesses or cellulitis), pin site pain, cerebrospinal fluid leak at pin sites, cranial nerve palsies, or nerve root or spinal cord palsies. Minor post-application pin site pain is expected for up to 48 hours postoperatively and can be treated with ibuprofen; persistent pain beyond this period merits checking for pin loosening and performing subsequent tightening as indicated. Risk of pin site infection can be mitigated by proper application and regular skin cleaning with a topical disinfectant and hygienic practices. Pin site infections are treated similar to other external fixators, typically with a short course of oral antibiotics providing staphylococcus and streptococcus coverage. However, worsening infection may require pin removal or replacement. CSF leaks are rare and usually occur at the time of placement. These should be treated with topical antibiotics, Gelfoam plugging, and compressive bandaging.[13] Patients should receive daily neurologic checks, with a decrease to the

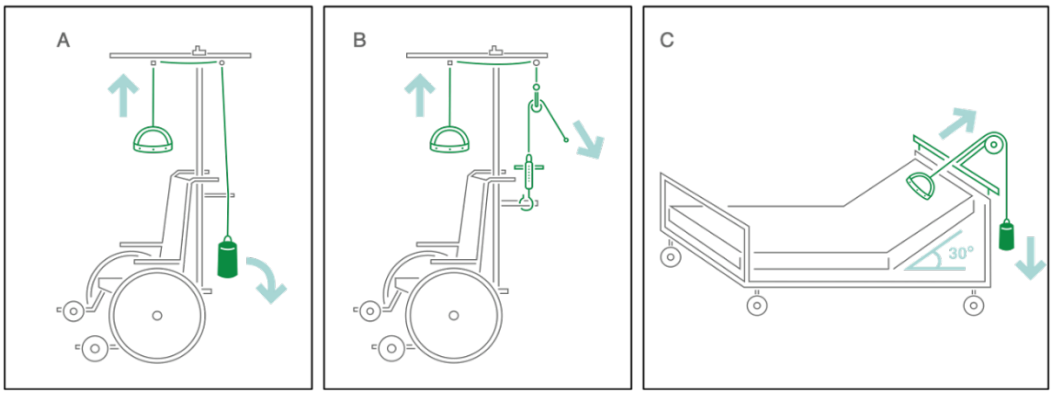


Figure 1. HGT Equipment
A) Wheelchair utilizing free weights for traction force
B) Wheelchair using spring and pulley for traction force (our preference, with modification)
C) Bed utilizing free weights (our preference)

preceding weight level if any palsies are noted. Cranial nerve VI is affected most often, and special attention should be taken by the medical team to test for any horizontal gaze palsy, diplopia, or strabismus. If weight removal is ineffective, corticosteroids may be considered, or traction can be stopped altogether. Any extremity or trunk deficit also merits immediate traction reduction or discontinuation and imaging.

Equipment Procurement and Modification

Design and Specifications
Designs for fitting wheelchairs and walkers with traction apparatus were drawn up by faculty in orthopaedic surgery who had experience implementing HGT at previous institutions, with additional technical input from fabricators in the instrument shop in the Department of Physics. Given the uniqueness of each patient and dynamic design, future alterations can be made. The wheelchair, walker, and bed must all be modified such that a traction rope attached to the patient's halo device can be suspended overhead and apply upward force (Figure 1).

Wheelchairs
This is the core piece of equipment – ambulatory and non-ambulatory patients alike will spend the majority of their out-of-bed time in this device. We used hospital-owned, manual wheelchairs, ranging from 14 to 18 inches wide. Generally, 14-inch chairs are used for patients < 8 years old, 16-inch chairs for patients > 8 years old, and 18-inch chairs for adolescent or adult-sized patients. The only requirements to enable safe modification with a rod and pulley system are 1) adequate space to secure a vertical traction beam at two locations on the wheelchair frame and 2) anti-tip rear wheels since the wheelchair will now have its center-of-mass shifted more posteriorly towards or past the rear wheels (Figure 2b).

Walkers
For ambulatory patients, we used modified front-entry pediatric walkers of three different sizes, with handle height ranging from 15.5–29 inches. Generally, small gait trainers are used for patients < 45 inches tall, medium for those 45–54 inches, and large for any patient > 54 inches in height. Individual proper handle height can also be determined by measuring ground-to-wrist distance in standing patients. Criteria for walker model selection are identical to those in wheelchair selection, as are requirements to enable safe modification with a rod and pulley system (Figure 2a). However, some of the walkers selected at our institution allowed for beam attachment anterior to the rear wheels, obviating the need for anti-tip wheels.

Bed
For the duration of traction, patients must have a bed capable of applying traction overnight. At our institution, standard hospital beds were used with an orthopaedic traction setup with rods and clamps supporting a pulley at the head of the bed—the same components used for lower extremity skeletal traction or trapeze attachments (Figure 1c). The head of the bed should be elevated to ≥30 degrees, so gravity

supplies adequate counter-traction and the patient does not migrate up the bed. For patients receiving traction at home, care teams should confirm that they will still have access to a bed capable of traction, either through DME vendors or home modification. If necessary, crib mattresses or wedge pillows can be used to "incline" a regular bed, and the wheelchair and walker can also be parked at the head of the bed to leverage the pulley system to apply traction in lieu of bed modification.

Applying Traction

The two methods of applying traction force are free weights and spring tension (using a spring scale) (Figure 1a-b). Previous literature has not identified any inter-institutional consensus as to a superior method, with previous analysis demonstrating a 55:45 split in favor of using free weights.[14] In conversations with other centers, those preferring free weights cited maintenance of a more constant tension throughout traction application, while those electing to use springs valued the perceived safety and ease of springs compared to weights. Because the safety concerns of free weights are less prevalent for a stationary bed, we elected to use free weights for bed-based HGT (Figure 1c). Unlike a spring system, this also allows constant tension even if a patient's body translates toward the head or the foot of the bed.

For mobile devices, we elected to use a spring-based model for multiple reasons. With hanging weight, there is concern for weights potentially hitting patients as they move, creating a source of avoidable potential risk (Figure 1a). Weights could also catch on objects, leading to a sudden and dramatic increase in tension that may cause adverse outcomes. Spring-based HGT wheelchairs are also lighter, easier to operate, and less expensive than a free-weight-based setup.[18]

However, a simple spring setup does have limitations. Notably, the applied force will vary with positional changes of the patient's head and halo. For wheelchairs and walkers, these variations are minimal and controllable with patient posture. This force variability can be further mitigated by utilizing a smaller spring constant, thereby decreasing the change in force per unit distance and allowing for more natural movement without significantly affecting force application. We currently use springs scales of two separate sizes (up to 25lbs. and up to 50lbs) and recommend using larger and stiffer springs only for higher weights, as smaller springs can minimize the variation in applied force given patient displacement. Further, spring scales with visible force readings allow for real-time traction monitoring and adjustments (Figure 3).

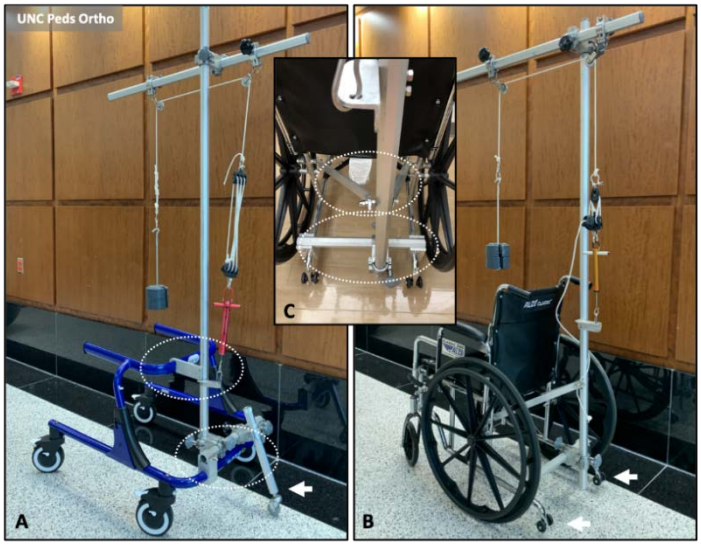


Figure 2 - HGT Equipment Modifications

A) Medium child walker with attached bars and pulleys. Key elements include fixation of vertical bar to the walker frame in two locations (white ellipses). The exact method of fixation will depend on available equipment and the preferences of the fabrication team. Our team primarily used custom clamps that were immediately available to the fabrication team. An anti-tip wheel was added due to extra weight posteriorly (white arrowhead). Anti-tip mechanisms should be considered more strongly if weighted systems are used and if the bar attachment is mounted eccentrically and significantly moves the unit's center-of-mass.

B) 18-inch wheelchair with attached bars and pulleys. Also, note the presence of anti-tip wheels due to extra weight posteriorly (white arrowheads). This is an option available on most commercially available wheelchairs and did not require custom modification

C) Inset demonstrates support struts (rather than clamps) for the superior attachment (white ellipses).

Finally, we advocate the use of a force-multiplier pulley system attached in series to the spring scale (Figure 4). This way, work needed to "shorten" the rope and "stretch" the spring is applied with less force over a longer distance, which can more easily facilitate heavier goal weight. In our setup, the pulleys allow for a 6x multiplier, where a change in rope distance of *d* on our setup requires a distance change of 6*d* through the pulleys to create tension. This allows for one-sixth force effort for caretakers to initiate or adjust traction in these devices.

Equipment Modification

Equipment development begins with the identification of individuals or departments to complete the following steps (our institutional choices noted parenthetically).

1) Procure base equipment (Department of Rehabilitative Services).

2) Select and purchase essential instrumentation and traction bars/clamps for equipment modification (Central Distribution in the Department of Supply Chain Services).

3) Engineer and assemble devices (Instrument Shop in the University Department of Physics).

When available, providers may prefer an orthopaedic brace shop model to circumvent the need for a multi-tiered model for steps 1) and 2). Other options include biomedical engineering departments, contracting an independent manufacturer, or self-assembly.

Equipment Maintenance

When in-use equipment is no longer needed by a patient, it is returned to the storeroom on the surgical floor (Figure 5). Medical Engineering (ME) wipes down all solid components, removes rope and disposables, re-strings traction rope, and carefully inspects any component that may constitute a safety risk in further use. Once the HGT pathway is reactivated for a new patient, ME spot checks equipment again to assess for damage that occurred during storage. If team members notice any weathered or depleted aspects of the devices during use, a request for repair or replacement is made through the ME team.

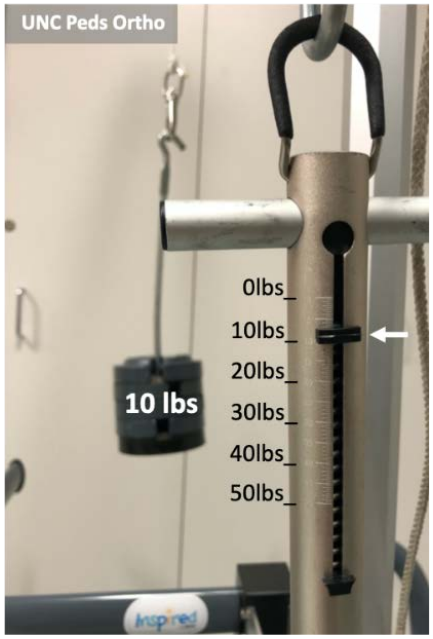


Figure 3. *Spring-based HGT system demonstrating 10lbs of hanging weight with corresponding correct reading on the scale (white arrowhead). When the system is applied to a patient with the head/halo in a fixed location, the tension is added by shortening of the rope using a pulley system (simple or block pulleys).*

Creating a Multidisciplinary Team

Caring for patients in HGT is an interprofessional and multidisciplinary endeavor. Thus, preparing a relevant team is of paramount importance before any patients can be placed in HGT. Members of our institution's care team, including respective roles and responsibilities, are detailed as follows.

Core Care Team Composition

Orthopaedic Surgeon: The patient-facing leader of the team—identifies eligible patients and steers their medical and surgical course.

Physical Therapy: Works with patients to adjust to life in HGT, especially from a mobility standpoint. Primary goals are to allow patients to gain and maintain independence through increased muscle mass and endurance. At our institution, act as the primary manager of HGT equipment.

Equipment Management: Purchases base equipment, parts for modification, and disposables such as traction rope and springs. They should also oversee the construction of new devices and the maintenance/turnover of existing devices. Our director of therapy services has assumed this role.

Floor Nursing: Serves as the primary day-to-day caregiver while patients remain in traction. Monitors both the patient as well as the HGT system. Full responsibilities can be found in the Online Resources.

OR Staff: Assists intraoperatively with initial halo application as well as its post-traction removal. Needs familiarity with equipment and bed setup.

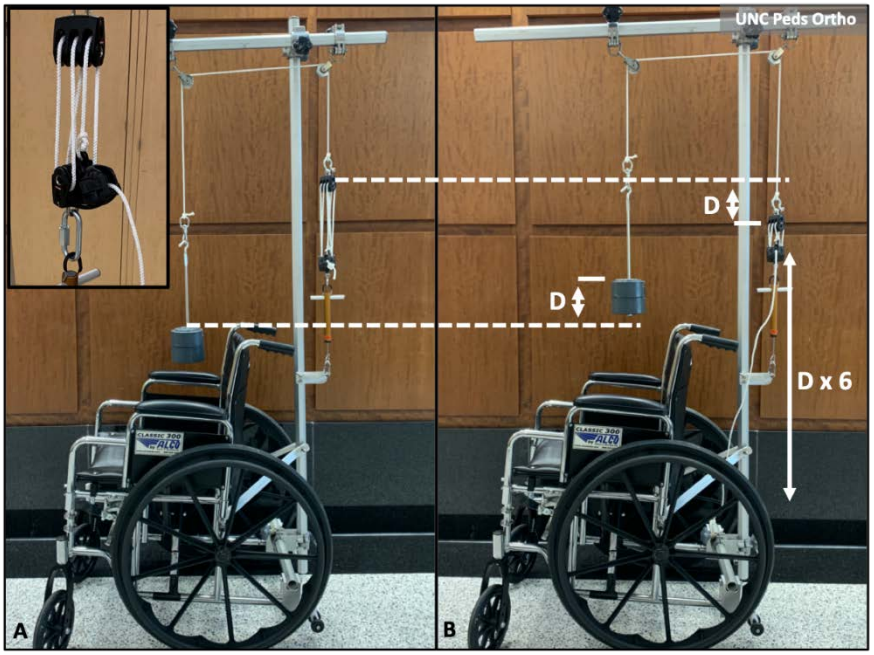


Figure 4. *Spring-based HGT system demonstrating the mechanical advantage of a "force-multiplier" or block pulley system in parallel. To shorten the circuit a distance of D, the operator must only apply a 1/6th of the force needed without a pulley over a distance of 6D, keeping the work the same (i.e., adding the same tension to the system) but lowering the force required.*

Child Life: Provides developmentally appropriate patient education, play, and planning with an emphasis on mental welfare during a long hospitalization with challenging conditions.

Case Management: Coordinates and oversees patient plan of care, particularly focusing on serving as an advocate for patient services and needs during and after hospital stay. In patients who are appropriate for transition to home HGT, case management will serve an expanded role to meet home equipment needs.

Adjunct Medical Consultants

Pulmonary: Assesses and optimizes respiratory function. Pulmonary function testing is routinely performed in this patient population pre- and post-traction when patient factors allow.

GI/Nutrition: Determines current nutritional status and recommends dietary supplementation and mode of feeding. Especially important as preoperative optimization of nutritional status reduces healing complications.

Child Psychiatry: Provides therapeutic relief and support to patients and families as needed. Often works in tandem with Child Life.

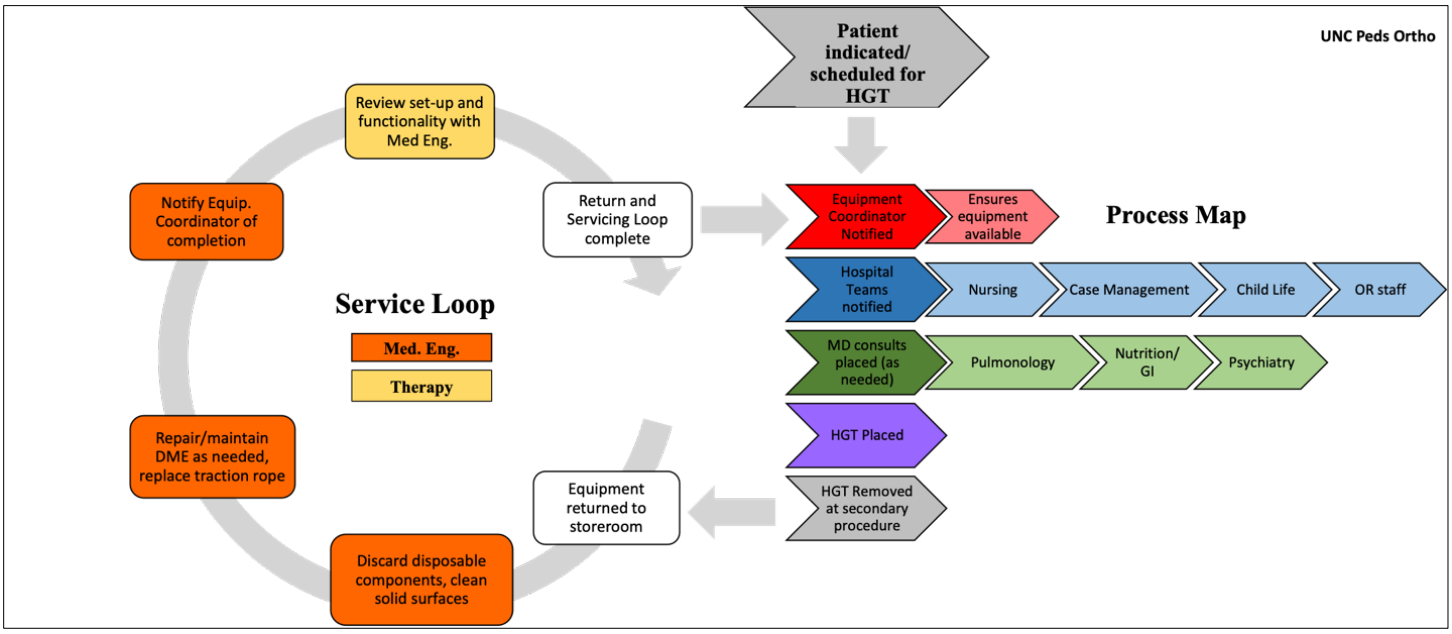
Families

Parents or guardians play a vital role in patient care. Appropriate education and preparation should be provided to all patient families prior to, during, and after HGT application. If patients elect to finish traction at home, comfort level should be assessed, and a documented educational session provided.

Education and Coordination of Teams

Full-team educational sessions led by surgeons experienced with HGT were held to discuss care protocols (see Online Resources) and create a standard implementation pathway for HGT implementation (Figure 5), with subsequent regular stakeholder meetings for continuous process improvement. Maintaining open

Figure 5. HGT Initiation Process Map with Equipment Return and Servicing Loop



communication channels between these providers is critical throughout the duration of care, with some institutions preferring a multidisciplinary conference model similar to Tumor Boards at academic cancer centers.

Cost Considerations

For hospitals and clinics, initial capital investment should amount to approximately $500 per wheelchair and $1,300 per gait walker. This includes costs for DME, reusables, and labor for initial alterations (the largest source of cost variation). Other indirect costs mostly involve new human capital requirements and time for initial training.

For patients, costs will depend on insurance status and various payors' policies with regard to HGT. Many major commercial payors have outlined specific policies on coverage with spinal deformities, and HGT is often covered in the treatment of patients with severe disease. Aetna, for example, considers HGT medically necessary adjunctive therapy for patients requiring spinal fusion, with a minimum of seven inpatient days and additional granted with documented response to traction on serial imaging.[19] For families, financial impact from medical costs, travel, and other indirect sources should be considered and discussed as anticipatory guidance.

Results

After implementing the program above, we have successfully treated multiple patients with severe spinal deformities using HGT. Here is a case example of one of the first HGT patients at our institution (Figure 6). He is a 6-year-old male with VACTERL syndrome, congenital rib fusions, and early-onset scoliosis previously treated with unilateral distraction-based growing rod at age 4. He experienced proximal loss-of-fixation, progressive deformity, and skin breakdown/infection from his early treatment and was treated with rod explantation. After his infection cleared, he was indicated for our HGT program. He spent 38 inpatient days in HGT, reaching goal traction weight of 19 lbs. During that time, the following improvements were noted (prior to secondary procedure):

- Gained 4.5kg (9.9lbs) from 31 lbs. to 40.9lbs with dietician-directed tube feed regimen.
- T1-T12 distance improved from 10.5cm to 16.2cm.
- Coronal deformity (Cobb angle) improved from 104 degrees to 61 degrees.

- Sagittal deformity (Cobb angle) improved from 119 degrees to 55 degrees kyphosis.

Pulmonary function data not available due to patient factors. At discontinuation of HGT, he underwent bilateral magnetically controlled growing rod implantation to maintain correction and to attempt continued growth.

Discussion

Starting an HGT program at a hospital can be a daunting task because of the required equipment needs, process coordination, staff cooperation and training, and potential costs. We offer here a streamlined process that provides a complete framework for others to adopt to create their own, with the following key steps.

Steps for Implementation

1. Perform initial needs assessment, including anticipated demand and quantity/sizing of HGT equipment.
2. Determine preference for ambulatory HGT style (spring vs. weight) to determine traction components needed.
3. Identify Equipment Manager.
4. Consult with appropriate department (e.g., Medical Engineering, Physics Shop) for ordering, delivery, and alteration protocols.
5. Notify stakeholders of decision to implement HGT and begin discussing interdisciplinary care protocols with divisional representatives.
6. Disseminate care protocols and train OR and floor nursing staff when equipment is available.
7. Plan maintenance and storage cycles with relevant parties (e.g., Medical Engineering, Rehabilitation Services).
8. After initiation of HGT, conduct regular process reviews and quality control checks.

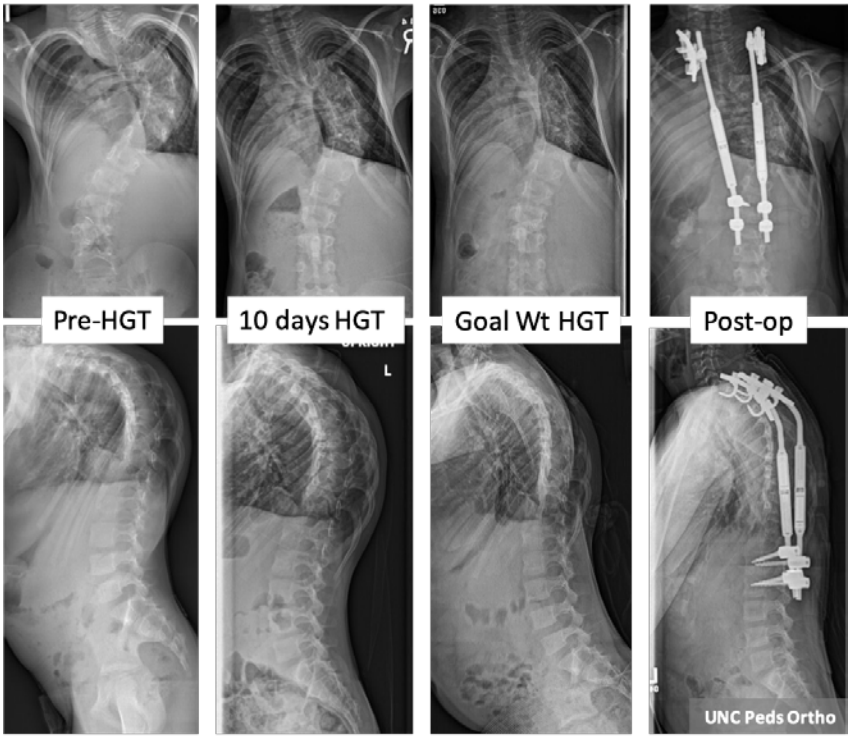


Figure 6. *Sequential radiographs of an early case treated with HGT at our institution*

Additional Links

SRS Patient Video: Halo Gravity Traction–Amy McIntosh, MD:
https://www.youtube.com/watch?v=ksEp1fM8-eQ

Halo Placement Anatomical Considerations–Nabil Ebraheim, MD:
https://www.youtube.com/watch?v=Fadi1EYDwww

Acknowledgements

The authors would like to acknowledge Skyler Muench for her contributions in the design of Figure 2.

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Appendix A

Halo Gravity Traction Pathway – For Surgical Team

PRE-OPERATIVE

- Decision for traction is *surgeon dependent*. Consider:
  - Indications
    - Avoid or minimize 3-column osteotomy
    - Improve major coronal/sagittal curves or balance
    - Improve nutritional status or pulmonary function
    - Generally curves >90 degrees, or patients with comorbidities/complexities
  - Contraindications
    - Open fontenelles
    - Abnormal skull morphology – evaluate if suspected (CT, Dexa, XR)
- If traction is decided:
  - Schedule patient for surgery, halo application
  - Notify PT, nursing, case management, and OR about impending surgical date (automate with schedulers)
  - Schedule second surgery (removal of halo with casting, GR, or fusion) at estimated time
  - Consider other health concerns as discussed in complex spine protocol

INTRA-OPERATIVE

- Halo with 6-8 pins, 4-8# of pressure, if 4# cannot be achieved, then increase pin density
- Establish goal weight.
  - Goal weight generally 50% body weight, can be more in some instances
  - Discuss plan for safe increase in weight with care team
- Place patient in bed with appropriate setup, plan to place 5# of weight when arrives to floor

POST-OPERATIVE ON FLOOR

- Traction weight is ordered by MD.
  - It helps to write and update daily traction weight on board in the room.
- Daily MD neurologic checks.
  - If cranial nerve deficit noted, take away most recently added weight
  - If extremity/trunk deficit noted, plan to remove all/most weight
- Order XRs of spine
  - Area-of-interest weekly while adding traction, q 2weeks once at goal
  - Cervical spine when at 50% of goal (check distraction), and with follow-ups.
  - If any neurologic issues noted

Appendix B

Patient Information: Halo-Gravity Traction (HGT)

Your surgeon has recommended use of Halo-Gravity Traction to help manage your child's spinal deformity. This is a modern technique that allows gradual deformity correction and may reduce the risk of complications for final treatment.

What is Halo-Gravity Traction?

HGT gently applies a "pulling" or distraction force to the spine to gradually improve the alignment. A small surgery is needed to place "pins" into a patient's skull that will allow us to pull upwards. The weight of the body applies a downward force to stretch the spine. The force is gradually increased to assure safety, then is left in place for about 2-3 months. Traction can be applied while in bed, while in a wheelchair, and even while standing/walking! Although it may seem overwhelming at first with all there is to learn, families and patients will adapt and studies show they are very satisfied with the results.

Frequently Asked Questions:

- **How long will we be in the hospital?** A typical hospital stay lasts 2+ weeks while the force is slowly increased and arrangements for home are finalized.

- **How do we transfer to home?** Once the goal weight is achieved and the family is comfortable with equipment and nursing care, the patient can go home with the same equipment and get back to normal life. Some can still go to school!

    - **Will we need special equipment?** All patients will need a bed and a wheelchair. Patients who can walk will also need a custom stander. These are loaned to the patient from the hospital and need to be returned when treatment is done.

    - **Will we need nursing support?** Most patients won't need extra nursing care and can be almost as independent as they were prior to traction. If extra care is needed, it will be evaluated in the hospital based on a patient's progress.

- **How will my child attend school?** Since treatment lasts for months, the patient will need to make arrangements to continue studies (if currently in school). If the student can get a one-on-one aide and the school can accommodate equipment, the patient can go to school. Otherwise, tutoring may need to be provided in hospital and at home.

- **Is it painful?** There can be mild headaches and pains for the initial few days, but most say they feel better in traction (less spine pain) and appetite and breathing can improve.

- **What are the risks?** The major risk is of pin site irritation related to the halo ring. There is a small risk of neurologic injury, although the eventual risks are generally higher if traction is not used. If this has been recommended for your child, the risks are outweighed by the potential benefits.

What happens at the end? At the end of traction, your surgeon will perform another procedure to further correct or maintain the correction obtained with HGT. This can be a cast, "growing rods", or a fusion procedure. The halo is removed during that surgery, and none of the equipment is needed anymore. The specifics of that surgery should be discussed with your surgeon.

Appendix C

Provider or Nursing Information: Halo-Gravity Traction (HGT)

OVERVIEW OF CARE

The halo is applied in the operating room and patients come to the floor with the halo-gravity traction set-up in the bed (usually 5-6lbs to start, attached to the halo).

- Starting off: Patients are usually in bed until POD1. With PT help, they will learn transitions out of bed to wheelchair (and stander, if ambulatory at baseline). PT will manage this equipment and instruct in its use, but nursing will also need to understand the equipment.
- Activity: Patients are encouraged to be OOB to chair/walker as much as able. Nursing should also help with transitions to/from bed to chair and walker when occurring outside of therapy. As the hospitalization continues, the family will learn how to do the transitions and care for the traction set-up. At time of discharge, families are usually comfortable with transfers on their own (may require 1-2 people).
- Traction progression: As the days progress, traction is increased by weights (usually 1-5 pounds every 1-2 days until reaching the goal traction depending on patients weight). Goal traction is often approximately 50% of the patient's weight. However, the goal will be determined by the surgical team. Goal traction weight is achieved prior to discharge from hospital.
- Frequent Monitoring: During the hospitalization, we will do neurologic checks daily and monitor BPs closely. If a patient's neuro exam changes, there may be too much distraction on the spine. X-rays are often taken to check correction and cervical spine distraction.
- Pain management: Mild headaches managed with Tylenol/ibuprofen. Some narcotics may be needed for the first few days.
- Hygiene: We also start daily nursing pin-site care for the halo via soap/water. However, we keep the pin-sites open to air. We monitor for any redness, drainage or irritation. Pin-sites can get infected.
- Home set-up: Specialists will ensure the family has a suitable home setup for bed traction. If this cannot be obtained, patient may be discharged to Ronald McDonald House once they are safe to leave hospital. Some patients will remain inpatients for all of traction duration.
- Equipment: Prior to discharge, wheelchair and/or walker w/ traction will be arranged for home delivery. Hospital bed can be delivered, or families can have their own setup.
- Home Nursing Care: Home nursing care visits may be needed depending on patient and family following hospital discharge. This is assessed during hospitalization and can be arranged prior to discharge.
- Transportation: Patients travel in cars out of traction but in a soft cervical collar for support. This supports the cervical spine when out of traction. Once out of the car, they can return to traction.
- Total time in traction: Patients are often in traction for 1-3 months, followed by halo removal in the OR and subsequent surgery, bracing or casting. They may not be in the hospital for that entire time, based off patient/family circumstances.

WHAT ARE NURSING RESPONSIBILITIES?

- Maintain integrity of system & proper traction weight
    - Can ask Therapy and MD teams if questions
- Ensure proper positioning and transfers between the bed, wheelchair, and walker/stander. Encourage maximal time OOB during the day
- Assess pin sites for erythema and drainage. Daily pin site care (which is just soap & water gently)
- Assess motor and sensation function, with special attention on integrity of **cranial nerve VI (abducens nerve)**, which is often the first to be affected. If problematic, the eyes will have difficulty looking laterally and the patient may have crossed eyes & double vision. The surgical team should be made aware of any concerns.
- Assess for **hypertension** or **difficulty swallowing**. The surgical team should be made aware of any concerns.
- Assess neurologic function of upper and lower extremities. The surgical team should be made aware of any concerns.

WHAT ARE DOCTOR/SURGEON RESPONSIBILITIES?

- Determine the amount of weight to be used for the day/night and update the nursing team
    - The MDs can add/subtract weight, but the nurses can also modify during the day based off orders!
- Monitor neurologic function (Cranial nerves & extremities daily)
- Monitor pin sites for drainage
    - If cranial nerve deficit noted, take away recently added weight
    - If extremity/trunk deficit noted, plan to remove all/most weight
- Order XRs of spine
    - Area-of-interest weekly while adding traction, q 2weeks once at goal
    - Cervical spine when at 50% of goal (check distraction), and q 2 weeks once at goal

SPECIFIC PROTOCOLS

- **Proper positioning in BED**
    - Generally the bed will be inclined 30 degrees so patient is not pulled up the bed "excessively". There should be a straight line from pulley through his halo/head and body. See attached pictures.
    - Some of the surgeons may prefer to have the patients head "suspended free" by positioning with head over top of wedge pillow or "crib-sized" (See picture below).
    - Apply free weights to rope as ordered.
    - The patient's position in bed will likely change as they move, so the weight position must be checked to ensure the weight isn't on the ground.
    - You will need to change position for skin protection. You can alternate between sides and back, using pillows *as needed* for trunk and leg support.
    - Encourage the patient to move head side-to-side to prevent stiffness

- **To transfer from BED to WHEELCHAIR (OR STANDER)**

PATIENT SHOULD BE OUT OF BED AS MUCH AS POSSIBLE DURING DAY

    - Apply neck collar first
    - Remove the clip from the halo
        - Gently pull on the halo while weight is released, so that it does not "jerk" or suddenly release the weight. Once it is unhooked, you can gradually decrease the force of your pull.
    - You will then need to lift patient (if cannot walk) from the bed to the wheelchair. If patient can walk, patient is free to transfer themselves to wheelchair or walker.
    - Once seating or standing in appropriate device, connect the clip to the halo
    - To set the appropriate tension, pull the rope on the back of the wheelchair (or stander) until the desired weight is achieved, then lock back in (between the black pieces).
    - Remove the neck collar
    - Be sure to watch that the tension remains at the desired weight. You may need to make minor adjustments throughout the day as the patient position changes.

- **To transfer from WHEELCHAIR (OR STANDER) to BED**
    - Apply neck collar first

- Release rope SLOWLY on the back of the wheelchair to remove the tension on the spring
- Unhook the clip from the halo bale
- Transfer back into bed under own power or with scoop transfer
- Position head so that it is handing over the top of the wedge pillow (if applicable) and head/halo frame are free to turn to side to side.
- While holding onto the traction weight rope, re-attach the clip to his halo and slowly lower the traction weight rope to increase tension
- Remove neck collar

- **Hygiene**
  - Patient can be unhooked from traction for showering, using the bathroom, changing diapers (if applicable). Be sure to support the head with a soft-collar when possible.
  - Patient will require sponge-baths until pin sites are healed, usually 1 week. After that patient may shower and shampoo hair as normal.
  - Pin sites only require daily bathing with soap and water
  - Try to avoid excessive scrubbing, pulling, or other measures that will traumatize skin

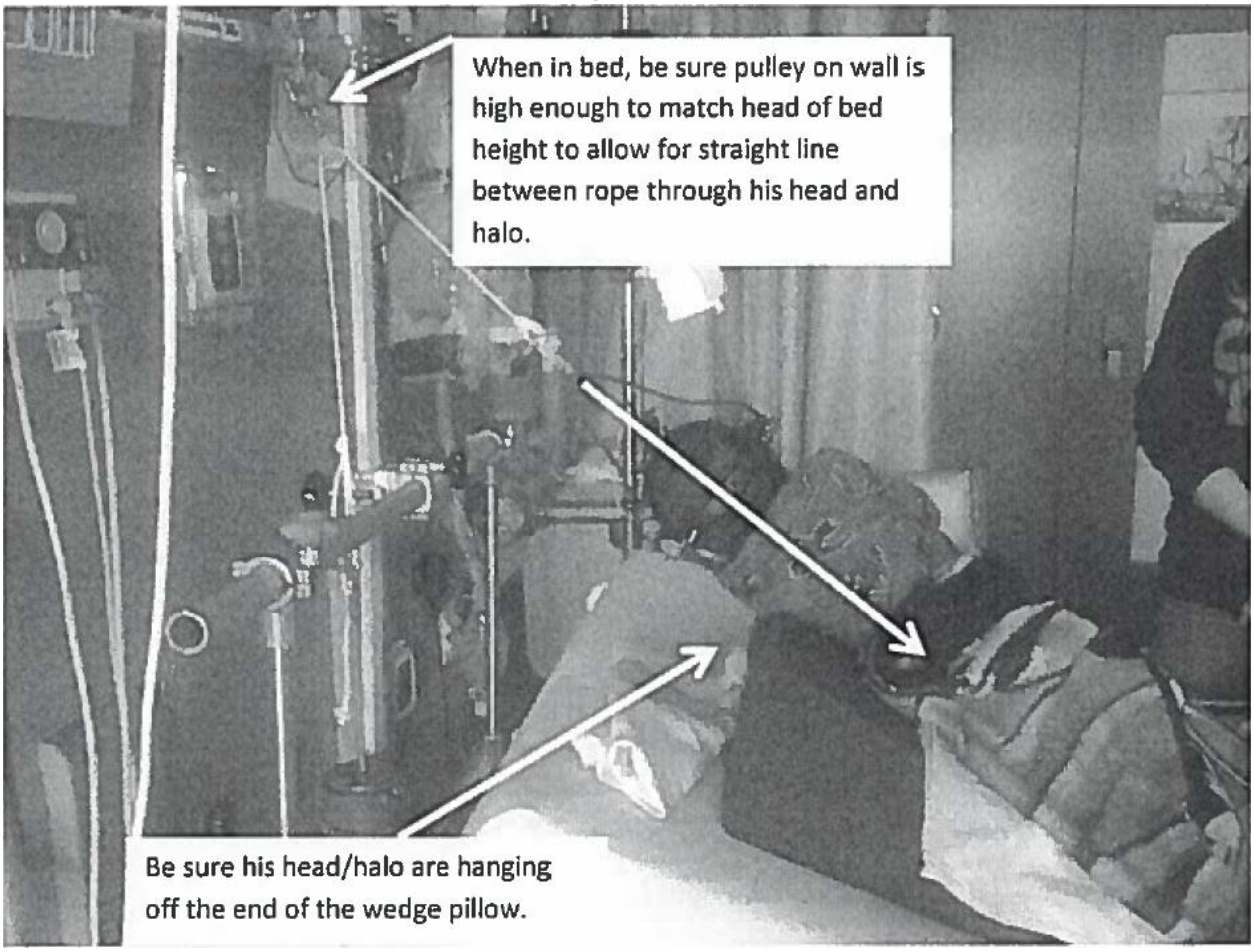
- **Getting dressed**
  - Shirts that button will be easiest to get on and off to avoid trying to put clothes over the patient's head.
  - Patient can be detached from traction for putting on clothing

- **To Transport in vehicle**
  - Patient will not be hooked to traction in a car. Patient will need to be in a neck collar
  - If a complete ring forces head to sit forward (away from chair), consider placing patient in car seat with a pad/pillow behind their back to bring body and head forward so that pins avoid hitting the seat. Padding/rolls on each side of the head can be used to further stabilize the head.
  - Fasten seat-belt as usual

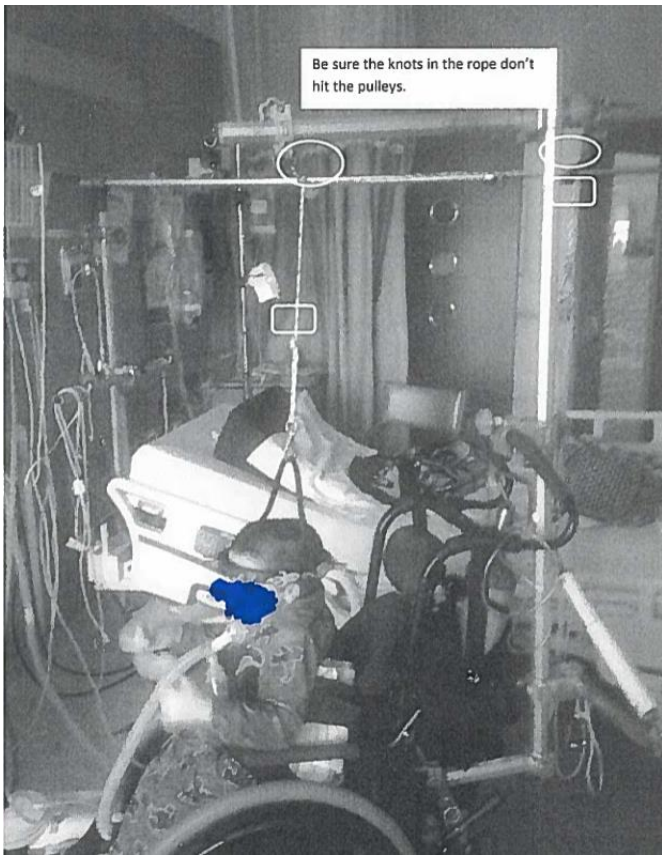
- **If going to school in the Halo**
  - Patient will need to have a one-to-one aide or family member help them with equipment and keep safe
  - Patient will remain in wheelchair with traction spring during the day, except for when needing to use the toilet

- As before, patient can be unhooked from traction temporarily to use the toilet

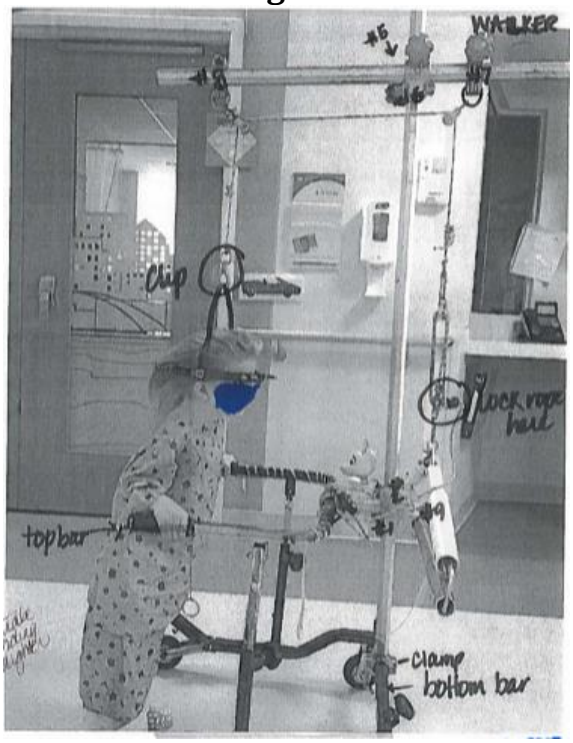
Positioning when in bed:



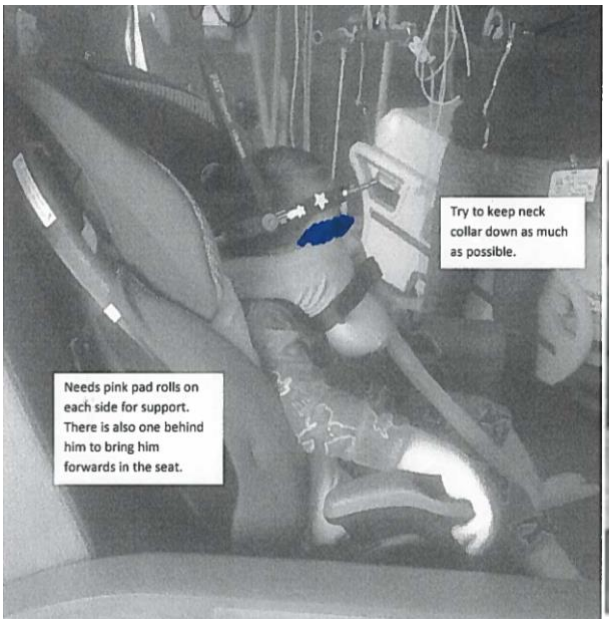
Positioning in wheelchair:



Positioning in stander:



Positioning in carseat:



Use of pads when halo ring or pins require to head to sit forward from the back of the seat

Use of soft-collar only when head position is normal

Appendix D - Child Life Specialist Handout for Patient

Halo Gravity Traction

When you come to the hospital, you will have a surgery to put a special tool called a "halo" across your forehead and sides of your head. The halo will have a triangle on top that hooks to rope that pulls up. The pulling helps to make your back straighter. Most kids say getting the halo doesn't hurt at all, but some kids might get a headache for the first day or two. You can decorate your halo with stickers and colorful tape to make it your own.

You can use your wheelchair or walker to go other places in the hospital. Make sure you check out at the nurse's station to get a Green Sticker. You can follow the brown paw prints in the hallway to get to the Playroom.

Important things for when you're in Traction:

- Make sure to walk and stand with your feet flat on the ground when using your walker
- It's okay to unhook from traction to go to the bathroom or take a bath
- Try not to hang or spin from your halo