Research Square

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Home-Based Halo Gravity Traction for Severe Pediatric Spinal Deformities Using a Novel Protocol

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Abstract

Purpose

We aimed to evaluate the safety and efficacy of an original structured protocol for preoperative home-based traction (home HGT) approach in children with severe spinal deformity.

Methods

A treatment protocol for preoperative home-based HGT was developed for children with severe spinal deformity submitted to posterior spinal fusion. The protocol comprises two phases. Phase 1 (hospital phase, 3–5 days) includes halo placement and Phase 2 (home phase) involves a gradual traction increase of up to 50% of body weight, with weekly clinical, neurological, nutritional, respiratory, and radiological assessments.

Results

43 patients were initially evaluated; 40 completed the home-based HGT protocol and were included in the analysis, while three were excluded because hospitalization was required due to non adherence. The mean age at the start of HGT was 12 years ± 2 months (5–18), and 67.5% were female. The mean pre-HGT scoliosis angle was 106° (90–144°), with a mean angular correction of 25° (23.6%). The mean duration of HGT was 14.7 weeks (4–57). Complications occurred in seven patients (17.5%)All patients were able to maintain their usual educational and social activities in their home communities, and families continued their work routines

Conclusions

The home-based HGT protocol achieved results comparable to those reported for hospital-based traction in the literature. It appears to be safe, and may provide psychosocial advantages together with a potential reduction in both hospital and family-associated costs. We recommend its use in carefully selected patients with adequate family support and sufficient educational and cultural resources.

Introduction

Pediatric patients with severe spinal deformities pose a considerable challenge in clinical and surgical practice. Halo gravity traction (HGT) is an established and commonly used method for the preoperative correction of these severe deformities.(1) The technique involves the placement of an HGT system in a hospital setting to increase spinal flexibility. In some severe cases, traction may be required for several months, and patients often remain hospitalized during this usually lengthy treatment period. Such extended hospitalization can adversely affect multiple domains, including child development (physical, social, and cognitive), economic factors (transportation, food, and loss of parental work), emotional and psychological well-being (anxiety and fear), family dynamics (logistical and emotional strain), social and

occupational integration of parents or caregivers, and clinical safety, particularly the risk of infection.(2–7)

In this context, and with the aim of optimizing patient management while facilitating earlier reintegration into school, social, and family environments, alternative strategies, such as care in lower-complexity settings or home-based traction programs, have been proposed.(2)

An outpatient protocol could facilitate treatment adherence in the pediatric population and, at the same time, be more functional for families and healthcare teams, thereby serving as a useful tool for standardizing medical criteria for traction management and contributing to patient and family education.(3)

The hypothesis of this study was that a home-based HGT management protocol would facilitate this preoperative stage without increasing complication rates, while achieving satisfactory deformity correction and significantly reducing costs for both families and the healthcare system, as suggested by previous reports in the literature.(4)

The objectives of this study were: (a) to develop a protocol for the outpatient management of HGT in pediatric patients with severe spinal deformity, enabling patients and their families to maintain social, educational, and work activities; and (b) to evaluate its feasibility and effectiveness, including the rate of deformity correction and associated complications, through its implementation in a cohort of pediatric patients at our hospital scheduled for surgery for severe kyphoscoliosis.

Materials and methods

A protocol for home-based HGT management was developed and divided into two phases. The first phase, or hospital phase, involves fitting the halo under general anesthesia or neurolept analgesia, using four to eight cranial pins tightened to a torque of six to eight inch-pounds. Pin position and fixation are checked and, if necessary, readjusted after twenty-four hours, unless earlier evidence of loosening or malposition is identified.

For a short period (three to five days), the patient remains hospitalized, alternating between supine and sitting positions while using the continuous HGT system in bed, in a chair, or in a standing frame. Traction weights in bed and chair are increased according to tolerance. This period is used to provide the patient and parents or caregivers with education on daily halo care and hygiene, as well as treatment guidelines and warning signs (red flags), including sensory, motor, or sphincter neurological deficits and surgical site infection, among others.

Traction is initiated with an average weight of three to five kilograms, corresponding to approximately 10% of total body weight. The traction load is then gradually increased by one kilogram every 24 to 48 hours, depending on patient tolerance and body weight. The maximum traction weight is set at up to 50% of the patient’s body weight, according to tolerance.

Halo gravity traction is applied for as many hours per day as tolerated, with continuous monitoring of patient comfort. Patients may temporarily disengage from the system to ambulate and perform basic personal hygiene activities. Respiratory physiotherapy is prescribed to optimize pulmonary and motor function, together with follow-up by the Nutrition Department to improve nutritional status and support from the Mental Health Department when indicated. The surgical team provides the patient and family with telephone contact details for medical emergencies while at home.

The second phase, or home phase, focuses on reinforcing the previously provided instructions and establishing remote monitoring for the early detection of complications. Clear guidelines are provided for scheduled clinical, neurological, and imaging assessments at the hospital, during which educational aspects, patient transfers, and treatment adherence are reviewed, and treatment effectiveness is evaluated.(6)

Emphasis is placed on the progression of traction weight, and alarm guidelines regarding potential neurological deficits (red flags) are reinforced. During the traction period, patients continue with weekly or biweekly outpatient follow-up visits. Respiratory physical therapy is maintained to optimize pulmonary status in the patient's city of origin, together with nutritional and mental health support as needed. Particular attention is given to regular pin-site hygiene to prevent infection or system malfunction. Pin adjustments are strictly limited to medical personnel.

Clinical and neurological assessments, imaging studies, patient transport to the hospital, and adherence to treatment are also monitored. During hospital visits, radiographs are obtained weekly or every two weeks throughout the traction period. For travel to medical appointments, patients may be temporarily disconnected from the system when using private or public ground transportation.

Patients are strongly encouraged to continue their schooling and social integration, and parents or caregivers are encouraged to maintain their work activities in their city of origin to avoid social, emotional, and educational isolation from peers and to minimize loss of productivity and work-related conflicts associated with parental absenteeism.

This original, simple, and reproducible protocol was implemented in a pediatric population at our hospital to evaluate its feasibility and effectiveness. All patients with spinal deformity undergoing home-based HGT at our surgical center between January 2020 and December 2024 were evaluated. A total of 43 patients aged between 5 and 18 years were followed. All patients were scheduled for primary spinal posterior fusion and presented with kyphosis and/or scoliosis greater than 90°, of idiopathic, neuromuscular, or syndromic etiology. Patients who understood the purpose of the study and had adequate sociocultural conditions for home management were included. Patients unable to attend regular hospital follow-up visits, those requiring prolonged hospitalization due to comorbidities, and those who did not adhere to the treatment protocol were excluded.

The following variables were reported: age, sex, underlying etiology, presence of scoliosis and/or kyphosis with corresponding angular values (AV) measured using the Cobb method, duration of traction

(weeks), traction weight (kg) relative to total body weight, curve correction on full-spine radiographs (Cobb angle), major complications (deep infection or neurologic injury), minor complications (superficial infection, pin loosening, ulceration), and the need for reintervention during treatment.

Approval was obtained from the hospital's Institutional Review Board to conduct this study, and informed consent was obtained from all patients and/or their parents or caregivers for participation in this home-based treatment protocol. IRB#175/22.

Results

Once the home-based HGT protocol was developed, it was implemented in a local cohort of 43 pediatric patients scheduled for spinal posterior fusion for severe scoliosis or kyphoscoliosis. Forty patients were finally assessed, as three were excluded due to non-adherence to halo-home treatment. Of these patients, 27 were female (67.5%) and 13 were male (32.5%). The mean age at the start of traction was 12 + 2 years (5.5–18 years). Reported etiologies were idiopathic scoliosis in six patients (15%), syndromic scoliosis in 24 patients (60%), including Goldenhar syndrome, Rett syndrome, DiGeorge syndrome, Prader-Willi syndrome, and unspecified genetic disorders, and neuromuscular scoliosis in 10 patients (25%).

Table 1.

The mean duration of traction was 14.7 weeks (4–57 weeks).The mean initial scoliosis angle was 106° (90°-144°). At the end of traction treatment, the mean scoliosis angle was 81° (71°-106°), with a median correction of 25° (11°-47°) between pre- and post-HGT measurements. The mean initial traction weight was 3 kg, and the final traction weight reached a mean of 46% (33%-60%) of the patient's total body weight.

At the end of the traction period, both coronal and sagittal plane corrections were documented in the medical records. During the first three weeks of treatment, at an average traction load of 46% of body weight, approximately 80% of the total correction in both planes was achieved; the remaining 20% occurred over the subsequent two weeks of HGT. Complications included the need for pin repositioning procedures in six (15%) and one case of superficial infection (2.5%), which resolved with local irrigation and debridement and oral antibiotic therapy. Complications are shown in Table 2.

Table 2
Complications.

Variables		min	max	Standard deviation
Mean traction time (weeks)	14.7	4	57	11.32409713
Mean scoliosis pre OP AV (Cobb-degrees)	106	90	144	16.10320125
Mean scoliosis post HGT AV (Cobb-degrees)	81	61	106	10.26274265
Mean HGT final weight in bed (%)	46	32	60	5.308010991
Mean HGT final weight in wheelchair (%)	46	32	60	5.489775689

Discussion

In line with the findings of Sink et al., the results of the present study support the hypothesis that HGT in a home setting represents a viable and effective alternative for the preoperative management of pediatric patients with severe kyphoscoliosis.(7) Park et al. reported that cost reduction, preservation of patients' social and educational integration, and the observed rate of deformity correction are notable advantages compared with traditional inpatient management.(8) We agree with the conclusions of these studies, as none of the 40 pediatric patients in our cohort experienced disruption of their educational or social environments remaining actively engaged in them, and no work-related difficulties were reported by parents or caregivers.

Davies et al., in a retrospective comparative study, evaluated outcomes, complications, and preoperative costs of HGT in inpatients versus outpatients treated in a hospital-affiliated residential facility. In a cohort of 29 patients with a mean traction duration of six weeks, they reported a low complication rate, including two cases of pin loosening in each group and one pin-site infection in the outpatient group. One neurological event occurred in each group, both of which resolved spontaneously after removal of the traction system. The average cost per hospitalized patient was 2.8 times higher than that of patients treated in the hospital-affiliated outpatient facility. Considering both complications and costs, the authors concluded that outpatient HGT represents a reasonable treatment option.(2) In line with these findings, we propose extending this approach to a fully home-based HGT program, aiming to achieve results comparable to those of hospitalized patients in terms of both deformity correction and complication rates.

One of the most important findings of this study is that the correction achieved with home-based HGT compares favorably with that reported for hospital-based traction. On average, a substantial reduction in deformity was obtained within the first three weeks of treatment using approximately 41% of the body weight in the traction system. These findings indicate that, when applied under an appropriate and structured protocol, outpatient HGT can achieve deformity correction comparable to that obtained during prolonged hospitalization, as reported in the international literature. Furthermore, weekly or biweekly clinical follow-up enabled early identification of complications and timely adjustment of treatment,

suggesting that management in the home environment does not increase complication risk.(2, 9–14) Overall, the data regarding the effectiveness of HGT in the treatment of kyphoscoliosis are encouraging. Both the rate of deformity correction and the management of complications appear comparable to hospital-based treatment, consistent with the findings reported by Li et al., supporting the viability of this alternative approach.(12)

The implementation of a rigorous monitoring and follow-up system—including regular neurological assessments, nutritional support, respiratory physiotherapy, and mental health care, together with continuous telephone availability of the clinical team—was crucial to the success of home-based treatment. This comprehensive approach not only ensured patient safety and well-being, but also optimized preoperative preparation and contributed to a reduction in associated costs. Infections, pin loosening, and non-adherence to the halo system were observed; however, appropriate management prevented major complications, reinforcing the importance of close clinical follow-up and thorough family training within the protocol. These findings are consistent with reports in the literature describing inpatient management.(15–18) On the other hand, it should be emphasized that the proposed home-based HGT protocol represents a significant improvement in the care of pediatric patients with severe spinal deformities. By allowing treatment to be delivered in the home setting, social, educational, and family relationships can be preserved.(4) We believe that our findings support this benefit and demonstrate that this objective was achieved in our cohort.

In another study, Frank et al.(4) evaluated the development of a device for continuous traction monitoring in pediatric patients with severe scoliosis, acknowledging that the traditional setting for HGT-based deformity correction is hospitalization. Five patients with severe scoliosis undergoing home traction were assessed using the device during both wheelchair-based and bed traction. No significant complications were reported, and the study demonstrated that home traction is feasible when supported by continuous monitoring with this device.

This study has certain limitations inherent to its design, including a relatively small sample size, patient heterogeneity, and the absence of a device for real-time monitoring of traction in the home setting due to technical constraints. However, despite these limitations, the preliminary findings suggest that home-based HGT could become a valuable tool within the therapeutic option for the management of severe spinal deformities, offering a safe and effective alternative to conventional methods. Among its strengths, this study is the first to propose and implement a structured home-based HGT management protocol for severe kyphoscoliosis in a pediatric population, achieving satisfactory clinical outcomes.

Conclusions

Our results indicate that preoperative home-HGT, using a simple, and reproducible protocol, represents a viable option for the management of severe kyphosis and scoliosis in the pediatric population, given the achieved deformity correction, acceptable complication rates, and the potential reduction in hospital, family, and healthcare system costs.

Declarations

Statements, declaration of interest and funding

Authors have nothing to declare.

No funding was received during the conduct of this study.

Author Contribution

Design of study: A,B,C,EConsulting references: B,C,D,AParticipation in draft manuscript: C,B,D,E,ARevise manuscript: C,E,D,AApproved the final version of the paper: A,C,B,E,DJose Luis Melgarejo ALucas Piantoni BCarlos A Tello CEduardo Galaretto DRodrigo Remondino E

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Supplementary Files

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- ESJTable1HGTDemographics.xlsx