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Posterior Focal Curettage and Spine Stability Reconstruction by Temporary Pedicle Screw Fixation in Children With Collapsed Vertebrae due to Eosinophilic Granuloma

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Abstract

Study Design: Retrospective case series.

Objectives: To evaluate the efficacy of growth-preserving posterior spinal column reconstruction surgery in children with collapsed vertebral eosinophilic granuloma (EG).

Methods: We retrospectively reviewed 15 confirmed cases of vertebral EG who met the inclusion and exclusion criteria from March 2015 to March 2018 in our hospital. The recovery of diseased vertebrae was assessed.

Results: The cases were composed of 11 males and 4 females with a mean age of 74.3 $\pm$ 38.8 months. Nine cases presented with thoracic vertebral destruction, 6 cases with lumbar vertebral destruction. Under Garg's classification, 10, 3 and 2 cases were classified as Grade IIA, IB and IIB lesions, respectively. All patients had mild to moderate night-aggravated back pain and recovered at 1-week after surgery. Three patients had Frankel D neurologic symptoms and recovered at 1-week, 1-week and 4-weeks after surgery, respectively. Follow-up time after surgery ranged from 1.9 years to 4.5 years, with a mean of 2.9 years. The median vertebral height at 12 months after surgery was significantly higher than the preoperative height. Furthermore, the vertebral heights of all diseased vertebrae displayed significant recovery trends at 3, 6 and 12 months after surgical treatment. The percentages of vertebral height recovery to references at 12 months after surgery ranged from 34.7% to 92.5%, with an average of 71.2%.

Conclusions: In children with collapsed vertebral EGs, active surgical treatment is necessary to retain the ability to restore height and to reconstruct the spine stability.

Keywords

eosinophilic granuloma, pathological vertebral body fracture, operative therapy, vertebral remodeling, child

Introduction

Langerhans cell histiocytosis (LCH) refers to the accumulation of dendritic cells with features similar to epidermal Langerhans cells in various organs.[1,2] Although LCH is a rare disease and any organ or system of the human body can be affected, the skeleton is most frequently involved and accounts for 80% of identified cases.[1,2] The clinical course is determined by the diseased organ or system and may vary from a self-limiting disease to a rapidly progressive one that might lead to permanent adverse sequelae (30-40%) or even death.[1,2]

LCH occurring in the skeletal system (also called bone eosinophilic granuloma [EG]) is seen more commonly in children or young adults, although it may be found at all ages.[1-4] EG is a common cause of vertebral destruction in children.[5] Due to its low clinical incidence, especially in the spine, and its nonspecific osteolytic performance, EG is difficult to clearly and

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timely diagnose.[1-3] Treatment options for EG vary depending on the extent of the disease and severity at onset.[1] Currently, the regimen of vinblastine and prednisone is a first-line treatment for multisystem LCH[1,6,7]; yet, no therapeutic strategy has been verified through clinical trials.[1] In addition, it is unclear whether spinal EG should be treated actively with surgery, and reports of this technique are relatively rare.[1-3]

Thus, for patients with local spinal kyphosis and even nerve symptoms due to EG-related vertebral damage, focal resection and temporary pedicle screw fixation can relieve local compression and improve nerve symptoms. Furthermore, spine stability reconstruction through temporary pedicle screw fixation in children with collapsed vertebral EG can reduce kyphosis and stabilize the spine.

In our hospital, posterior focal curettage with preservation of the vertebral epiphysis and temporary pedicle screw fixation with slight distraction has been implemented since 2015. This early report summarized the outcome of 15 children with vertebral EG treated with this strategy.

Materials and Methods

This study was approved by the relevant Institutional Review Board and was conducted according to the principles set forth in the Declaration of Helsinki for medical research involving human subjects. Written informed consent was obtained from the parents of each child for the publication of their clinical data and medical images. Parents were informed of their right to withdraw consent personally or via relatives, a caretaker, or a guardian.

Participants

We retrospectively reviewed all 37 cases who were diagnosed with spinal lesion between March 2015 to March 2018 in our institution. Inclusion criteria included (1) medical imaging showed collapsed vertebral; (2) biopsy and histological and immunophenotypic examinations confirmed vertebral EG; and (3) treated by posterior focal curettage with preservation of the vertebral epiphysis and temporary pedicle screw fixation. Exclusion criteria included: (1) patients didn't receive surgical treatment;(2) presence of congenital spinal malformations; and (3) follow-up for less than 1 year. A total of 15 cases who met the criteria were included in this study. Clinical information was collected from the records, including age, sex, medical history, symptoms, neurological findings, radiographs, CT and MR images.

The patients received routine spinal, skull, limb and pelvic plain radiography examinations; local computed tomography (CT) and magnetic resonance imaging (MRI); and whole-body bone scintigraphy preoperatively.

The vertebrae adjacent to the upper instrumented vertebrae were selected for reference of normal vertebral height (to eliminate the effect of internal fixation). The height of both the diseased and reference vertebrae were calculated by taking the average value of the anterior and posterior heights of the vertebral body.

Garg's Classification System[8] was used for radiographic classification of maximal vertebral collapse. Grade-I lesions have 0% to 50% collapse, and grade-II lesions have 51% to 100% collapse. The lesion is also graded as either A (symmetric) or B (asymmetric), on the basis of the morphology of the vertebral collapse. Grade-III lesions involve the posterior elements of the vertebra and are not subclassified as A or B.

Operative Procedure

The indication of the procedure includes (1) patients with vertebral body compression greater than 50% or kyphosis angle of more than 30 degrees and (2) worsened symptoms or image evidence after conservative treatment for 3 months, or (3) with neurological symptoms. The main steps and purpose of current surgical treatment are (1) posterior surgery exposes the diseased vertebrae; (2) biopsy and histological examination confirms vertebral EG; (3) posterior focal curettage with preservation of the vertebral epiphysis; (4) temporary pedicle screw fixation with slight distraction for 1 year. For convenience, we named our strategy growth-preserving posterior spinal column reconstruction surgery (GPPSCR). Intraoperative biopsy with frozen pathology was performed by the Department of Pathology in our hospital to obtain an accurate diagnosis. Patients were placed in a prone position under general anesthesia. A midline incision was made between the adjacent segments above and below the lesion site. After exposure of the diseased vertebra, the lesions were scraped off from the vertebral body transpedicular and then sent for pathological examination. Monoaxial pedicle screws with 3.5mm to 5.0mm diameter, determined by the spinal levels and age, were then implanted in the adjacent vertebrae. Then, physiological arc pre-bent rods were placed into screw ends, with distraction to restore the intervertebral height to the same as the reference height before the caps were locked. Two lateral x-ray film were performed before and after the distraction respectively. Then the interval heights of anterior and posterior vertebral bodies were measured and compared to ensure an equal distraction on both the anterior and posterior vertebral bodies. After reconstruction of spinal stability, the lesion curettage and neural decompression were performed. Great attention was paid to protect and retain the epiphyses of the vertebrae, as no bone graft or fusion or posterior decompression was performed.

The patients who completed chemotherapy and were followed up for more than 1 year, with vertebral height recovery greater than 50% as the reference vertebral height, received internal fixation removal surgery through the original incision.

Postoperative Care and Follow-Up

After the first surgery, patients were encouraged to exercise as early as possible. A brace was used for 3 months. Chemotherapy was initiated 2 weeks after surgery according to the

Table 1. Summary of Clinical Features.

Case no.	Sex	Age at operation (months)	Diseased level	Grades	Duration of operation (minutes)	Reference level	Stabilization level	Vertebral body height to reference before operation	Vertebral body height to reference 1-year after operation	Duration of follow-up (years)
1	M	56	L5	IIA	180	L3	L4, S1	21.6%	51.8%	4.5
2	M	93	L4	IB	116	L2	L3, L5	79.1%	92.5%	4.3
3	M	56	T10*	IIA	120	T8	T9, T11	2.8%	34.7%	4.1
4	M	62	T8	IB	120	T6	T7, T9	54.3%	71.2%	3.7
5	F	142	L3	IIA	99	L1	L2, L4	30.0%	72.2%	3.7
6	M	25	T11	IIB	120	T9	T10, T12	10.6%	89.2%	3.1
7	F	118	L4	IIA	141	L2	L3, L5	28.6%	51.9%	3.1
8	M	78	T7	IIA	124	T5	T6, T8	22.8%	56.3%	2.3
9	M	31	L3	IIA	102	L1	L2, L4	42.0%	83.3%	2.2
10	M	130	T5	IIA	70	T3	T4, T6	8.6%	62.6%	2.2
11	M	48	T12	IB	118	T10	T11, L1	59.9%	86.2%	2.2
12	F	41	L3	IIB	155	L1	L2, L4	50.3%	92.1%	2.1
13	F	119	T4	IIA	186	T2	T2, T5	41.1%	70.5%	2.1
14	M	18	T10	IIA	98	T8	T9, T11	25.8%	75.4%	2.0
15	M	97	T9	IIA	94	T7	T8, T10	46.2%	76.4%	1.9

* Patient with multiple bone damage at C2–4, T10 and L5, with collapse of T10 and otherwise minor bone damage.

DAL-HX90 protocol.[9] The follow-up interval was 3 months within the first year and, after that, every 12 months.

Statistical Analysis

We treated our data as non-independent data with unknown distribution, continuous data in descriptive statistics is presented as the mean ± standard deviation to be easy to understand, and classified data is expressed as frequencies. Nonparametric tests were applied. To observe significance in the recovery trends, the Friedman 2-way ANOVA test on the four chronological vertebral heights was performed. To determine the difference between the preoperative vertebral heights and vertebral heights 12 months after surgery, the Wilcoxon signed rank test on the median was applied. Significance was considered when $P < 0.05$. Statistical analysis was performed using SPSS 22.0 software.

Results

General Clinical Features of GPPSCR-Treated Patients

The cohort consists of 11 males and 4 females, with an average age of 74.3 ± 38.8 months at the time of diagnosis (Table 1). There were 9 and 6 cases of thoracic and lumbar vertebral destruction. Under Garg's Classification, 10, 3 and 2 cases belonged to grades IIA, IB and IIB, respectively. All patients had mild to moderate back pain, which was aggravated at night. Three cases had Frankel D neurologic symptoms. One case had multiple bone damage at C2–4, T10 and L5, with collapse of T10 and otherwise minor bone damage.

The follow-up interval was 3 months within the first year and then every 12 months. The follow-up duration ranged from 1.9 to 4.5 years, with a mean of 2.9 years. Plain radiography examinations were performed and the heights of effected and referred vertebrae were measured at each return visit (Figure 1). No significant complications or additional surgeries were recorded during follow-up.

Evaluation of GPPSCR. Of all patients, the symptom of back pain recovered 1 week after surgery, and the 3 cases of neurologic symptoms recovered at 1-week, 1-week and 4-weeks after surgery, respectively. The heights of diseased vertebrae before surgery ranged from 0.3mm to 17.0mm and displayed grade IB, IIB, and IIA vertebral collapse when compared to the corresponding reference vertebral heights. In general, vertebral EG after surgery displayed a trend in recovery of vertebral heights at 3, 6 and 12 months after surgery, although the recovery rates differed by case and by vertebrae. The Friedman 2-way ANOVA test on the 4 chronological vertebral heights displayed significant recovery trends ($P < 0.001$), and the Wilcoxon signed rank test on the median of preoperative vertebral heights and vertebral heights at 12 months after surgery also showed a significant increase in vertebral heights ($P = 0.001$) (Figure 2A). The corresponding heights of reference at each of the 4 time points were also plotted. Since these heights were for reference only and the vertebrae were located in different locations, we did not advocate that these references be used for the comparison analysis (Figure 2B). An extreme case was the aforementioned patient with multiple vertebrae damaged, with collapse of T10 (height of 0.3 mm) and otherwise minor bone damage in the rest of the vertebrae; the surgery on T10 led to height recovery to 1.3, 2.8 and 4.2 mm at 3, 6 and 12 months after surgery, respectively.

Outcome summary by grade. As shown in Table 2, there are 3, 10 and 2 cases of Grade IB, IIA and IIB, respectively. Of these, 2 and 1, 6 and 4, and 1 and 1 were thoracic and lumbar EG, respectively. The vertebral height recovery percentages to reference vertebrae of Grade IB, IIA and IIB were 71.2 ~ 92.5%, 34.7 ~ 83.3% and 89.2 ~ 92.1%, respectively. The ratio of

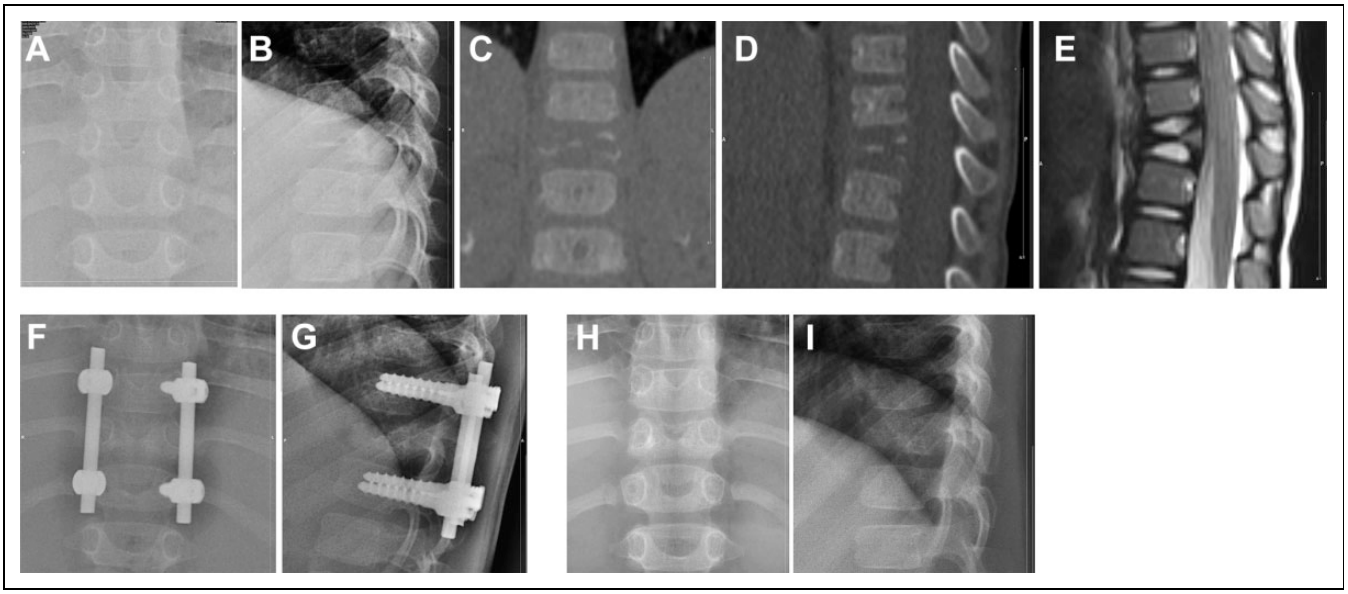

Figure 1. An instance of surgical treatment in a 2-year-old boy with EG. A and B, lateral plain radiography shows collapsed T11. C and D, CT scan shows diseased vertebrae. E, T2-weighted MRI demonstrates a grade IIB lesion of T11. F and G, progress at follow-up 1-year after surgery. H and I, progress at follow-up 3 years after surgery, shows almost complete remodeling of the vertebra.

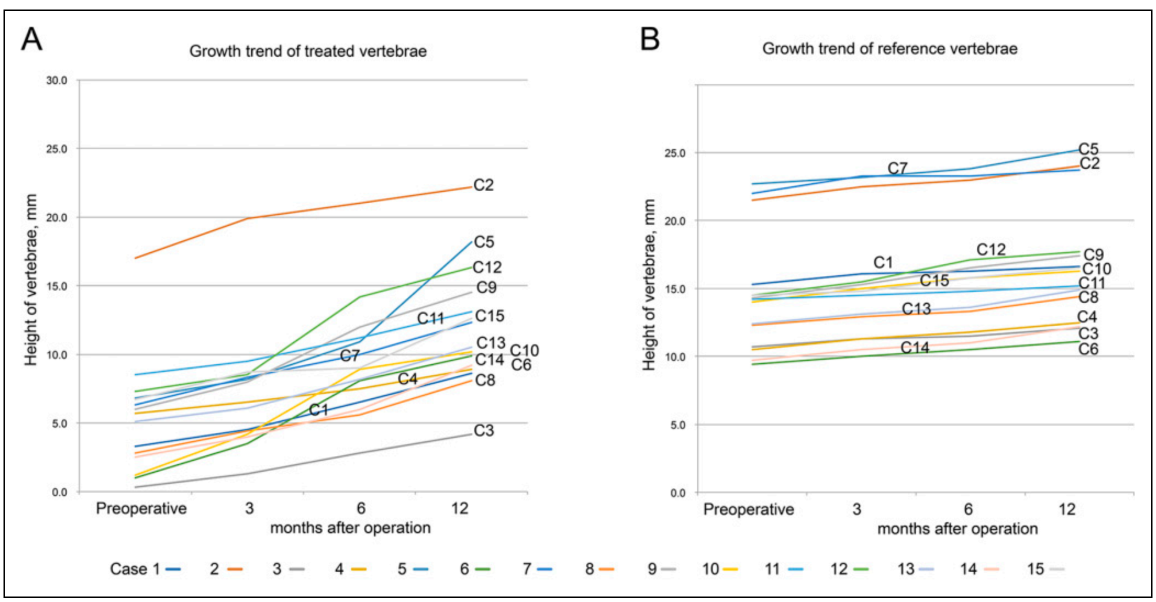

Figure 2. The recovery trend of vertebral EG after surgical treatment. The heights of diseased vertebrae and corresponding references at preoperative and 3, 6 and 12 months after surgery were measured and plotted. The trend of each case was labeled with "C & case number." A, vertebrae with EG treated with active surgical intervention; the recovery of vertebral EG displayed significant trends when evaluated by Friedman 2-way ANOVA test. B, corresponding reference vertebrae.

vertebral height 1 year after surgery to that before surgery were 1.3 ∼ 1.6, 1.9 ∼ 14.0, and 2.2 ∼ 9.9, respectively; the corresponding growth ratio of reference vertebral heights were 1.1 ∼ 1.2, 1.1 ∼ 1.3, and 1.2 ∼ 1.2, respectively. A nonparametric Wilcoxon signed ranks test showed that the growth rates of Grade IB and IIA treated by surgery were significantly higher than the reference rates. No significant difference was found in the ratio of Grade IIB treated by surgery, and this finding might be caused by small sample size ($N = 2$). Taken together, treatment with GPPSCR displayed satisfactory spine stability reconstruction.

Discussion

Conservative treatment, surgical treatment, chemotherapy and radiotherapy are 4 major therapeutic strategies for pediatric

Table 2. Summary of Outcome by Lesion Grade.

	IB	IIA	IIB
Number of cases	3	10	2
Thoracic case/lumbar case	2/1	6/4	1/1
Male/female	3/0	7/3	1/1
Vertebral height recovery to reference, %	71.2 ∼ 92.5	34.7 ∼ 83.3	89.2 ∼ 92.1
The ratio of vertebral height 1 year after surgery to that before surgery	1.3 ∼ 1.6*	1.9 ∼ 14.0*	2.2 ∼ 9.9
The corresponding growth ratio of the reference vertebral height	1.1 ∼ 1.2	1.1 ∼ 1.3	1.2 ∼ 1.2

* indicates $P < 0.05$ compared to corresponding reference vertebral indexes. Continuous data was presented by range from lowest to highest.

spinal EG at present.[1,10,11] The conservative treatments, such as bed immobilization, braces and acesodyne medication, should be used for patients with good spinal stability and without spinal deformity or neurological symptoms, because EG has certain self-limitations.[10,11] For patients have spinal deformity or worsened pathological evidence or poor curative effect after conservative treatment, surgical treatment should be adopted.[12] For patients have nerve injury, Raab proposed that surgical decompression should be actively carried out.[13] For the choice of surgical methods, some researchers suggest that such patients should be treated with margin resection or radical resection followed by bone graft, fusion and internal fixation.[12] However, in a growing child, premature fusion of the spine may affect the normal development of the fused vertebra and contribute to the degeneration of the adjacent segments of the fusion segment.

In our hospital, patients with EG, with or without spine involved, were mainly treated with chemotherapy after percutaneous biopsy. The purpose of GPPSCR treatment, through timely surgical intervention, is to maintain the normal anatomical structure and function of the vertebral body and to avoid degenerative changes of spine. For the patients who met the aforementioned surgical indications, posterior instrumentation of the spine was adopted, and biopsy of the diseased vertebral body was performed during surgery to make a definite diagnosis. The neurological symptoms and back pain of all the children were disappeared completely after surgery. Destruction of spinal stability is a common manifestation of EG however, the vertebral end plates are usually left unaffected by the disease process itself. So, the vertebral bodies will continue grow with age and are able to undergo self-reconstruction.[8] The potential for vertebral body reconstruction in younger children is the best.[14] As a result, bone grafting and interbody fusion were not employed in this study.

The vertebral body destruction may accelerate the progression of degenerative disorders of spine. Data from some studies revealed, without description of classification, the average recovery percentage was 67% (average 5.6-year follow-up)[14] and 57% (average 7-year follow-up).[15] In contrast, in this study the vertebral height recovery percentages of whole, Grade I and Grade II were 71.2% (range, 34.7%-92.5%), 83.3% (range, 71.2%∼92.5%) and 68.0% (range, 34.7%∼92.1%) at 1-year follow-up, respectively. It seems that the GPPSCR contributes to faster and better recovery of vertebral heights, especially in severe cases. Therefore, although the long-term follow-up to learn the effect of our GPPSCR is still needed, we believe that our approach, posterior focal curettage with preservation of the vertebral epiphysis and temporary pedicle screws fixation with distraction for 12 months, may be the suggested surgical strategy for the treatment of children with collapsed vertebrae due to EG.

We had reported that LCH graded chemotherapy can prevent the spread of lesions and control or even cure the disease.[16] All the children in this study were treated with DAL-HX90 chemotherapeutic regimen initiated 2 weeks after surgery in the outpatient department of our hospital, and the chemotherapy regimens were adjusted according to personalized conditions. No new EG lesion was found. Nevertheless, it should be noted that, according to our hospital's long-term experience, the recovery of vertebral structure and function is mainly due to our active surgical intervention.

Some limitations of this study, common to retrospective research, can't be ignored. Firstly, the data is only as precise as the available medical records. Secondly, the conclusion has limited power and low evidence grade as a result of relatively small case numbers and shorted follow-up period.

Conclusions

The results suggest the concept that surgical treatment is beneficial for those EG patients who failed conservative treatment with symptoms like spinal deformity or neurological sign. GPPSCR makes it possible to take a biopsy and treat the lesion directly. By preserving the epiphysis of the diseased vertebra, GPPSCR retains the ability to restore the height of the vertebra, and distraction of the adjacent segments during the surgery leaves space for vertebral height recovery, which may avoid further compression and collapse of the vertebrae and neurological impairment. In children with collapsed vertebral EGs, active surgical treatment is advised to retain the ability to restore vertebral height and to reconstruct the spine stability.

Declaration of Conflicting Interests

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References

1. Haupt R, Minkov M, Astigarraga I, et al. Langerhans cell histiocytosis (LCH): guidelines for diagnosis, clinical work-up, and treatment for patients till the age of 18 years. *Pediatr Blood Cancer*. 2013;60(2):175-184.
2. Girschikofsky M, Arico M, Castillo D, et al. Management of adult patients with Langerhans cell histiocytosis: recommendations from an expert panel on behalf of Euro-Histio-Net. *Orphanet J Rare Dis*. 2013;8:72. Published 2013 May 14. doi:10.1186/1750-1172-8-72.
3. Prasad GL, Divya S. Eosinophilic Granuloma of the Cervical Spine in Adults: A Review. *World Neurosurg*. 2019;125:301-311. doi:10.1016/j.wneu.2019.01.230.
4. Brown CW, Jarvis JG, Letts M, et al. Treatment and outcome of vertebral Langerhans cell histiocytosis at the Children's Hospital of Eastern Ontario. *Can J Surg*. 2005;48(3):230-236.
5. Osenbach RK, Youngblood LA, Menezes AH. Atlanto-axial instability secondary to solitary eosinophilic granuloma of C2 in a 12-year-old girl. *J Spinal Disord*. 1990;3(4):408-412.
6. Ng Wing Tin S, Martin-Duverneuil N, Idbaih A, et al. Efficacy of vinblastine in central nervous system Langerhans cell histiocytosis: a nationwide retrospective study. *Orphanet J Rare Dis*. 2011;6:83. Published 2011 Dec 12. doi:10.1186/1750-1172-6-83.
7. Dhall G, Finlay JL, Dunkel IJ, et al. Analysis of outcome for patients with mass lesions of the central nervous system due to Langerhans cell histiocytosis treated with 2-chlorodeoxyadenosine. *Pediatr Blood Cancer*. 2008;50:72-79. doi:10.1002/pbc.21225.
8. Garg S, Mehta S, Dormans JP. Langerhans cell histiocytosis of the spine in children. Long-term follow-up. *J Bone Joint Surg Am*. 2004;86(8):1740-1750.
9. Minkov M, Grois N, Heitger A, Pötschger U, Westermeier T, Gadner H. Treatment of multisystem Langerhans cell histiocytosis. Results of the DAL-HX 83 and DAL-HX 90 studies. *Klin Padiatr*. 2000;212(4):139-144.
10. Erol B, Sofulu Ö, Topkar MO, Caliskan E, Turkoz HK. Long-term follow-up of long and flat bone eosinophilic granulomas managed only with biopsy. *Acta Orthop Traumatol Turc*. 2015;49(2):144-150.
11. Mammano S, Candiotto S, Balsano M. Cast and brace treatment of eosinophilic granuloma of the spine: long-term follow-up. *J Pediatr Orthop*. 1997;17(6):821-1827.
12. Knoeller SM, Uhl M, Adler CP, Herget GW. Differential diagnosis of benign tumors and tumor-like lesions in the spine. Own cases and review of the literature. *Neoplasma*. 2004;51(2):117-126.
13. Raab P, Hohmann F, Kühl J, Krauspe R. Vertebral remodeling in eosinophilic granuloma of the spine. A long-term follow-up. *Spine (Phila Pa 1976)*. 1998;23(12):1351-1354.
14. Ippolito E, Farsetti P, Tudisco C. Vertebra plana. Long-term follow-up in five patients. *J Bone Joint Surg Am*. 1984;66(9):1364-1368.
15. Naoyuki N, Yutaka I, Yoichi A, Machida J, Saito T. Characteristic reconstitution of the spinal langerhans cell histiocytosis in young children. *J Pediatr Orthop*. 2019;39(4):e308-e311.
16. Wang DH, Chen Q, Ma RX, et al. Clinical analysis of chemotherapy for eosinophilic granuloma of bone in children. *J Clin Ped Sur*. 2005;4(1):14-17.