

Elastic Intramedullary Nail Drainage in the Treatment of Long Bone Cyst with Pathological Fracture in Children

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Abstract: Background: Unilateral bone cyst (UBC) is a common lesion in children. Currently, the commonly used treatment methods for UBC have the defects of large surgical trauma and high recurrence rate. Objective: To investigate the effect of elastic intramedullary nail in the treatment of long bone cyst in children with pathological fracture. Methods: 11 patients with pathological fracture long bone cyst were treated with elastic intramedullary nail. There are 7 men and 4 women. The age ranged from 6 to 12 years, with a mean age of 7.6 years. There were 3 cases of proximal humerus, 2 cases of middle humerus, 1 case of whole humerus, 2 cases of proximal femur, 1 case of middle femur, and 2 cases of middle tibia. Results: t test was performed on the remaining static penetration area of the cyst measured at two adjacent time points using SPSS25 statistical software. $P < 0.05$ was considered statistically significant. Results All the 11 patients were followed up for 4 to 24 months, with an average of 12 months. The cyst healed in 4 cases (36.3%), the defect healed in 4 cases (36.3%), the healing rate was 72.7%, and 3 cases were sustained (1 case was followed up for 4 months). Discussion: Minimally invasive elastic nail fixation is effective in the treatment of bone cyst. However, the limitations of this study are influenced by the duration of follow-up, which is still ongoing for some UBC children. Long-term elastic titanium intramedullary nail implantation in the treatment of long bone cyst has the characteristics of single intervention, small injury, good stability and prevention of pathological fracture.

Keywords: Elastic Intramedullary Nail, Internal Drainage, Bone Cyst, Pathological Fracture

1. Introduction

Unicameral bone cysts (UBC) are common lesions in children and are more consistent with developmental or reactive changes than true tumors. The disease occurs in all bones of the extremities, and is most common in children and adolescents, especially in the proximal humerus and femur. Bone cysts can also be reported in metacarpals [1]. The lesions are active during bone growth and development and heal themselves after maturation [2]. The disease was first described in 1876. According to epidemiological statistics, UBC often occurs in children aged 5-15 (mean 9 years old), with a ratio of 2:1 to 2:1. Bone cysts in children are often discovered by chance on an X-ray or after a pathological fracture [3]. The most common clinical manifestations of UBC are local pain caused by minor trauma, pathological fracture on X-ray films, and a few are found by routine radiographs. Although UBC tends to heal after bone maturation, it can cause repeated pathological fracture and

growth inhibition before bone maturation, while only 14.8% of the patients can spontaneously heal after pathological fracture, and repeated pathological fracture occurs. Internal cysts located 1cm in the epiphyseal plate were active cysts, while those closer to the diaphysis were static cysts [4]. Diagnosis and treatment of UBC vary, but minimally invasive techniques have recently become more important in cases requiring surgery [5]. Therefore, children UBC should be actively treated. At present, capsule decompression, open curettage and bone grafting, capsular drilling with indwelling Kert wires, hollow nail continuous decompression and drainage, intramedullary nailing and other methods are generally adopted for UBC treatment [6], but these methods have large surgical trauma and high recurrence rate. The cases of children with UBC treated by Dabor titanium elastic intramedullary nail with simple internal drainage in our hospital were analyzed and summarized, and the therapeutic

effect and characteristics of this method were discussed.

2. Data and Methods

2.1. General Information

From February 2010 to December 2020, 11 children with UBC were treated in our department, including 7 males and 4 females. The age ranged from 6 to 12 years, with a mean age of 7.6 years. There were 3 cases of proximal humerus at UBC, 2 cases of middle humerus, 1 case of full humerus, 2 cases of proximal femur, 1 case of middle femur, and 2 cases of middle tibia. According to Neer and other criteria, 4 cases were active and 7 cases were quiescent. In 6 cases (54.5%), lesions accompanied by pathological fractures were found for the first time due to local pain after low-energy injury. Pathological fracture occurred in 2 cases during the follow-up of conservative treatment (pathological fracture occurred after trauma and then underwent surgical treatment), accounting for 18.2%; Two patients with UBC combined with fracture underwent puncture biopsy to extract bloody fluid, and one patient without fracture underwent puncture biopsy to extract pale yellow fluid. CT or MR May assist in diagnosis. Radiographs: The lesion is a central, simple osteolytic lesion with clear boundaries. Sometimes, separated bone crista are visible to make it multilocular. The lesion may expand and grow, but does not penetrate the cortex.

2.2. Treatment

All patients were treated with closed elastic intramedullary nails, and the cyst lesion was not treated.

Elastic intramedullary nail with rubo titanium: Two titanium elastic intramedullary nails occupying 2/3 of the diameter of the medullary cavity were selected according to the preoperative X-ray film. The femoral entry point was located about 1.5cm near the epiphyseal plate of the distal

femur, the distal humerus entry point was located about 2cm below the epiphyseal of the proximal humerus, and the upper and lower levels of the proximal humerus entry points were about 1.5cm apart, respectively. In case the cortex splits. The intramedullary nail should be placed after proper prebending. Due to the thin cortical margin of bone cyst and easy penetration, fluoroscopy should be performed during implantation to ensure that the intramedullary nail is located in the medullary cavity and does not damage the epiphyseal plate. When the intramedullary nail head passes through the cyst cavity, it can be moderately rotated under fluoroscopy to destroy the cyst wall and clear the cyst cavity. Leave the nail tail about 1cm outside the bone cortex and cover it with muscle and fascia to prevent skin irritation.

2.3. Postoperative Management

For children with pathological fractures, if the UBC is located in the lower extremity, the plaster or brace of the hip is used for postoperative fixation, and the cast or brace is removed after fixation for 4-6 weeks according to the fracture and fracture healing. If the UBC was located in the upper limb, the upper limb was protected for 4 weeks after surgery with a suppositories of the shoulder joint. Children without pathological fracture can resume daily activities after surgery.

2.4. Evaluation Criteria

Radiographs were taken before surgery and at 1, 3, 6, 12, and 24 months after surgery (annual review in the later stage), and the healing of bone cyst was evaluated according to postoperative X-ray findings and Chang et al. 's evaluation criteria for X-ray healing of bone cyst (Table 1). PACS image analysis system (Haina Yinxin Beijing Software Technology Co., LTD.) was used to measure the area of the remaining still light transmittable area of the cyst shown by positive position X-ray at different time points.

Table 1. Classification of evaluation criteria for X-ray healing of bone cyst.

classification	X-ray manifestation
Cyst healing	New bone was formed in the cyst, and the area of residual static light transmittance was less than 1cm
Defect healing	The residual static light zone is less than 50% of the diameter of the bone, and the bone cortex is sufficient to prevent pathological fracture
persistent existence	The residual static light transmittance area is greater than 50% of the bone diameter. The bone cortex is thinner. The cyst is no longer enlarged, but it needs to be limited in movement or treated
Cyst recurrence	The cyst reappears in the area of healing or the area of residual static light transmittance increases

3. Result

SPSS25 statistical software was used to perform t test on the area of the cyst residual static transmittance measured at two adjacent time points. $P < 0.05$ was considered statistically significant.

Results All the 11 cases were followed up for 4~24 months (mean 12 months). According to the evaluation criteria of Chang et al., 4 cases (36.3%) of the cyst were healed, 4 cases (36.3%) of the defect was healed, the healing rate was 72.7%, and 3 cases were sustained (1 of them was followed up for 4

months). The measurement showed that the area of the residual light penetrating area of the cyst gradually decreased, the center of the cyst cavity gradually moved away from the epiphysis plate, and no bone bridge formation was observed in the epiphysis. The comparison of the area of the residual static light penetrating area of the cyst at different time points showed statistically significant differences. The elastic intramedullary nails were placed for a long time. Postoperative nail tail skin irritation occurred in 1 patient, no other complications were found, and no pathological fracture occurred. At the last follow-up, no malformation occurred in the patients.

4. Discussion

4.1. Pathogenesis of UBC

The pathogenesis of this disease is still unknown. The widely accepted theory is that focal defects during remodeling of the metaphyseal block the return of interstitial fluid, resulting in increased pressure, focal necrosis, and accumulation of interstitial fluid.

4.2. Treatment for UBC

Open curettage and bone grafting: It is the traditional method of UBC treatment. The recurrence rate after surgery is about 50%, so most scholars believe that it should not be used as the first choice therapy.

Transcutaneous cavity aspiration injection: The main idea is to inhibit bone resorption or promote bone formation. Compared with open surgery, this method has less trauma and fewer complications, and the final treatment result is no less than that of open surgery, but its single intervention effect (especially hormone) is not satisfactory. (1) **Hormone injection therapy [7]:** The theory is that hormone can promote the degeneration of the wall membrane, thus inhibiting the formation of cyst fluid, reducing the absorption of bone damage, and restoring osteogenic activities. The study included 129 pediatric patients with UBC treated at the University Children's Hospital of Belgrade over an 8-year period using three approaches, in which intracyclic methylprednone acetate drip was a good choice for initial treatment of UBC, complete healing of UBC was required by open surgery, and intracyclic methylprednone acetate drip was a good choice for initial treatment of UBC [8]. Liu Q et al. evaluated the feasibility of minimally invasive surgery to control the progression of active single-ocular bone cyst (AUBC) by intrasular methylprednisolone injection, percutaneous curettage, and autologous bone marrow transplantation [9]. In short, hormone treatment of bone cysts has a long cycle and uncertain efficacy. 50% to 76% require multiple treatments, and an average of 3 injections are usually required to achieve satisfactory healing, but the recurrence rate is still 15% to 88%, and about 10% of patients do not respond to treatment. Bezirgan U et al. were able to monitor VEGF-A to evaluate the effect of steroid injections on bone cysts [10]. (2) **Autologous bone marrow capsular injection [11]:** The idea of treatment is to stimulate bone formation and temporary capsular decompression under the action of osteogenic elements in the bone marrow. Since the healing rate after a single injection of autologous bone marrow is about 60%, most scholars believe that its curative effect is better than hormone injection therapy. (3) **Continuous decompression of the capsular cavity:** It is an improved method of decompression of the capsular cavity, including porous indwelling needle, hollow nail and intramedullary nail continuous decompression. (4) **Minimally invasive bone transplantation:** Nunziato C et al. have investigated that the treatment of UBC with SBGS may reduce the reoperation

rate [12]. Studies on Rajeswaran S have found that X-guided chemical sclerosis and bone graft have advantages as the minimally invasive treatment of monococular bone cyst [13]. Sivakumar B et al. found that bone replacement injection is a potential minimally invasive technique for the treatment of bone cysts [14], and Karr JC et al. found that calcium sulfate/calcium phosphate (CSCP) bone gap filler (BVF) has advantages of less damage and faster recovery in the treatment of root bone cysts [15].

The characteristics of titanium elastic intramedullary nail placement for a long time [16]: (1) Intramedullary nail throughout the medullary cavity can balance intramedullary and intramedullary pressure in time, relieve venous obstruction, improve local blood circulation, and the intramedullary nail placement can sustain drainage and decompression, so even if the residual lesions produce cystic fluid, it can also be drained through the intraosseous venous system. Bone marrow stem cells in bone marrow fluid have abundant bone induction and osteogenesis ability, and promote the healing of cyst with intramedullary nail to the lesion site. (2) The curved flat shape of the tip of the intramedullary nail can effectively destroy the cyst wall, so that the endosseous membrane can grow and extend to the cyst wall, and form a bone microenvironment in the cyst cavity to complete the endogenic bone and cartilage endogenic bone. Moreover, the cyst cavity with the destruction of the envelope and septum is conducive to the injection of bone marrow stem cells to induce bone formation, which is equivalent to the completion of window drainage and lesion cureting. The process did not damage the surrounding soft tissue, the outer bone membrane and the bone cortex. (3) Elastic intramedullary nails can provide mechanical stability to prevent or fix pathological fractures. Zhang KX et al. found that ESIN had higher effective rate and cure rate than ABM [17].

5. Conclusion

In the cases of bone cysts treated with minimally invasive elastic nail internal fixation, 36.3% were found to have cyst healing and 36.3% were found to have defect healing, with a healing rate of 72.7%, and 3 cases continued to exist, indicating that minimally invasive elastic nail internal fixation was effective for a long time, but the limitation of this study is affected by the time of follow-up, and some UBC children are still being followed up. The effect of long-term intramedullary nail implantation alone on the treatment of long bone cyst in children needs longer follow-up and more samples. In conclusion, long-term placement of titanium elastic intramedullary nail as a method for the treatment of long bone cyst is characterized by a single intervention, small damage, stability and prevention of pathological fracture. Children can resume daily activities in early stage, but bone cyst healing is slow, and some cases need to wait for bone maturation to heal themselves.

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Biography

Hua Zheng, male, attending physician, mainly engaged in pediatric orthopedics and trauma orthopedics research.