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Case Report

Surgical Management of Forearm Exostosis in Children: 3 Cases Report

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Abstract

Hereditary Multiple Exostoses (HME) is a rare genetic disorder characterized by the growth of multiple benign bone tumors, particularly affecting the forearm [1]. This study presents three cases of children with forearm exostosis, focusing on the surgical management and outcomes. We describe the clinical presentation, radiological findings, surgical techniques employed, and post-operative results. Our findings suggest that early intervention with appropriate surgical techniques can significantly improve functional outcomes and prevent complications in these patients [2].

Keywords: Exostosis; Forearm; Pediatric Orthopedics

Introduction

Hereditary Multiple Exostoses (HME), also known as Multiple Osteochondromas (MO), is an autosomal dominant disorder characterized by the development of multiple benign cartilage-capped bone tumors (exostoses) [3]. The forearm is one of the most commonly affected sites, with involvement reported in 30-60% of cases [4]. This high prevalence in the forearm region significantly impacts the quality of life of affected individuals, particularly children who are still in their growth phase.

Forearm involvement in HME can lead to various deformities, including ulnar shortening, radial bowing, and radial head dislocation [5]. These deformities can result in significant functional impairment, affecting the range of motion of the elbow and wrist, and causing pain and cosmetic concerns. The complexity of these deformities often increases as the child grows, making early intervention crucial for optimal outcomes [6].

The management of forearm exostoses in children presents unique challenges due to the ongoing skeletal growth and the risk of recurrence [7]. Surgical intervention aims not only to correct existing deformities but also to prevent further progression and potential complications. This case series aims to contribute to the existing literature by presenting our experience with three pediatric cases of forearm exostosis, highlighting the surgical approaches used and their outcomes.

Materials and Methods

Study Design and Patient Selection

This retrospective case series included three pediatric patients diagnosed with forearm exostosis who underwent surgical treatment at our institution between January 2022 and December 2023. We employed a comprehensive approach to patient selection and data collection to ensure a thorough analysis of our surgical outcomes.

Inclusion criteria for this study were:

- Age under 18 years at the time of surgery
- Radiologically confirmed forearm exostosis
- Surgical intervention for the condition
- Minimum follow-up period of 12 months

Exclusion criteria included:

- Patients with incomplete medical records
- Those who underwent surgery for exostoses in locations other than the forearm
- Patients with less than 12 months of follow-up

Data Collection

We conducted a thorough review of the patients' medical records to collect comprehensive data. This included:

- Demographic information: age, sex, family history of HME
- Clinical presentation: chief complaints, duration of symptoms, functional limitations
- Physical examination findings: range of motion measurements, presence of visible deformities
- Radiological findings: pre-operative and post-operative radiographs, CT scans (when available)
- Surgical details: type of procedure, duration of surgery, intraoperative findings
- Post-operative care: rehabilitation protocol, compli-

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cations

- Follow-up information: functional outcomes, patient satisfaction, recurrence

Pre-operative and post-operative radiographs were analyzed to assess the degree of deformity correction. We used standardized measurements including ulnar variance, radial articular angle, and carpal slip to quantify the radiographic outcomes.

Surgical Techniques

The surgical procedures varied based on the type and extent of deformity, classified according to the Masada classification. This classification system, widely used in the management of forearm exostoses, guided our surgical decision-making process. The techniques employed included:

1. Simple excision of exostosis: This procedure was used for isolated, symptomatic exostoses without significant deformity. It involved careful dissection and removal of the exostosis, taking care to preserve the surrounding neurovascular structures.
2. Ulnar lengthening: For cases with significant ulnar shortening, we employed gradual distraction using an external fixator. This technique allowed for controlled lengthening of the ulna to restore proper forearm alignment.
3. Corrective osteotomy of the radius: In cases of severe radial bowing, a corrective osteotomy was performed. This involved carefully planned cuts in the radius to realign the bone, followed by internal fixation.
4. Radial head reduction: For patients with radial head dislocation, we performed open reduction of the radial head, often in combination with other procedures to address the underlying deformity.

Outcome Measures

We assessed the following outcomes to evaluate the effectiveness of our surgical interventions:

1. Range of motion (ROM) of the elbow and forearm: Measured using a goniometer, we assessed flexion-extension of the elbow and pronation-supination of the forearm.
2. Radiographic parameters: We measured ulnar variance, radial articular angle, and carpal slip on standardized radiographs to quantify the degree of deformity correction.
3. Complications: Any adverse events related to the surgery were carefully documented and classified as minor or major.
4. Patient satisfaction: We used a simple questionnaire to assess patients' satisfaction with the functional and cosmetic outcomes of the surgery.

Statistical Analysis

Due to the small sample size, descriptive statistics were primarily used. Continuous variables were reported as means and ranges, while categorical variables were presented as frequencies and percentages. We used paired t-tests to compare pre-operative and post-operative measurements where appropriate, with a p-value < 0.05 considered statistically significant.

Results

Our case series included three pediatric patients with forearm exostoses who underwent surgical intervention. The mean age at the time of surgery was 10 years (range: 8-12 years), with two females and one male. All patients had a confirmed diagnosis of Hereditary Multiple Exostoses (HME) and presented with progressive forearm deformities.

Case 1

A 10-year-old girl presented with progressive deformity of the left forearm and limited pronation-supination. Clinical examination revealed visible bowing of the forearm and restricted forearm rotation. Radiographs showed a Masada type I deformity with significant ulnar shortening and radial bowing.

Surgical Intervention: Ulnar lengthening using an external fixator and gradual distraction was performed. The procedure involved a corticotomy of the ulna followed by application of a unilateral external fixator. Gradual distraction was initiated at a rate of 1 mm per day, with regular radiographic monitoring to assess the progress of lengthening **(Figure 1)**.

Outcome: At 18-month follow-up, ulnar length was restored, and forearm rotation improved significantly. The range of pronation-supination increased from 40° preoperatively to 140° postoperatively. Elbow flexion-extension remained unchanged at 140°. Radiographs showed improvement in ulnar variance from -8 mm to -2 mm. No complications were observed during the treatment period or follow-up.

Figure 1: Pre and post-operative radiological images Masada type I exostosis (elongation of the ulna).

Case 2

A 12-year-old boy presented with a prominent ulnar styloid and pain during activities. He reported difficulty in performing daily tasks and participating in sports. Physical examination revealed a palpable exostosis at the distal ulna and limited elbow range of motion. Imaging studies, including radiographs and CT scan, showed a Masada type IIb deformity with radial head dislocation.

Surgical Intervention: This case required a more complex surgical approach. We performed exostosis excision, ulnar lengthening, and radial head reduction. The procedure began with careful excision of the prominent exostoses. Ulnar lengthening was then performed using a similar technique as in Case 1. Finally, open reduction of the radial head was carried out, with temporary K-wire fixation to maintain reduction **(Figure 2)**.

Outcome: At 2-year follow-up, the patient showed remarkable improvement. The radial head remained reduced, and pain was completely resolved. Elbow flexion-extension arc improved from 90° preoperatively to 130° postoperatively. Forearm rotation also showed significant improvement, with pronation-supination range increasing from 60° to 120°. Radiographic parameters showed correction of ulnar variance from -12 mm

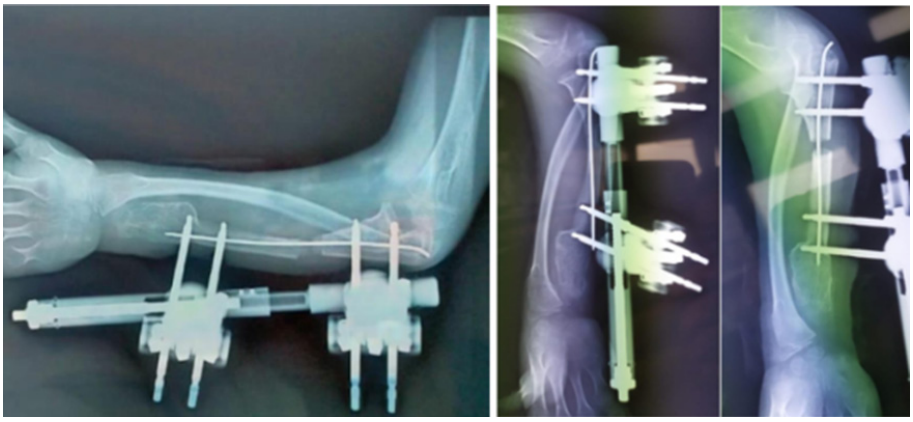

Figure 2: Postoperative radiological results of a Masada type IIb exostosis (partial resection of the exostosis + lengthening of the ulna).

to -3 mm, and improvement in radial articular angle from 40° to 25°.

Case 3

An 8-year-old girl presented with a visible deformity of the right forearm but minimal functional limitations. Her parents were primarily concerned about the cosmetic appearance and potential for future functional issues. Radiographs showed a Masada type I deformity, but with less severe involvement compared to Case 1.

Surgical Intervention: Given the mild functional impairment, we opted for a less invasive approach. Simple excision of the largest exostoses was performed through carefully planned incisions to minimize scarring.

Outcome: At 1-year follow-up, the cosmetic appearance had improved significantly, and no functional deficits were observed. The range of motion remained excellent, with only a slight improvement in pronation-supination from 110° to 120°. Elbow flexion-extension remained unchanged at 140°. Radiographic parameters showed minimal changes, with ulnar variance improving from -5 mm to -4 mm. However, mild recurrence of smaller exostoses was noted, emphasizing the need for continued monitoring.

Summary of Results

To provide a comprehensive overview of our outcomes, we have summarized the key functional and radiographic results in the following tables:

These results demonstrate significant improvements in both functional and radiographic parameters across all three cases, with varying degrees of correction based on the initial severity of the deformity and the surgical approach employed.

Discussion

The management of forearm exostoses in children with HME remains a challenging aspect of pediatric orthopedics due to the variety of deformities and the potential for recurrence [8]. Our case series demonstrates that tailored surgical approaches can lead to significant improvements in both function and appearance, highlighting the importance of individualized treatment plans for these complex cases.

In Case 1, the use of ulnar lengthening effectively addressed the relative ulnar shortening, a common feature in Masada type I deformities. The gradual distraction technique allowed for controlled correction and resulted in substantial improvement in forearm rotation. This aligns with previous studies that have shown the efficacy of ulnar lengthening in restoring forearm function. For instance, Akita et al. reported similar improvements in forearm rotation and ulnar variance in their long-term study of forearm deformity correction in HME patients [9].

The more complex scenario presented in Case 2, with radial head dislocation (Masada type IIb), required a multi-faceted approach. The combined technique of exostosis excision, ulnar lengthening, and radial head reduction proved effective in addressing multiple aspects of the deformity. The significant improvement in elbow range of motion and pain resolution underscores the importance of addressing radial head dislocation in these cases. This finding is consistent with the work of Cho and Jung, who demonstrated the benefits of gradual ulnar lengthening combined with radial head reduction in patients with similar deformities [10].

The management approach in Case 3, involving simple excision of prominent exostoses, demonstrates that less invasive interventions can be appropriate in cases with minimal functional impairment. This strategy aligns with the principle of

Table 1: Pre- and Post-operative Functional Outcomes.

Case	Pre-op Pronation-Supination	Post-op Pronation-Supination	Pre-op Flexion-Extension	Post-op Flexion-Extension
1	40°	140°	130°	140°
2	60°	120°	90°	130°
3	110°	120°	135°	140°

Table 2: Radiographic Outcomes.

Case	Pre-op Ulnar Variance (mm)	Post-op Ulnar Variance (mm)	Pre-op Radial Articular Angle	Post-op Radial Articular Angle
1	-8	-2	35°	22°
2	-12	-3	40°	25°
3	-5	-4	30°	28°

minimizing surgical intervention in growing children when possible. However, the observed mild recurrence underscores the need for long-term follow-up in these patients, as highlighted by Woodside et al. in their study on the natural history of multiple osteochondromas in the hand [11].

Our results support the notion that early surgical intervention can prevent progression of deformities and improve functional outcomes [12]. The significant improvements in range of motion across all cases suggest that surgery can effectively address the functional limitations associated with forearm exostoses. This is particularly important in the pediatric population, where early intervention may prevent the development of secondary deformities and degenerative changes.

The radiographic outcomes, particularly the improvements in ulnar variance and radial articular angle, corroborate the clinical findings. The correction of these parameters is crucial in restoring normal forearm biomechanics and preventing long-term complications such as chronic pain and degenerative changes. Gottschalk et al. have previously demonstrated the correlation between radiographic parameters and functional outcomes in patients with multiple hereditary exostoses, further supporting the importance of achieving radiographic correction [13].

It's important to note that despite the positive outcomes, the risk of recurrence remains a concern, particularly in skeletally immature patients [14]. This emphasizes the need for continued monitoring and potential repeated interventions as these patients grow. The mild recurrence observed in Case 3 is a testament to this ongoing challenge in managing HME.

The timing of surgical intervention in these cases remains a subject of debate. Our experience suggests that early intervention, when significant deformity or functional impairment is present, can lead to favorable outcomes. However, the decision to operate must be balanced against the risks of surgery and the potential need for repeated procedures. Jiya et al. have reported good long-term outcomes with early surgical intervention, but also noted the need for additional procedures in some patients as they continued to grow [15].

The choice of surgical technique is critical in achieving optimal outcomes. Our case series demonstrates the effectiveness of different approaches tailored to the specific deformity pattern. Ulnar lengthening, as used in Cases 1 and 2, has been shown to be particularly effective in addressing relative ulnar shortening and improving forearm rotation. The technique of gradual lengthening allows for controlled correction and minimizes the risk of neurovascular complications [16].

The management of radial head dislocation, as seen in Case 2, remains challenging. Our approach of combining ulnar lengthening with radial head reduction proved effective in this case. However, long-term follow-up is necessary to assess the stability of the reduction and the potential development of degenerative changes in the elbow joint [17].

The role of simple excision, as demonstrated in Case 3, should not be underestimated. In cases with minimal functional impairment, this less invasive approach can provide significant cosmetic improvement and potentially delay the need for more extensive surgery. However, patients and families should be counseled about the possibility of recurrence and the potential need for future interventions [18].

One of the strengths of our study is the comprehensive assessment of both functional and radiographic outcomes. The use of standardized measurements allows for objective evaluation of the surgical results. However, we acknowledge several limitations of this study. The small sample size limits the generalizability of our findings, and the relatively short follow-up period may not capture long-term outcomes or complications. Additionally, the lack of a control group makes it difficult to compare our results with the natural history of untreated forearm exostoses.

Future research directions should include larger, prospective studies with longer follow-up periods to better elucidate the long-term outcomes of different surgical approaches. The development of more refined classification systems that incorporate both radiographic and functional parameters could help guide treatment decisions. Additionally, investigation into the molecular mechanisms underlying exostosis formation and growth could potentially lead to novel therapeutic approaches to prevent recurrence [19].

Conclusion

This case series demonstrates that individualized surgical management of forearm exostoses in children with HME can lead to significant improvements in function and appearance. The choice of surgical technique should be based on the specific deformity pattern and functional impairment, with consideration given to the child's age and skeletal maturity. While our results are encouraging, they also highlight the need for long-term follow-up to monitor for recurrence and potential need for additional interventions. Future research should focus on refining surgical techniques and developing strategies to minimize recurrence in this challenging patient population.

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