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Case Report

A Challenging Case of a Physeal Bar Endoscopic-Assisted Resection in a Short Stature Child: Case Report and Literature Review

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Abstract
Partial physeal bars may develop after injury to the growth plate in children, eventually leading to disturbance of normal growth. Clinical presentation, age of the patient, and the anticipated growth will dictate the best treatment strategy. The ideal treatment for a partial physeal bar is complete excision to allow growth resumption by the remaining healthy physis. There are countless surgical options, some technically challenging, that must be weighted according to each case's particularities. We reviewed the current literature on physeal bars while reporting the challenging case of a short stature child submitted to a femoral physeal bar endoscopic-assisted resection with successful growth resumption. This case dares surgeons to consider all options when treating limb length discrepancy, such as the endoscopic-assisted resection which might offer successful results.

Introduction

Partial physeal bars (PPB) occasionally develop in children's long bones after injury to the growth plate. Subsequent disturbance of growth can result in significant deformities, such as limb length discrepancy (LLD), angular deformity, or both, which in turn may cause pain, loss of function, and disability [1].

The distal femoral physis is one of the most frequently affected locations by PPB and of greater therapeutic interest as it is the largest and fastest growing physis in the body [2].

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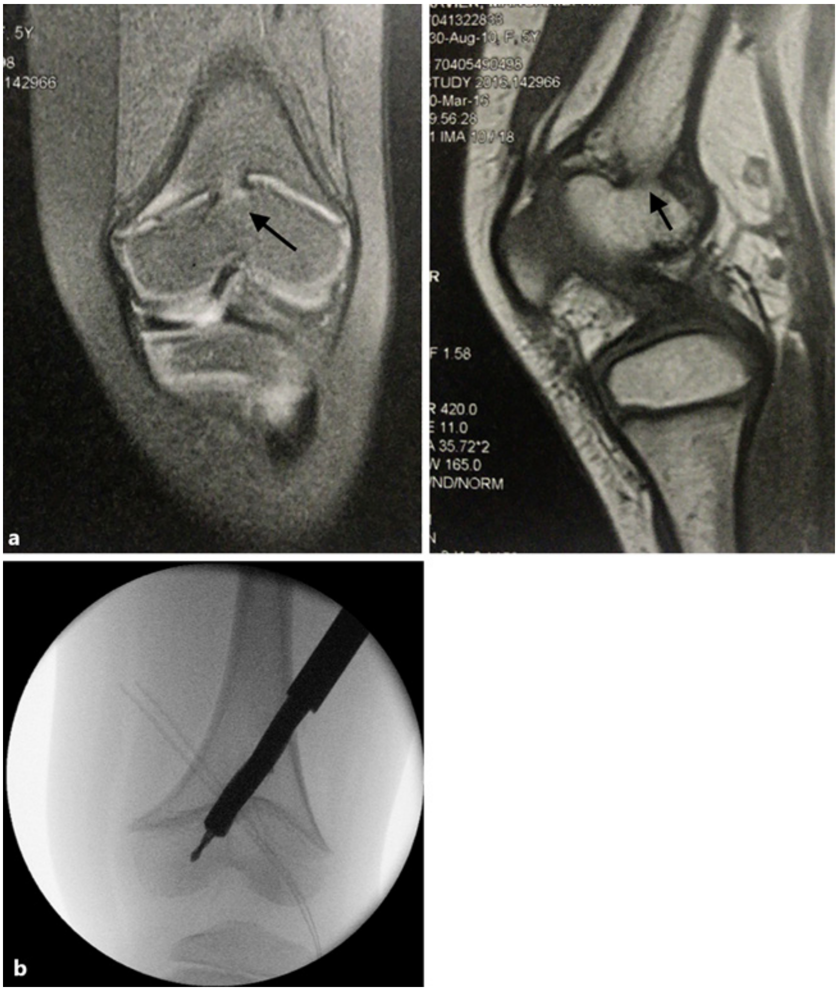

Fig. 1. PPB. **a** Preoperative image on MRI showing the bar occupies <20% of the DFP (black arrows indicating the central physeal bar). **b** Intraoperative fluoroscopic imaging of a high-speed burr. PPB, partial physeal bar; DFP, distal femoral physis.

The clinical presentation, extent, and location of the arrest, the age of the patient, and the anticipated growth will help defining the best treatment strategy which might include observation, desepiphysiodesis, contralateral epiphysiodesis, or elongation used alone or in a combined approach [1]. For the purpose of this article, we report the case of a child with a PPB treated with endoscopic-assisted resection, while briefly reviewing the literature on the subject.

Case Presentation

A 5-year-old female child was admitted for progressive painless claudication and maternal impression of LLD. She had a history of intrauterine growth restriction and a height-for-age percentile of 3 (99 cm). There was no other relevant medical history, except for a vague report of having a knee trauma under unclear circumstances. On physical examination, the LLD was evident, and, accordingly, Galeazzi sign was positive. The long-film radiograph revealed 37 mm of shortening of the left femur, and the MRI identified a central PPB occupying <20% of the distal femoral physis (shown in Fig. 1a). PPB resection was pursued before any further LLD developed.

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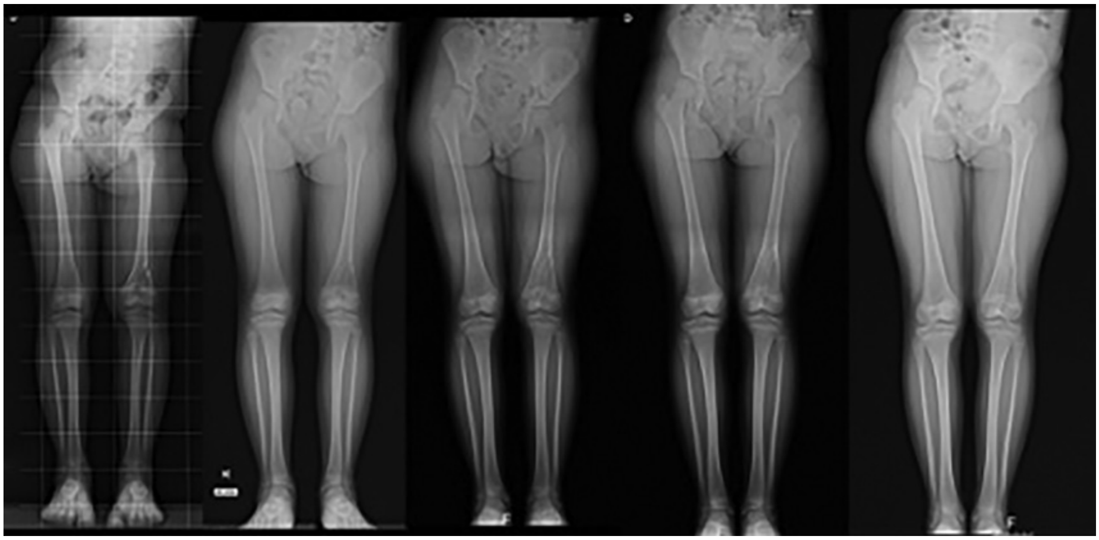

Fig. 2. Long X-ray follow-up at 3, 9, 15, 24, and 30 months (from left to right).

The bar was approached from above through a lateral metaphyseal cortical window avoiding any damage to the perichondral ring. Under fluoroscopic guidance, a cavity directed at the bar was made with a high-speed burr until the physeal bridge (PB) area was reached. Once the working channel was created, a 30° endoscope was introduced in order to identify the healthy physeal cartilage. The bar was differentiated from normal bone because, as expected, it had greyish more sclerotic bone than the surrounding metaphysical marrow cavity. The cavity was then extended into the epiphysis, within the substance of the bar itself. Using the curette and the high-speed burr, as shown in Figure 1b, the cavity was enlarged centrifugally until the healthy, bluish-white tint, physeal tissue could be observed at the perimeter of the enlarging cavity. After completing the resection, the cavity was filled with autologous fat from the distal thigh to prevent reformation of the bar.

In the immediate postoperative period, active motion was encouraged, whereas weight bearing was only permitted after 6 weeks with a shoe insole of 2 cm in order to achieve a tolerable LLD of around 1.5 cm. The assessment of subsequent growth was carried out by long-film radiographs at 3 months after surgery and then every 6 months. Thirty months after surgery, the left femur showed an additional growth of 7 mm compared to the contralateral side, and the child has an LLD of 30 mm (shown in Fig. 2).

During follow-up, there were no reported complications. At the age of 7, the girl was diagnosed with premature thelarche and started treatment with trimestral intramuscular triptorelin.

Because of this patient's short stature and early age, performing a simultaneous epiphysiodesis on the right femur was not the preferred option. The authors intend to continue monitoring femoral bone growth until the patient reaches skeletal maturity and then consider a left femur's lengthening procedure. The perfect timing will be decided upon imaging of the hand in order to evaluate skeletal maturity [3].

Discussion

Physeal bridging occurring after trauma [4] but also after infection, tumors, irradiation, vascular insufficiency, and metabolic disorders (vitamin A intoxication [5], disuse [6], and iatrogenic injury [7]) happens when there is contact between the epiphysis and the metaphysis

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resulting in osseous consolidation in that region. Although physeal injuries represent 15–30% of all fractures, only 1–10% of those injuries result in PB [6, 8]. The PB must occupy >10% of the growth plate in order to produce complications such as growth arrest or axial deformity [9].

Salter and Harris [10] produced a widely used epiphyseal fracture classification, which they believed would be of a great prognostic value and useful for management's decision. All 5 Salter-Harris (SH) types of physeal fracture, as well as Rang's sixth type, have been reported to cause PB [11]; however, the SH type IV physeal fractures detain the greatest potential [11].

Lower extremity bars occur more frequently than do upper extremity bars because injuries are often more violent and associated with high-energy mechanisms. This might explain why despite <3% of all physeal injuries occur at the physis around the knee, these represent >50% of all PB resections [7, 8, 12].

Physeal growth disturbance related to an injured physis can be classified as partial or complete depending on the amount of physis affected. Complete physeal injury most often leads to LLD as opposed to partial physeal injuries which are usually associated with angular deformities.

Three patterns of partial physeal growth disturbance have been described: a peripheral growth arrest is located at the perimeter of the physis and leads to angular deformity; a central growth arrest is completely surrounded by a perimeter of healthy physis and typically leads to articular distortion due to tethering of the physis as well as progressive shortening; a linear bar involves both peripheral and central elements flanked on both sides by healthy physis and is typically found after SH type IV fractures where the fractured ends of the physis may remain mal reduced and in contact with the metaphyseal and epiphyseal bone [1].

In patients with documented existing or developing deformities, with at least 2 years or 2 cm of growth remaining, surgical treatment must be considered [6, 13]; however, not all patients who develop a PB require treatment as some might resolve spontaneously [14–16]. Before treating a physeal bar, the first step is to assess both its location and size using plain radiography or MRI, the second step is to estimate the amount of remaining growth from the involved physis [17], and finally the best surgical option is chosen.

There are many options depending on each case such as completion of physeal arrest, desepiphysiodesis, contralateral epiphysiodesis, osteotomies, or elongation used alone or in a combined approach. While complete physeal arrest is best managed by contralateral epiphysiodesis [18] or limb lengthening, partial physeal arrests demand a more complex approach.

Completion of a physeal bar can be indicated if the current, acceptable deformity might become unacceptable with further growth associated or not with a contralateral epiphysiodesis if the estimated LLD at the end of growth is >20 mm. In the presented case, LLD was already almost twice this mark (37 mm) making the deformity unacceptable; however, combining the procedure with a contralateral epiphysiodesis was not an option given the girl's short stature. That said, the authors decided that the best option was to perform a desepiphysiodesis allowing growth resumption and address the LLD closer to the time the girl reaches skeletal maturity.

Physeal bar resection was first introduced by Langenskiöld [19] in 1967 for treating physeal bars occupying <50% of the physis [17]. Since that time, clinical series by Bright, Peterson et al. [8], Langenskiöld [20], and more recently Marsh and Polzhofer [16] have supported the efficacy of this procedure in restoring longitudinal growth, correcting angular malalignment, and preventing joint deformity.

In general, resumption of growth after resection of central or linear arrest is more likely than after resection of a peripheral arrest. Nevertheless, lesions >25% of the surface area of the affected physis have a poorer prognosis for growth resumption [6, 21].

Conclusions

When growth arrest occurs, it can have devastating effects on function, comfort, cosmesis, and quality of life. The ideal reconstructive treatment should allow resumption of normal growth, which can be accomplished, in some cases, by surgical resection of the physeal bar. The surgeon must carefully consider the specific indications for the Langenskiöld procedure as it can be technically challenging. While there is still scope for future research into the use of growth signaling molecules and chondrocyte grafting techniques, the authors believe that assisted endoscopic excision of physeal bars is a minimally invasive option to allow complete resection in selected cases.

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Statement of Ethics

The parents of the subject have given their written consent to publish their child's case and any accompanying images.

Conflict of Interest Statement

Each author certifies that he or she has no conflicts of interest for this publication. Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, and patent/licensing arrangements) that might pose a conflict of interest in connection with the submitted article.

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Author Contributions

Melanie Ribau: collection of data and interpretation, investigation, manuscript writing, and review and final approval of the manuscript. Mário Baptista: collection of data and interpretation, investigation, and review and final approval of the manuscript. Nuno Oliveira: collection of data and interpretation, investigation, and review and final approval of the manuscript. Bruno Direito Santos: conception and design and review and final approval of the manuscript. Pedro Varanda: review and final approval of the manuscript. Ricardo Maia: conception and design, data interpretation, investigation, and review and final approval of the manuscript.

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