CASE REPORTS

Case Reports: Treatment of Traumatic Triradiate Cartilage Epiphysiodesis

What is the Role of Bridge Resection?

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Abstract

Background Acetabular fractures are rare in children and can be complicated by premature fusion of the triradiate cartilage resulting in secondary acetabular dysplasia. Early recognition and treatment of a physeal bar in this location can be difficult. The purpose of this case report was to investigate whether early intervention could restore acetabular growth and prevent secondary acetabular dysplasia as measured on plain radiographs.

Case Description We report a series of three patients (3, 4, and 5 years old) who underwent physeal bridge resection and methylmethacrylate or fat interposition through an extended Pfannenstiel approach. The mean followup was 6 years. After resection of the osseous bridge the physis initially remained open with evident acetabular

growth in all three patients. In one patient, the bridge reformed 6 years after the procedure. All patients had a slight increase in the thickness of the acetabular wall relative to the contralateral side but no radiographic evidence of acetabular dysplasia.

Literature Review To our knowledge, there are only two reports of physeal arrest resection of triradiate cartilage with one successful result.

Clinical Relevance Posttraumatic, partial physeal arrest of the triradiate cartilage may be treated with resection of the bone bridge resection through an extended Pfannenstiel approach. The potential benefits of this treatment must be weighed against the risks.

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All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request. Each author certifies that his or her institution approved the reporting of this case report, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained. This work was performed at Hôpital Armand Trousseau, Paris, France.

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Introduction

Pelvic fractures are rare in children. Their treatment is usually conservative [19]. Some acetabular fractures are responsible for partial or complete epiphysiodesis of the triradiate cartilage and subsequent acetabular dysplasia. The age of the patient at the time of physeal bar formation is the most important factor in the development of acetabular dysplasia and subluxation of the femoral head [2, 16, 18].

Bridge resection is an effective procedure to treat traumatic long bone growth arrest in children. Technical difficulties with operating in the region of the triradiate cartilage [18] combined with typically fast and complete growth arrest after a Type V Salter-Harris fracture [2] explains the lack of available data on bridge resection for triradiate cartilage growth arrest. There are only two studies of physeal arrest resection of triradiate cartilage [4] of which one reported a successful result [12].

We report the cases of three children who underwent physeal bridge resection and methylmethacrylate or fat interposition through an extended Pfannenstiel approach, at a mean followup of 6 years (range, 4–8 years), to ascertain whether this surgery prevented the development of acetabular dysplasia.

Case reports

Patient 1

A four-year-old girl who was hit by a car sustained a seemingly minor pelvic fracture involving the superior pubic ramus (Fig. 1A), an avulsion fracture of the lesser trochanter, and a severe head injury. On the initial radiographs, the pelvic fracture is minimally displaced and the involvement of triradiate cartilage is not evident. The pelvic injury was treated with bed rest. One year later, radiographs and CT scans showed a peripheral osseous bar on the vertical limb of the triradiate cartilage (Fig. 1B–D). Excision of the osseous bridge was performed to decrease the likelihood that acetabular dysplasia would develop. On the contralateral side the child had been treated at birth for hip dysplasia. At 7 years of age, she had a valgus deformity of the femoral head develop in the hip with congenital dysplasia, probably owing to partial lateral physeal closure. At last followup, the patient was 13 years old and remained

asymptomatic. A radiograph obtained 8 years after surgery (Fig. 1E) showed no acetabular dysplasia.

Patient 2

A three-year-old boy, involved in a motor vehicle accident, sustained a right femoral shaft fracture, a fracture of the pelvic ring including fractures of the pubic rami, a non-displaced sacral fracture, and an acetabular fracture. The acetabular fracture was a minimally displaced (less than 2 mm) Salter-Harris Type II physeal fracture (Fig. 2A). The treatment consisted of lower extremity traction followed by hip spica casting. One year after injury, partial closure of the triradiate cartilage was evident on a plain radiograph (Fig. 2B). A CT scan confirmed the presence of an osseous bar on the ilioischial limb. The bone bridge then was removed and replaced by a cement spacer. At followup 4 years after surgery, the growth plate remained open and active (confirmed by CT). No acetabular dysplasia was seen on the patient's radiographs but the iliac wall was thicker than the other side (Fig. 2C).

Patient 3

A five-year-old boy sustained three ipsilateral right pubic ramus fractures and a right femur fracture (Fig. 3A) after a car accident. A CT scan showed a double fracture of the

Fig. 1A–E (A) A plain AP radiograph of the pelvis at the time of injury shows a minimally displaced pubic rami fracture. (B) The CT scan obtained 1 year after the initial trauma shows a peripheral osseous bar on the vertical limb of the triradiate cartilage (arrow). (C) On the tridimensional CT scan, the osseous bridge can be

localized on the vertical limb of the triradiate cartilage (arrow). (D) The CT scan obtained after surgery shows replacement of the osseous bridge by a cement spacer (arrow). (E) An AP radiograph of the pelvis obtained 8 years after surgery shows good development of the right hip and no acetabular dysplasia.

Fig. 2A–C A three year-old boy sustained a fracture of the pelvic ring including fractures of the pubic rami, nondisplaced sacral fracture, and acetabular fracture. (A) An AP radiograph of his pelvis shows a small displaced fragment located near the triradiate cartilage on its pelvic side (arrow). (B) The AP radiograph of the pelvis

obtained 1 year after injury shows partial closure of the triradiate cartilage (arrow). (C) Four years after surgery, no acetabular dysplasia is seen, but the iliac wall is thicker than the other side. The arrowheads border the cement spacer.

Fig. 3A–D (A) The patient's AP pelvic radiograph shows three ipsilateral right pubic rami fractures. (B) A CT scan of his pelvis obtained on arrival at our institution shows a bifocal fracture (arrowhead) of the superior pubic ramus with no involvement of the triradiate cartilage. The intermediate fragment is displaced overlapping the triradiate cartilage. (C) The CT scan obtained 1 year after the

trauma shows physeal growth arrest of the triradiate cartilage on the pelvic side (arrowhead). (D) A radiograph obtained when the patient was 15 years old shows an increase in the thickness of the acetabular wall on the right side. The triradiate cartilage is closed on both sides, and acetabular dysplasia with slight lateral displacement of the femoral head also is present.

superior pubic ramus with no involvement of the triradiate cartilage (Fig. 3B). The intermediate fragment was displaced, overlapping the triradiate cartilage. One year later, partial physeal growth arrest was evident on the patient's radiographs and CT scan. Treatment consisted of resection of the osseous bridge and cement interposition. At 12 years of age an increase in the thickness of the acetabular wall and slight lateral displacement of the femoral head were seen on his plain radiographs. However, the physis was still open. A CT scan showed a bony reaction around the cement spacer which bridged the triradiate cartilage. A second surgical

procedure was done consisting of spacer resection and fat interposition. No worsening of hip dysplasia as measured radiographically (Shenton's line interruption, modification of Wiberg's center-edge angle, and the acetabular angle of Sharp) was noted until maturity. At 15 years of age, an increase in the thickness of the acetabular wall was present on the affected side (Fig. 3D) and there was slight lateral displacement of the femoral head measured using a modification of the femoral-head extrusion angle.

In all cases, for resection of the osseous bridge we used an extended Pfannenstiel approach, known as the modified

Stoppa approach, as described by Cole and Bonhofner for acetabular fractures [3]. It allows surgical access to the quadrilateral plate. A transverse incision, curved at the lateral edges, is made 1 cm proximal to the symphysis pubis. The incision of the fascia is superficial and therefore is unlikely to impinge on the inferior epigastric vessels. In the subcutaneous fat, care should be taken to avoid injury laterally to the spermatic cord or round ligament. A vertical incision is made through the linea alba. The plane between the rectus abdominis muscle and the bladder is accentuated by the operator's spread finger. A blunt, malleable retractor protects the bladder. A longer vertical split between the two rectus abdominis muscles can facilitate the exposure.

Dissection is continued laterally between the internal iliac vessels and inferior epigastric vessels. Care must be taken, as communicating vessels tend to be a few centimeters lateral to the symphysis. Retractors are placed over the anterior aspect of the superior ramus to retract the iliopsoas muscle and external iliac vessels. The obturator vessels and nerve are retracted inferiorly with great care. The insertion of the obturator internus muscle is elevated subperiosteally, allowing access to the quadrilateral plate. The osseous bar is excised with a small curette until normal physis can be seen.

Methylmethacrylate cement was used as interposition material in all three patients; for the third patient, the bone bridge relapsed and the cement spacer was replaced by fat.

Discussion

Complete or partial growth arrest of the triradiate cartilage may be seen after pelvic fractures [1, 2, 7, 15, 16, 18], infection [4, 20], or iatrogenic damage after pelvic osteotomy [13]. The consequences of physeal growth disturbance, shown by experimental [5, 6] and clinical studies [1, 2, 15, 16, 18], include acetabular dysplasia and subluxation or dislocation of the femoral head. Conceptually, restoration of normal growth is the goal of treatment no matter the location of the physeal bar; in most locations, this is achieved surgically. For physeal bars located in the long bones, bridge resection is often an effective procedure [9] if the bar is not too large and there is sufficient remaining growth left from that physis [9, 11]. Some authors consider that a physeal bar in the location of the triradiate cartilage should not be addressed surgically because the location is difficult to access, therefore the intervention poses a risk of injury to surrounding structures [18]. Another argument against surgery for physeal bars of the triradiate cartilage is that posttraumatic bars in this location may be too large to resect and still hope to regain growth [12]. Finally, it has been postulated that if a physeal bar of the triradiate cartilage leads to acetabular dysplasia

years later [2, 15], the dysplasia can be treated with reconstructive pelvic osteotomies that provide reliable results [18].

There are only two reports, to our knowledge, of physeal arrest resection involving the triradiate cartilage. Dias et al. attempted epiphysiodesis of an infectious growth arrest after neonatal septic hip arthritis [4]. The treatment was done 3 years later and was complicated by a deep infection and bridge recurrence. Paterson and Robertson described a minimally displaced superior pubic ramus fracture, at the junction with the triradiate cartilage, complicated 2 years later with a physeal growth arrest [12]. In that study, the treatment consisted of the resection of the osseous bridge and wax interposition. The physis remained open and there was only a slight increase in the thickness of the acetabular wall and minimal lateral displacement of the femoral head. In our series, we favored the use of methacrylate to fill the space left after bar resection; we used autogenous fat in one revision surgery. An alternative can be wax packing. The intrapelvic aspect of triradiate cartilage can be reached by three different approaches: iliofemoral [8, 10, 17], ilioinguinal [8, 10], or an extended Pfannenstiel approach [3]. We think the extended Pfannenstiel approach gives direct access to the triradiate cartilage, respecting the anatomic structures, and avoiding extensive dissection of the inguinal canal. For each of our patients, the physeal arrest involved a different limb of the triradiate cartilage. This approach permitted physeal bar resection in all three patients with no technical difficulties.

In our patients, all pelvic fractures initially were treated nonoperatively. In Patient 2, the growth arrest of the triradiate cartilage was secondary to a Salter-Harris Type II acetabular fracture with less than 2 mm displacement. In Patients 1 and 3, the fracture of the pubic ramus did not involve the triradiate cartilage but the displaced fragment was juxtaposed with the pelvic side of the triradiate cartilage (Fig. 1A and Fig. 3B). Rodrigues reported the formation of a physeal osseous bar after a nondisplaced acetabular fracture in a 3-year-old boy [15]. He hypothesized that the bone bridge was formed by ossification of the fracture hematoma. Trousedale and Ganz proposed the same explanation for one of their five patients with triradiate physeal arrest [18]. Ponseti reported that the intrapelvic side of the triradiate cartilage is covered by a perichondrium and fibrous tissue, and traumatic stripping of these structures may result in formation of abundant local callus [14]. It is also our opinion that the osseous callus formation can bridge the triradiate cartilage on the pelvic side even in nondisplaced fractures of the pelvic ring. In all three cases we described, there was a peripheral physeal arrest located at the intrapelvic side of one flanges of the triradiate cartilage. The rest of the physis was healthy. Physiodesis was done 1 year after the trauma. As Paterson and

Robertson recommend, the treatment should be done early [12]. In the case reported by Rodrigues, only a peripheral, intrapelvic bridge was seen 17 months after trauma, but complete fusion of triradiate cartilage developed 4 years later [15].

In Patient 3, we noted recurrence of the bridge after 6 years. The cement spacer was surrounded by an osseous reaction. The recurrence of the bridge is not uncommon after this type of surgery for the limbs; it can be treated by iterative resection and cement interposition [9]. In our patient, the growth continued after the second procedure.

The radiographic aspects of the hip for the two patients who reached maturity are not perfect. An increase in the thickness of the acetabular wall was seen in two patients and slight lateral displacement of the femoral head was seen in one of these two patients. The third patient is still growing and followup after skeletal maturity is needed. Paterson and Robertson observed the same anomalies at maturity after triradiate physiolysis [12].

Even if the incidence of triradiate physal arrest is low, it is important to be vigilant and image patients in whom this diagnosis is suspected after pelvic or acetabular trauma. If a bone bridge is identified, we have shown that it can be removed through a Pfannenstiel approach, and perhaps preserve growth and avoid later acetabular dysplasia. Such a procedure, by an extended Pfannenstiel approach, can be safe and effective. In this way, the risk of growth disturbances of the acetabulum and subsequent hip dysplasia may be minimized.

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