Avulsion fractures of the pelvis in the pediatric population. A review of the literature and case report

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INTRODUCTION

The forces affecting the bone through the soft tissues attached to them have the ability to form its shape and structure. An example of such kind of interactions are apophyses, which occur at the site of the attachment of muscles and ligaments. When these forces exceed the strength of the bone tissue, it can result in an avulsion fracture, in which a fragment of bone is torn out of the main mass of bone [1]. There are many types of these fractures, but their exact number is not known due to the lack of literature describing their epidemiology [1,2]. Some of these fractures are frequent in paediatric patients. The most common avulsion fractures of the lower extremity in a group of these patients are the pelvic apophyseal avulsion fractures [3]. They usually result from excessive exploitation of the immature musculoskeletal system. Avulsion fractures of the pelvic apophysis usually occur in young athletes. Non-traumatic avulsion fractures are rare [4]. Sites of pelvic apophyseal avulsion fractures include anterior inferior iliac spine (AIIS), anterior superior iliac spine (ASIS), ischial tuberosity (IT), iliac crest (IC), and superior corner of the pubic symphysis (SCPS) [1,3,5] (Fig. 1).

FREQUENCY AND LOCALISATION

Avulsion fractures of the pelvis typically occur in children and adolescents. Due to the lack of statistical studies currently, it is impossible to determine the exact incidence of avulsion fractures of the pelvic apophysis. Current literature mainly consists of case studies and case series [1,2,6]. In studies comparing the incidence of particular types of pelvic avulsion fractures, the most common are fractures...
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Mechanism of injury

The majority of pelvic apophyseal avulsion fractures are a result of the excessive tensile force applied to the immature pelvic. Sudden muscle contraction (often uncoordinated) avulse a bone fragment from the place of the tendon insertion, which causes detachment and displacement of the bone fragment. The bone strength is reduced due to the unterminated process of ossifying the pelvic which results from a postponed fusion of secondary ossification centres of the apophysis. This leads to local weakness of the bone structure and thus an increased risk of damage by tensile forces transmitted through the musculotendinous unit attached to them [3].

Knowledge of the anatomy of muscle insertions is essential for properly diagnosing and treating pelvic avulsion fractures (Tab. 2). The direction of bone fragment displacement and the symptoms accompanying the fracture depend on the locations of these muscles. If muscles with different force vectors are attached to one apophysis, the displacement of the bone fragment depends on which muscle had caused the avulsion. For this reason, we distinguish two types of ASIS avulsion fractures. The fracture caused by contraction of the sartorius is usually more minor and displaced anteriorly, and the tensor fasciae latae dependent fracture is larger and displaced laterally [11].

Table 1. Relative frequency of pelvic apophyseal avulsion fracture.

<table>
<thead>
<tr>
<th>Avulsion of the</th>
<th>Relative frequency of fracture [5]</th>
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<tbody>
<tr>
<td>Anterior inferior iliac spine</td>
<td>33.2%</td>
</tr>
<tr>
<td>Anterior superior iliac spine</td>
<td>27.9%</td>
</tr>
<tr>
<td>Ischial tuberosity</td>
<td>29.7%</td>
</tr>
<tr>
<td>Iliac crest</td>
<td>6.7%</td>
</tr>
<tr>
<td>Superior corner of pubic symphysis</td>
<td>1.2%</td>
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Clinical appearance and imaging

Patients who sustain an avulsion fracture often report a popping sensation at the time of injury, accompanied by severe pain [3,5,11,12]. The location of the pain is determined by the place where the fracture occurs. Pain is increasing during physical activity and deadens with rest [3,8,5].

Physical examination of patients with avulsion fracture usually shows tenderness and swelling over the area of injury [5,11]. Due to pain after pelvic apophyseal avulsion, the range of motion of the hip joint is also limited [3,13]. Symptoms mainly depend on the location of the fracture (Tab. 3). Furthermore, when the displacement of bone fragments is significant, it may be possible to palpate a break in the pelvis bone [8].

These symptoms largely overlap with those that may accompany the much more frequent muscle injuries. For this reason, the symptoms of an avulsion pelvic apophyseal
fracture can be misinterpreted, which can lead to misdiagnosis [3,7,14,15]. The literature particularly emphasizes the possibility of incorrect interpretation of symptoms of ischial tuberosity avulsion fracture due to the high similarity of those in hamstring muscle damage [5,8].

As a usual interview, a physical examination, followed by imaging tests, is necessary [7,16,17] (Fig. 2). If an avulsion fracture of pelvic apophyseal is suspected, the first imaging examination should be an X-ray of the pelvis in at least two projections [12,15,16]. This procedure allows the diagnosis of most fractures, but computed tomography (CT) scans may be needed to visualize small fragments not visible on X-rays [8,15]. It is important to note, that sometimes in radiological evaluation the pelvic apophysis during the healing period and forming callus can resemble bone tumours [18].

### Treatment

No clear guidelines for the treatment of avulsion fractures have been established in the available literature. Most patients are treated conservatively with good results [19]. Even with an immediate and correct diagnosis, controversy exists regarding the optimal treatment options. Current literature describes that for undislocated fractures or with incomplete displacement, conservative treatment is the treatment of choice. Cases with complete displacement also repeatedly have high healing potential. Surgical intervention is indicated in adolescents with >1.5 cm fragment displacement. This method of treatment leads to very good functional results and a high return to sport rate [20].

Some authors report that a displacement >3 cm has been considered the threshold for surgical management with open repositioning and internal fixation. Indications for surgical treatment given in the literature include joint trauma, neurovascular disorders, and displacement relevant to fusion [19].

Non-operative treatment consists of cessation of sporting activities, no weight-bearing of the injured limb, in some cases temporary immobilisation, and possible physiotherapy. Entire therapy may take up to 12 weeks [21]. The main advantage of conservative treatment is the lack of need for anaesthesia and minimal risk of infection. However, surgically treated patients achieve full ROM quicker and can start full weight-bearing and exercise sooner compared to conservatively treated patients [22].

In a meta-analysis, Eberbach et al. indicate that the overall success rate and return to sport were higher in patients who underwent surgery, especially in patients with fracture displacement greater than 1.5 cm. The mean recovery time was 3.1 months in patients treated conservatively and 2.4 months in patients treated surgically [5]. The acute surgical intervention leads to better functional outcomes compared to delayed procedures [20]. The literature suggests that surgical treatment is the preferred method for competitive athletes and patients with significant displacement. In contrast, conservative treatment provides sufficiently good clinical outcomes in most adolescents involved in non-competitive sports [22].

Several surgical treatments have been described including lag screw and tension band fixation, as well as transossseous refixation techniques [21-23].

Willinger also described the case of two patients with fractures of the superior anterior iliac spike treated with
open repositioning and fixation with the suture bridge with anchors technique with excellent clinical results [23].

The literature is inconclusive on the evidence of the superiority of one surgical treatment method and significantly better final treatment results. All techniques give good clinical data with few complications [21-23].

Complications

The most common complications of conservative treatment are the risk of loss of strength, local irritation, and bone healing in a displaced position with additional callus formation. [22]. Other complications of conservative treatment are also heterotopic ossification and pseudarthrosis. The risk of non-union is significantly increased when the displacement of the fracture is more than 1.5 cm. [9].

Patients undergoing surgical treatment have an accelerated recovery and activity, but this may be associated with a higher risk of nerve damage and irritation to surrounding tissues caused by implants [19].

There is a lack of explicit information in the available literature on the complications of conservative and surgical treatment.

Summary

Summarising, it can be concluded that avulsion fractures are rare injuries resulting from excessive loads affecting the immature skeletal system. They occur mainly in young athletes, more often in men. Local pelvic pain, which has started suddenly, especially with a popping sensation at the moment of injury, should be a guide to considering the possibility of an avulsion fracture of the pelvis in the differential evaluation. The diagnosis can usually be confirmed by pelvic X-ray.

The available literature does not clearly define the criteria for the surgical treatment of pelvic avulsion fractures. Most of these fractures can be treated conservatively. The qualification for surgical treatment should be strictly individualised. Sources suggest that surgical treatment should be considered first in professional athletes and when the displacement of the fractures exceeds 1-3 cm. None of the surgical treatments has achieved significant superiority in clinical outcomes over the other methods.

References


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