7-1-2022

# Pelvic Avulsion Fractures in Adolescent Athletes: Analyzing the Effect of Delay in Diagnosis

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**Abstract**

**Objective:** To evaluate whether delay in the diagnosis of pelvic avulsion fractures in young athletes leads to prolonged treatment and prolonged return toward sport activities, whether fractures at certain locations are associated with a greater risk of diagnostic delay, and what reasons may exist for delay in diagnosis. **Design:** Retrospective chart review of young patients who presented with pelvic region avulsion fracture to a community-based sports medicine clinic over a 19-year period. **Setting:** Private practice, primary care sports medicine clinic. **Patients:** Patients younger than 20 years diagnosed with pelvic region avulsion fracture. **Interventions:** None, this was a retrospective study. **Main Outcome Measures:** Clearance for return toward sport activities. **Results:** Two hundred twenty-five cases were reviewed for reasons for delay in diagnosis; 208 cases met criteria for the duration of treatment and return to play activities portions of the study. The mean time from date of injury diagnosis was 19.59 days, and the mean duration from date of injury to clearance for return to play advancement was 67.20 days. Duration of treatment varied slightly depending on timing of diagnosis, whereas duration from date of injury to clearance for return to play advancement varied greatly depending on diagnostic delay. Those who did not sense a "pop" at the time of injury were more likely to experience diagnostic delay, as were athletes with ischial tuberosity fractures. The most common cause of diagnostic delay was patient/family decision on when to seek care; misdiagnosis as a muscle strain was also common. **Conclusions:** Diagnostic delay of adolescent pelvic avulsion fractures may unnecessarily prevent athletes from returning to play within an optimal time frame. Our observations highlight a need for educating athletes and their families on when to seek initial or follow-up medical care as well as educating medical providers regarding the diagnosis of pelvic avulsion fractures.

**Key Words:** pelvic avulsion fracture, diagnostic delay, play advancement, adolescent athletes

(*Clin J Sport Med* 2022;32:368–374)

## INTRODUCTION

As participation in youth sports has increased, acute and overuse injury rates have also increased. Although injuries such as lateral ankle sprains and knee sprains remain common, rates of other injuries such as concussions or elbow ulnar collateral ligament injuries in young throwers are on the rise.[1,2] Fractures of the pelvic apophyses are relatively unusual, but the true incidence is unknown. These injuries may be mistaken for muscle strains, which could lead to delayed diagnosis and prolonged recovery.

Delay in diagnosis is defined as a nonoptimal interval of time between onset of symptoms, identification, and initiation of treatment. A delayed diagnosis may occur because of several factors, but commonly occur when the correct diagnosis is delayed from failure in or untimely ordering of tests.[3] The first report of pelvic avulsion fracture[4] described an ischial tuberosity (IT) avulsion fracture in a runner who was diagnosed 3 years after the injury event. In our institution's recent report on these injuries, it was noted that accurate diagnosis in many patients was often delayed for many weeks.[5] Considering the acute nature of this injury with the associated degree of pain and disability, early access to medical care after the injury event and subsequent early diagnosis would be expected, but this is not always the case. Although it was not the objective of our original work on the topic, we believed it is important to determine whether a delay in diagnosis altered the primary outcome of return to sport activities and what factors may contribute to diagnostic delay. The purpose of this study was to (1) determine whether delay in making an accurate diagnosis of pelvic avulsion fracture leads to prolonged treatment and prolonged return to activities, (2) determine whether fractures at certain locations are associated with a greater risk of diagnostic delay than others, and (3) assess the possible reasons for delay in making an accurate diagnosis.

## METHODS

After institutional review board approval, pelvic avulsion fractures of the anterior inferior iliac spine (AIIS), anterior superior iliac spine (ASIS), iliac crest (IC), and IT diagnosed in patients younger than 20 years treated at a single, community-based sports medicine practice between January 1, 2000, and December 31, 2018, were reviewed. The current study did not include patients identified in our previous study[5] with lesser trochanter or greater trochanter injury because those numbers were small and were not expected to be of significant strength for appropriate comparisons. One patient presented 1 year after their injury event, and their information was not included in this analysis.

Medical records were reviewed for demographic and injury data including patient age, sex, sport, mechanism of injury,

*Submitted for publication February 16, 2021; accepted August 13, 2021.*

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*The author reports no conflicts of interest.*

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*http://dx.doi.org/10.1097/JSM.0000000000000977*

presence of a "pop" at the time of injury, time from date of injury (DOI) to diagnosis of avulsion fracture, affected side, location of injury, evaluations by other providers before diagnosis of avulsion fracture, duration of treatment, and duration to return to play advancement (DRTPA, defined as time from the DOI to the day of patient clearance to return to play advancement).

Because there is no consensus on what time frame constitutes a delayed diagnosis for this type of injury, we grouped and analyzed the data in 2 different ways. First, we divided the data into 5 separate groups based on timing of diagnosis; groups included those diagnosed from days 0 to 7 (group 1), days 8 to 14 (group 2), days 15 to 21 (group 3), days 22 to 30 (group 4), and 31+ days (group 5) after the injury event. Next, we analyzed the data after dividing the full study group into those diagnosed by day 14 compared with those diagnosed after day 14 (we termed this the "C-14" comparison), and then repeated the analysis with the full study group divided into those diagnosed by day 21 compared with those diagnosed after day 21 ("C-21" comparison).

Patient data were excluded from analysis in the duration of care and return to play advancement components of the study if the patient completed their care with another provider or were lost to follow-up. All patient data were included in the reason for delay component of the study.

### Statistical Analysis

All continuous data are described using mean ± SD, medians, and range, whereas categorical data are described using counts and column percentages. Two group comparisons are assessed using independent T-tests for continuous variables and using $\chi^2$ or Fisher exact tests (if expected cell counts are <5) for categorical variables. For continuous variables, overall group comparisons are performed using analysis of variance (ANOVA) if the variable is approximately normally distributed, and using Kruskal–Wallis if assumptions are violated. Post hoc analysis methods used include Tukey or Dunn tests, as appropriate, to determine which groups significantly differ from one another. Statistical significance is set at $P < 0.05$. All analyses performed using SAS 9.4 (SAS Institute Inc, Cary, North Carolina).

## RESULTS

A total of 225 pelvic avulsion fractures were diagnosed in the study period. All patients were included in the reason for delay in diagnosis component of the study, and 208 patients were included in the duration of care and DRTPA components of the study (2 patients completed care with an orthopedic surgeon and 15 patients were lost to follow-up). The mean age at diagnosis was 14.71 years (range 8.98-19.76 years). Males comprised 65.3% (147/225) of the patients. Soccer was the most common sport activity at the time of injury (27.1%; 61/225), followed by track/cross-country/running (22.2%; 50/225) and football (12.4%; 28/225). Injury was noted more commonly on the right (51.6%; 116/225).

When evaluating the 225 patients who were diagnosed with avulsion fracture, 34.7% (78/225) reported feeling or hearing a "pop" at the time of injury. The most common location of injury was the ASIS (32.4%; 73/225), followed by the IT (28.0%; 63/225), AIIS (25.8%; 58/225), and IC (13.8%; 31/225). The mean time from DOI to diagnosis of avulsion fracture (n = 225) was 19.59 days (range 0-180 days).

Analysis of the 208 patients who were followed through the completion of treatment showed a mean duration of care of 47.74 days (range 14-143 days). Decision for medical release for return toward full participation was based on subjective report of pain-free daily and rehabilitation activities and a pain-free examination that also revealed symmetric range of motion and strength. Patients were instructed on a gradual, pain-free activity advancement program and advised to take 4 to 6 weeks to advance to full participation. Actual time to return to full play is not known. The mean DRTPA was 67.20 days (range 17-242 days). All 208 patients were eventually cleared for RTPA. No patient required surgical intervention and no patient returned because of chronic pain issues in the region of the injury.

Females were more likely to experience a delay in diagnosis compared with males. Nearly half of the males with pelvic avulsion fracture (45.95%) were diagnosed in the first week after injury compared with 37.18% of females. At the 2-week postinjury mark, 61.49% of the males had been diagnosed compared with 48.72% of the females. By the 3-week postinjury mark, this difference was negligible (71.63% of males vs 69.23% of females). There were no statistically significant differences in timing of diagnosis, duration of treatment, or DRTPA between females and males.

Patients who reported hearing or feeling a "pop" at the time of injury were more likely to be diagnosed early compared with those who did not hear a pop. Nearly two-thirds of those who experienced a pop (51/78; 65.4%) were diagnosed in the first week after the injury event, and 84.6% (66/78) of those experiencing a pop were diagnosed within 14 days. In comparison, only 43% of the patients who did not experience a pop at the time of injury were diagnosed in the first 2 weeks [31.3% (46/147) in group 1 and 11.6% (17/147) in group 2]. Group 3, 4, and 5 patients were significantly less likely to have experienced a pop at the time of injury compared with group 1 patients ($P < 0.001$ in all groups).

There were no statistically significant differences in timing of diagnosis, duration of care, or DRTPA for injuries on the right side compared with the left. Consideration of anatomical location of injury, the mean time to diagnosis, duration of care, and DRTPA is presented in Table 1. Patients with IT avulsions were significantly more likely to experience diagnostic delay than those with AIIS, ASIS, or IC injury. The mean time to diagnosis for patients with IT injury was 36.68 days, a delay of approximately 2.5 to 3 times the other sites; this difference was statistically significant ($P < 0.0001$ comparing IT with each of the other locations).

The mean duration of care ranged from 39.70 days for IC injuries to 51.95 days for IT injuries. An overall ANOVA test was performed but did not detect a significant difference in the mean duration of care across injury locations ($P = 0.156$), which would typically not lead to further investigation. The appearance of the 12-day difference in treatment duration between IC and IT injuries led us to perform a *t* test between these 2 locations alone and revealed a *P* value of 0.0260. However, with a multiple comparison adjustment, the difference between IT and IC duration of care was not statistically significant. Duration to return to play advancement was longest in the IT injury group, reaching a mean of nearly 3 months; this was significantly longer compared with all other sites ($P < 0.0011$ vs AIIS; $P < 0.0002$ vs ASIS; $P < 0.0004$ vs IC).

**TABLE 1. Time to Diagnosis, Duration of Care, and DRTPA Based on Location of Injury**

| | Time to Dx, Days ± SD | Duration of Care, Days ± SD | DRTPA, Days ± SD |
|---|---|---|---|
| AIIS | 11.67 ± 10.90* | 46.56 ± 28.23 | 58.49 ± 31.23† |
| ASIS | 14.15 ± 17.15* | 48.36 ± 28.63 | 62.58 ± 35.83‡ |
| IC | 12.48 ± 9.64* | 39.70 ± 18.30 | 52.63 ± 23.31§ |
| IT | 36.68 ± 37.97 | 51.95 ± 30.83 | 88.09 ± 48.49 |

*All cases are included in the time to Dx calculations (AIIS n = 58; ASIS n = 73; IC n = 31; IT n = 63). Only cases followed through clearance to return to play advancement included in duration of care and DRTPA calculations (AIIS n = 55; ASIS n = 69; IC n = 27; IT n = 57).*
**P < 0.0001 compared with IT.*
*† P = 0.0011 compared with IT.*
*‡ P = 0.0002 compared with IT.*
*§ P = 0.0004 compared with IT.*

We compared the top 5 ranked sports in which injury occurred (basketball and dance/ballet tied for fifth most common sport; thus, both are included) to assess for differences in time to diagnosis, duration of care, and DRTPA (Table 2). Because basketball and dance/ballet injuries were few, we used the Kruskal–Wallis test. A significant difference was noted in timing of diagnosis. A post hoc multiple comparison test was performed to determine which sports significantly differed from one another. It was determined that football, basketball, and dance/ballet athletes all demonstrated a significantly longer time to diagnosis compared with baseball/softball athletes. There were no statistically significant differences between sports in duration of care or DRTPA.

Analyzing groups based on timing of diagnosis revealed that 43.1% (97/225) of patients were accurately diagnosed within 1 week of the injury, 57.3% (129/225) by 2 weeks, 71.1% (160/225) by 3 weeks, and 86.7% (195/22) by the 30-day mark. Mean age, time to diagnosis, duration of care, and DRTPA are presented in Table 3. Regarding age, no significant differences were noted between the groups with the exception of patients in group 4; patients in this group were significantly older than those in group 1 ($P = 0.03$). An overall comparison of groups 2, 3, 4, and 5 showed no significant difference in mean age at the time of diagnosis ($P = 0.194$).

There was no significant difference ($P = 0.8275$) in duration of care between groups, but there were significant differences in DRTPA between groups, which started when diagnosis was delayed beyond 3 weeks. Patients in group 1 had a significantly shorter DRTPA compared with those in group 4 ($P < 0.0001$). Patients diagnosed in group 5 had a significantly greater DRTPA compared with all other groups ($P < 0.0001$ vs group 1, group 2, and group 3; $P < 0.005$ vs group 4) (Table 3). Although some group comparisons of DRTPA did not meet statistical significance, variances between these groups ranged from 8.56 to 23.24 days, which may be clinically significant for the athlete.

In trying to determine a specific time cutoff that might constitute a definition of delayed diagnosis for pelvic avulsion fractures, we divided the cohort into 2 groups for comparison.

**TABLE 2. Time to Diagnosis, Duration of Care, and DRTPA for Subjects in the Most Commonly Represented Sports**

| Sport | N | Variable | Mean Days | Median Days | Min. Days | Max. Days |
|---|---|---|---|---|---|---|
| Soccer | 61 | Time to Dx | 16.34 | 10.0 | 1.0 | 120.0 |
| | 57 | DoC | 50.74 | 39.0 | 14.0 | 155.0 |
| | 57 | DTRPA | 67.82 | 56.0 | 17.0 | 185.0 |
| Track/XC/Running | 50 | Time to Dx | 13.62 | 7.0 | 0.0 | 73.0 |
| | 47 | DoC | 47.02 | 42.0 | 14.0 | 130.0 |
| | 47 | DTRPA | 60.87 | 53.0 | 17.0 | 132.0 |
| Football | 28 | Time to Dx | 16.29 | 16.5* | 1.0 | 30.0 |
| | 27 | DoC | 43.63 | 34.0 | 21.0 | 108.0 |
| | 27 | DTRPA | 59.96 | 53.0 | 22.0 | 110.0 |
| Baseball/Softball | 15 | Time to Dx | 13.07 | 3.0 | 0.0 | 90.0 |
| | 12 | DoC | 45.50 | 45.0 | 21.0 | 78.0 |
| | 12 | DTRPA | 50.50 | 50.0 | 22.0 | 79.0 |
| Basketball | 9 | Time to Dx | 43.56 | 15.0* | 3.0 | 180.0 |
| | 8 | DoC | 36.50 | 28.0 | 16.0 | 65.0 |
| | 8 | DTRPA | 83.63 | 62.5 | 22.0 | 208.0 |
| Dance/Ballet | 9 | Time to Dx | 34.33 | 30.0* | 2.0 | 120.0 |
| | 8 | DoC | 50.00 | 33.0 | 30.0 | 103.0 |
| | 8 | DTRPA | 82.38 | 86.5 | 39.0 | 155.0 |

*The Kruskal–Wallis test was used for comparison and revealed a significant difference between sports (P = 0.0103). The post hoc Dunn test determined which groups differed significantly, but does not calculate a P value.*
** Significant difference compared baseball/softball athletes.*
*DoC, duration of care; Dx, diagnosis; Max., maximum; Min., minimum; N, the number of patients for each portion of the analysis; XC, cross country.*

**TABLE 3. Comparison of Age at Time of Diagnosis, Timing of Diagnosis, Duration of Care, and DRPTA Between Study Groups**

| Delay Group | Age, Years ± SD | Time to Dx, Days ± SD | Duration of Care, Days ± SD | DRTPA, Days ± SD |
|---|---|---|---|---|
| Group 1 (diagnosis on days 0-7) | 14.59 ± 1.65 | 3.52 ± 2.24 | 45.51 ± 26.03 | 48.96 ± 25.85 |
| Group 2 (diagnosis on days 8-14) | 14.53 ± 1.60 | 11.75 ± 2.46 | 47.44 ± 21.83 | 59.07 ± 21.97 |
| Group 3 diagnosis on days (15-21) | 14.87 ± 1.33 | 19.97 ± 1.99 | 47.48 ± 25.32 | 67.93 ± 26.07 |
| Group 4 (diagnosis on days 22-30) | 15.18 ± 1.22* | 28.43 ± 2.45 | 53.66 ± 36.03 | 82.31 ± 36.66† |
| Group 5 (diagnosis on days 31+) | 14.55 ± 1.42 | 69.23 ± 37.69 | 48.82 ± 33.17 | 116.93 ± 54.09†‡§¶ |

*Age at time of diagnosis and time to diagnosis numbers include all study subjects (n = 225), mean duration of care, and mean DRTPA only include subjects who were treated through DRTPA (n = 208).*
**P = 0.030 compared with group 1.*
*† P < 0.0001 compared with group 1.*
*‡ P < 0.0001 compared with group 2.*
*§ P < 0.0001 compared with group 3.*
*¶ P = 0.005 compared with group 4.*
*Dx, diagnosis.*

The "C-14" scenario set a proposed diagnostic delay cutoff of 14 days, comparing patients diagnosed from 0 to 14 days versus all those diagnosed after 14 days. The "C-21" scenario set the diagnostic delay cutoff at 21 days and compared patients diagnosed from 0 to 21 days versus all those diagnosed after 21 days.

In the C-14 scenario, duration of care was 5.7 days longer for patients diagnosed after 14 days than for those diagnosed by day 14, and this increased to 7.2 days longer when the C-21 scenario was evaluated. These differences did not meet statistical significance in either scenario. Duration to return to play advancement differences were significant in both the C-14 and C-21 scenarios. In the C-14 scenario, DRTPA in athletes diagnosed after 2 weeks was 42.3 days longer than those diagnosed within the first 2 weeks ($P < 0.001$). In the C-21 scenario, DRTPA was 51.3 days longer in those diagnosed after 3 weeks ($P < 0.001$). In other words, delay in diagnosis as little as 2 to 3 weeks may result in an additional 6 to 7.5 weeks away from sport participation for the athlete.

Regardless of the cutoff time used, the most common reason for delayed diagnosis was delay in seeking treatment due to patient/family choice. Other common reasons included diagnosis of hip flexor strain by a medical provider without x-ray obtained (this included AIIS, ASIS, and IC cases) and diagnosis of hamstring strain by a medical provider without x-ray obtained (IT cases). Over one-third of patients in this cohort were seen by a medical provider, in some cases more than one, without the diagnosis of avulsion fracture being made at the time of the initial medical evaluation (Table 4).

Diagnostic delay due to patient/family choice was the reason for delay over half the time at all time checks. It accounted for 57.3% of the cases in the C-14 and 52.3% of the cases in the C-21 scenarios. This persisted when we looked at a 28-day cutoff as well, although we did not perform a formal analysis of a "C-28" scenario. A total of 21 patients who were eventually diagnosed with an AIIS, ASIS, or IC avulsion fracture in the C-14 scenario were initially diagnosed with anterior hip strain by another provider without having undergone x-ray evaluation; 10 of those patients presented by the end of the third week postinjury (Table 5).

The number of patients initially diagnosed clinically with hamstring strain (without x-ray being obtained) remained high as time passed. There were 13 cases of clinical diagnosis of hamstring strain in the C-14 scenario, and the IT fracture in all of these patients was still undiagnosed at the end of the third week (at the end of the fourth week, 12 of these patients remained undiagnosed). The reasons for delay in diagnosis did not differ between women and men in either scenario.

## DISCUSSION

Delay in diagnosis is most commonly studied in medical illnesses including a variety of cancers, hypertension, and diabetes. Diagnostic delay of these conditions may lead to increased morbidity and mortality.[6–9] Many of these conditions can be detected before the onset of symptoms; therefore, screening is recommended to identify the presence of disease at the earliest possible time.[6–11] The US Preventive Services Task Force does not currently recommend screening for any specific musculoskeletal condition in adolescents.[11]

Delayed diagnosis of musculoskeletal disorders may also lead to adverse outcomes. Slipped capital femoral epiphysis (SCFE) is the most common hip disorder in adolescents and is more common in males and obese adolescents. Treatment of SCFE is surgical, and outcomes are best if treated early, when the slip is stable; delayed diagnosis may lead to advanced slip and worse outcomes. In a study of 102 patients with SCFE, Green et al[12] noted a mean duration of symptoms of 20 weeks before evaluation and diagnosis at their specialty center. If the patient saw a primary care physician before referral to the specialty center, there was a 76-day delay from the date of the first primary care visit to the visit with the specialist. In 2016, Schur et al[13] reported 481 cases of SCFE over a 10-year period, comparing time from onset of symptoms to diagnosis and found a mean time of 17 weeks. When dividing the study period into 2-year intervals, they found no improvement in speed of diagnosis over the study period.

Diagnostic delay of scaphoid fracture has been widely studied. Scaphoid nonunion rates of 40% may occur when diagnosis and treatment are delayed by 4 weeks, compared with 3% when diagnosis and treatment occur within 4 weeks.[14] Reasons for delay of scaphoid fracture diagnosis are variable but include delay in seeking treatment, delay of initiating appropriate treatment based on clinical findings (low suspicion of injury based on unimpressive patient symptoms and examination findings), normal initial x-rays, and lack of compliance with immobilization.[14–20]

Pelvic avulsion fractures in adolescent athletes are considered relatively uncommon, but the true incidence is unknown. Delay of accurate diagnosis is often due to misdiagnosis as a

**TABLE 4. Number of Patients Evaluated by a Medical Provider and Not Diagnosed With Avulsion Fracture Before Presenting to the Sports Medicine Clinic (N = 225)**

| Medical Provider(s) | Number (%) |
|---|---|
| Primary care physician (PCP) | 19 (8.4%) |
| Emergency department | 16 (7.1%) |
| Athletic trainer | 12 (5.3%) |
| Physical therapist (PT) | 8 (3.6) |
| Orthopedic surgeon | 7 (3.2%) |
| Urgent care (UC) | 7 (3.2%) |
| Chiropractor | 6 (2.7%) |
| PCP and PT | 3 (1.3%) |
| PCP and orthopedic surgery | 1 (0.4%) |
| Physiatry | 1 (0.4%) |
| UC and orthopedic surgery | 1 (0.4%) |
| UC and PT | 1 (0.4%) |
| No evaluation before sports medicine clinic | 143 (63.6%) |

muscle strain.[21–24] Few larger studies discuss the length of time from injury event to accurate diagnosis, rather designating injuries simply as acute or chronic.[25,26] Most medical conditions are considered chronic if they have been present for more than 3 months. There is no specific amount of time from injury event to diagnosis which defines diagnostic delay for pelvic avulsion fractures. Because an avulsion fracture is typically an acute event and typically leads to sudden onset of pain and various levels of disability, early access to the healthcare system could be expected.

When time from injury to diagnosis is discussed, case reports and most smaller series report presentation and diagnosis within hours or days,[27–31] although greater delays in diagnosis have commonly been reported. In Fernbach series of 20 patients, presentation was within 24 hours in 10 cases, and the exact time frame for diagnosis of the other 10 cases is not reported.[32] Ferlic et al[33] noted 3 of 13 cases of IT avulsion fracture that presented more than 4 weeks after the injury event. Six cases of IT avulsion in adolescent athletes were included in the report by Gadwani and Bircher,[21] and diagnosis was delayed in 5 of these cases (range 3 months to 3 years) because these patients were being treated for presumed mid substance tear of the hamstrings. In a different report, Gadwani et al[22] describes IT avulsion fractures in 3 athletes who were diagnosed at 4, 15, and 24 months after the injury event. Nine patients with AIIS avulsion described by Uzun et al[34] presented at a mean of 3 months postinjury. Time from injury to diagnosis in the current cohort ranged from the day of the injury to 6 months postinjury; 23 patients (10.2%) were diagnosed within 24 hours of the injury event, whereas only 10 patients (4.4%) presented with chronic (90 or greater days) pain.

Misdiagnosis as muscle strain has been reported as a reason for delay in pelvic avulsion fracture diagnosis. We found the absence of a "pop" at the time of injury increased the likelihood of delaying diagnosis past 2 weeks. Perhaps the presence of a pop acted as an alarm to the patient/family of the severity of the injury event. Females were less likely to be diagnosed in the first 2 weeks compared with men. Females experienced a pop at the time of injury in 25.6% (20/78) cases compared with 39.4% (58/147) in males. Although likely a contributing factor to diagnostic delay in females, it is not likely the only factor. Both females and males who experienced a pop at the time of injury were very likely to be accurately diagnosed within 2 weeks of the DOI (85% of females and 84.5% of males).

Athletes with IT avulsions experienced a significant delay in diagnosis compared with injuries at other sites. Perhaps this is, in part, due to the common occurrence of hamstring strain in sports; patients may assume a strain to be present and delay seeking care. We also noted, however, that IT injuries may be misdiagnosed as hamstring strains by medical professionals, and when this occurs, patients continue to delay seeking additional care, likely due to trust in the initial diagnosis. Early diagnosis of a hip flexor strain in athletes with ASIS, AIIS, and IC avulsions also led to delays in diagnosis, but the delay was not as prolonged as in the cases of IT avulsion.

Although there were differences in duration of care based on timing of diagnosis location of injury, there was no significant difference in duration of care according to our ANOVA analyses. Duration to return to play advancement, on the other hand, did show statistically significant differences across some groups. Patients in group 5 experienced a significantly longer DRTPA than patients in all other groups, and patients in group 4 experienced a significantly longer DRTPA than those in group 1. Although it would seem the significant differences come from the delay in diagnosis alone, our analyses cannot rule out at least a small contribution from

**TABLE 5. Reasons for Delay in Diagnosis**

| | Diagnosis > 14 d (N = 96) | Diagnosis > 21 d (N = 65) | Diagnosis > 28 d (N = 51) |
|---|---|---|---|
| Patient/family choice | 56 | 35 | 27 |
| Initially diagnosed as hip flexor strain, no x-ray obtained | 21 | 11 | 7 |
| Initially diagnosed as hamstring strain, no x-ray obtained | 13 | 13 | 12 |
| Diagnosed as hip strain, x-ray misread by initial provider | 4 | 4 | 3 |
| Diagnosed as hip strain, x-ray normal, diagnosis by MRI | 2 | 2 | 2 |

*The data in this table represent only those patients diagnosed after the cutoff day.*
*MRI, magnetic resonance imaging.*

the slight differences in duration of care. Differences in DRTPA, although not statistically significant across all groups, may be extremely significant to the injured athlete.

Reasons for delay in diagnosis of pelvic avulsion fracture have never been evaluated. As in many cases in medicine, patient delay in seeking care plays a role in diagnostic delay, and in this cohort, patient/family decision on when to seek care was the most common cause of delay regardless of the cutoff used to define diagnostic delay. Previous diagnosis of a strain by a medical provider was a reason for delay which tended to persist over time. Specifically, IT fractures diagnosed as hamstring strain without the benefit of x-ray remained a consistent cause of delayed diagnosis. Accurate diagnosis is very important because misdiagnosis as muscle strain commonly leads to greater delays in diagnosis which subsequently leads to significant delay in DRTPA.

There is no specific time frame recognized as the definition of diagnostic delay in pelvic avulsion fractures. In our initial analyses comparing groups at 1-week intervals for the first month after the injury event, we started noting significant differences in DRTPA when patients were diagnosed beyond 3 weeks. Additional analyses in which we defined "no delay versus diagnostic delay" time points, we noted statistically significant DTRPA when delayed diagnosis cutoffs of 14 and 21 days were used; a delay in diagnosis of 2 to 3 weeks may lead to an additional 6 to 7.5 weeks away from sport activities.

There are some limitations to this study. First, this is a retrospective study, relying on historical data obtained at the time of the visit. If the examiner did not ask about previous evaluations, a patient with a delayed presentation would be placed in the "patient/family choice" group, possibly leading to a false elevation in this number. Second, the low number of athletes representing basketball and dance/ballet made comparisons between sports less reliable and *P* values in this comparison could not be calculated. Third, a total of 17 patients did not complete their care with the sports medicine clinic either because of referral to orthopedic surgery or being lost to follow-up. Because there was fairly even distribution of these patients between males and females, injury locations and timing of initial diagnosis, we suspect these variables were equally affected. Finally, because there is no recognized cutoff that defines diagnostic delay for these injuries, we selected 2 reasonable, yet random, time points for comparison. It is possible that analysis at more time points could lead to a more specific definition of diagnostic delay for pelvic avulsion fracture.

## CONCLUSIONS

Pelvic avulsion fracture in adolescent athletes is a relatively uncommon occurrence. Despite the acute nature of the injury, the average length of time to make an accurate diagnosis is 19.59 days. Athletes who do not experience a "pop" at the time of injury and those who avulse the IT are significantly more likely to experience diagnostic delay, particularly if the IT injury is initially misdiagnosed as a hamstring strain. Females experienced more diagnostic delays than males, but not significantly. The most common reason for delay in making an accurate diagnosis was patient/family delay in seeking medical care, but up to one-third of patients were misdiagnosed by a medical provider before accurate diagnosis, and this played a large role in diagnostic delay as well. Although delay in diagnosis does not lead to a significant increase in duration of care from time of diagnosis, it is associated with a significant increase in total recovery time, especially when the diagnosis is delayed beyond 21 days.

Clinicians need to be aware of pelvic avulsion fracture and consider that what seems to be strain at muscle/tendon origins in the pelvis of adolescent athletes may be an avulsion fracture. X-rays should always be obtained to rule out avulsion fracture in adolescent athletes with acute onset hip pain during sport if the pain is located in the region of the AIIS, ASIS, IC, or IT. Early, accurate diagnosis and treatment can significantly affect an adolescent athlete's length of time away from sports.

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