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Focal Periphyseal Edema: Are We Overtreating Physiologic Adolescent Knee Pain?

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Abstract

The goals of this study were to (1) introduce the MRI phenomenon of focal periphyseal edema (FOPE) to the orthopaedic community and (2) describe characteristic features and clinical outcomes of a small series of adolescents with FOPE lesions about the knee. The inclusion criterion was the presence of activity-related knee pain and periphyseal edema on T2-weighted MRI. Exclusion criteria were skeletal maturity, history of traumatic knee injury, and the presence of other knee abnormalities. Participants completed the Short Form 10 and Pediatric International Knee Documentation Committee (pedi-IKDC) outcome assessments. Four patients (average age, 13.7 years) with atraumatic activity-related knee pain and FOPE lesions were retrospectively identified. At follow-up (average, 15.8 months), all patients reported the ability to participate in physical activities at the desired level. The mean pedi-IKDC score was 71.2. With supportive treatment, patients with FOPE were able to return to sport, although they had lower-than-average outcome scores. Increased awareness and understanding of this clinical entity are necessary for provision of effective, cost-efficient care to patients with FOPE.

Knee pain in active adolescents is a common reason for presentation to the pediatric orthopaedic surgeon. Not infrequently, patients report activity-related knee pain with neither associated mechanical symptoms nor history of knee trauma. Physical examination of these patients is often reassuring, and radiographic evaluation may not demonstrate skeletal pathology. In this setting, first-line medical management typically consists of some combinations of activity modification, analgesics, physical therapy, and bracing.

For patients whose symptoms persist despite a course of nonsurgical treatment, advanced imaging studies may be obtained. MRI is useful for revealing the presence of intra-articular and periarticular pathologies such as osteochondritis dissecans lesions, although MRI does not elucidate a clear causative etiology for some young patients with knee pain. Alternatively, MRI occasionally demonstrates an abnormality whose clinical significance is uncertain. This case series focuses on one such phenomenon that has been described in the radiology literature: focal periphyseal edema (FOPE).



Figure 1
Sagittal T2-weighted MRI image through the knee of a 12-year-old skeletally immature female who presented with atraumatic, activity-associated knee pain. The arrow points to the characteristic “starburst” pattern of edema about the closing physis, extending into both the metaphysis and epiphysis.



Figure 2
Coronal T2-weighted MRI image of the knee demonstrating physeal patency and normal-appearing menisci and cartilage. The arrow points to an area of focal periphyseal edema, characteristic of the clinical entity.

Initially described in 2011 by Zbojnicwicz and Laor,¹ FOPE is characterized by a pattern of bone marrow edema centered on the physis that extends into both the metaphysis and epiphysis in a characteristic “starburst” pattern. The FOPE “lesion” is notable in all magnetic resonance sequences but most easily identified on fat-suppressed T2-weighted images as a hyperintensity

centered on the physis (Figure 1). As described, FOPE appears near the end of skeletal growth.

In their landmark article, Zbojnicwicz and Laor¹ postulated that FOPE might represent a physiologic process rather than a pathologic one. They suggest that during early physeal fusion, the bone bridges that are formed to begin to unite the epiphysis to the metaphysis represent discrete areas of decreased physeal

pliability and resultant increased local stress. Repetitive loading activities (such as those experienced during sports) may result in micro-trauma through the areas of nascent fusion, causing local inflammation, activity-related knee pain, and the characteristic MRI finding of edema centered on the closing physis (the FOPE lesion).

Although this explanation makes intuitive sense, the clinical significance of FOPE lesions is uncertain, posing a dilemma for the healthcare provider: although the clinical presentation of FOPE seems fairly benign, its magnetic resonance appearance mimics that of physeal injury. This is important because the rapidly growing physes of the distal femur and proximal tibia, when injured in skeletally immature children, are at high risk of growth disturbance and the subsequent development of limb deformity.² Yet if FOPE-associated knee pain is truly a physiologic phenomenon associated with the onset of physeal closure, supportive treatment aimed at alleviating pain should be all that is required and symptoms should resolve when skeletal maturity is reached. Furthermore, “injury” to the closing physis should not be associated with the development of long-term sequelae. Ultimately, uncertainty over the relevance of

Table 1

Demographic Characteristics, Abnormal Physical Examination Findings, Treatment Strategies, and Clinical Outcomes for Each Patient

Patient	Age at Presentation (yr + mo)	Sex	Affected Knee	Sport	Presenting Symptoms	Mechanical Symptoms Present?	History of Swelling/Effusion?
1	13 + 0	Female	Left	Soccer	Medial knee, activity-related pain	No	No
2	12 + 1	Female	Left	None formal	Anterior knee, activity-related pain	No	No
3	15 + 11	Male	Left	Basketball, cross country	Diffuse, activity-related knee pain	No	No
4	13 + 0	Female	Right	Basketball	Diffuse, activity-related knee pain	No	No

N = no, PT = physical therapy, Y = yes

FOPE may result in costly—and possibly unnecessary—diagnostic tests, specialist referrals, and treatments.

In an effort to enhance our understanding of FOPE, this study was undertaken with the following aims: (1) to introduce the FOPE phenomenon to the orthopaedic community and (2) to describe characteristic features and short-term clinical outcomes of a series of adolescents with atraumatic knee pain and MRI-demonstrated FOPE.

Methods

In this institutional review board–approved investigation, patients were retrospectively identified from the records of two fellowship-trained pediatric orthopaedic surgeons. The inclusion criterion was the presence of activity-related knee pain and periphyseal edema on T2-weighted MRI. Exclusion criteria were skeletal maturity, history of traumatic knee injury, and the presence of other knee abnormalities. Patient’s age, sex, presenting symptoms, physical findings, radiographic findings, and treatment plans were extracted from patient charts. Magnetic resonance images were reviewed to confirm physeal patency, presence of periphyseal edema, and absence of associated injuries (Figure 2). Patients who met the

study criteria were contacted by telephone to obtain consent for participation and to administer two clinical outcome instruments, the Short Form 10 (SF-10) and the Pediatric International Knee Documentation Committee (pedi-IKDC).³ Results of the SF-10 were analyzed using Quality Metric scoring software provided by OptumInsight; results of the pedi-IKDC were analyzed using Microsoft Excel software.

Results

Three females and one male (average age, 13.7 years) were identified as having clinical and MRI findings consistent with FOPE. Most patients were active in impact sports, including running, basketball, and soccer. Their demographic and clinical data are summarized in Table 1. All patients reported atraumatic, activity-related knee pain without mechanical symptomatology. Physical examinations were notable for the absence of swelling, atrophy, and motion limitations; provocative maneuvers for meniscal and ligamentous abnormalities were normal. Four-view radiographs did not reveal osseous abnormality.

The mean time between clinical presentation and study enrollment was 17 months. In this interval, all

patients had returned to their desired level of sport participation, although knee pain continued to be reported by two patients. In addition, two of four patients had undergone repeat MRI to evaluate unresolved knee pain.

The mean score on the pedi-IKDC was 71.2 (range, 47.8 to 80.0). Recently published normative data for this validated outcome measure suggest a mean score of 86.7 (SD, 16.8) in adolescents aged 10 to 18 years.³ No patient in the current study achieved this score, even >1 year after initial presentation. Similarly, three of four patients scored markedly below the US general population for their sex and age groups on at least one subscore of the SF-10 questionnaire: one female patient had a physical health T-score of 39.26 and a psychosocial health T-score of 38.22, both markedly below peer-matched norms. Another female patient scored 38.22 on the psychosocial health T-score, and the male patient scored 42.69 on the physical health T-score; again both scores were markedly lower than age- and sex-matched “normal” peers.

Discussion and Summary

In 2011, Zbojniewicz and Laor¹ described a pattern of physeal edema in a series of adolescent patients with knee pain and without evidence of

Table 1 (continued)

Demographic Characteristics, Abnormal Physical Examination Findings, Treatment Strategies, and Clinical Outcomes for Each Patient						
Pertinent Physical Examination Findings	Treatment	Time to Final Visit (mo)	Repeat MRI?	Return to Sport/Activities?	Symptoms (Pain) Resolved?	Clinical Growth Disturbance?
Isolated tenderness over the anteromedial joint line; equivocal Thessaly test	Activity modification (self-limited)	23	Y	Y	N	N
Isolated tenderness over the anterior proximal tibia	NSAIDs, ice, brace, and PT	15	N	Y	Y	N
Mild tenderness over the anteromedial knee	Activity modification	25	Y	Y	Y	N
Nonfocal examination	Activity modification, brace, and PT	5	N	Y	N	N

N = no, PT = physical therapy, Y = yes

fracture or infection. Seven boys and five girls were included in their study of 12 patients (15 knees) who presented with atraumatic knee pain. Most of them were active in sports (75%), with reported symptoms lasting between 2 days and 1 year. When the authors assessed physeal patency of the knee using cartilage signal intensity on MRI, they noted that adolescents with FOPE lesions had remarkably similar skeletal maturation patterns. Interestingly, most patients described here and in the Zbojniec study were involved in sports, lending support to the etiologic hypothesis that FOPE represents load-induced localized microtrauma to a few physeal-spanning trabeculae, with resultant inflammation and pain.

To our knowledge, this study is the first in the orthopaedic literature to introduce FOPE as a possible etiology for unexplained atraumatic adolescent knee pain and to attempt to delineate short-term clinical outcomes for affected patients. Despite the hypothesized physiologic nature of the FOPE phenomenon, this small series demonstrates that >1 year after presentation to a pediatric orthopaedic surgeon for management of atraumatic knee pain, adolescents with FOPE may have lower physical and psychological functioning than their peers (the mean pedi-IKDC score in our FOPE cohort was similar to that reported for patients with previous knee surgery [69.9]³). Although all study patients were functioning at their desired physical activity level at final follow-up, non-limiting activity-related knee pain persisted in half the group. Repeat MRI studies in persistently symptomatic patients demonstrated the continued presence of FOPE. Thus, although FOPE has been hypothesized to be the result of benign local

disruption of physiologic early-stage physeal closure, our study suggests that FOPE-associated knee pain may not be clinically benign, with negative effects on the function and well-being of affected adolescents.

In terms of a discussion of the clinical entity “FOPE,” it is not possible to comment on the true incidence of FOPE in the developing knee. The scant literature on this MRI finding may mean that FOPE zones are recognized simply as an MRI abnormality without diagnosis. It is also possible that FOPE may be asymptomatic and therefore unnoticed in most adolescents; small, central FOPE zones may not cause sufficient edema for capsular or periosteal nerve irritation and may therefore exist undetected.¹ Also, problematic FOPE zones have not been established as a definitive cause of knee pain: although bone marrow edema has been hypothesized to be associated with pain, with a proposed mechanism of increased intraosseous pressure and periosteal irritation, a causative association has not been shown.¹

Although this small study does not provide definitive answers regarding the most appropriate management of FOPE, it does have the potential to change current clinical practice. Namely, patients with FOPE may be needlessly referred to pediatric subspecialists for management of the “abnormal” physis. Anecdotally, they may be told to expect surgical treatment. They may be removed from physical activity for fear of incurring additional physeal “damage.” As demonstrated here, patients with FOPE may undergo repeated MRI testing for persistent knee pain in the absence of mechanical symptoms and physical examination abnormalities and with an otherwise normal previous MRI results. Understanding that FOPE is likely a physiologic phenomenon that requires neither subspecialist attention, repeated MRI

testing, nor surgical intervention should lead to reduction in unnecessary tests and referrals and ultimately in more efficient (and more cost-efficient) care.

The small sample size and retrospective design of this case-series study are clear weaknesses. The retrospective nature of patient identification limits the evaluation of the natural history of FOPE and its possible effect on patient function. The pedi-IKDC and SF-10 were not administered at the time of diagnosis, and therefore, the effect, if any, of treatments cannot be addressed in this study. Furthermore, sequelae of FOPE have not been systematically described. Future studies that compare patients with FOPE to a group of age- and sex-matched adolescents with atraumatic knee pain and normal MRI may help clarify the role that FOPE plays in adolescent knee pain.

Ultimately, additional research will be required to elucidate the pathophysiology, natural history, treatment efficacy, and long-term outcomes for patients with symptomatic FOPE lesions. This should enable clinicians to devise evidence-based management strategies for adolescents affected by FOPE to appropriately counsel active patients about safe return to sports and to avoid costly, unnecessary testing and treatment.

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