

## Case Report

# Focal Periphyseal Edema (FOPE) Zone: A Possible Cause of Unexplained Knee Pain In Adolescents. A Case Report and Literature Review.

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## Abstract

Focal periphyseal edema (FOPE) is a recently described condition seen on Magnetic Resonance Imaging (MRI) scans of adolescent patients in relation to knee pain. Since its description in 2011, and proposal as a possible reason for adolescent knee pain, few case series have been published. We report a case of an adolescent male with activity-related knee pain and FOPE finding on MRI scan of his knee. On reviewing medical literature we found nine case series reported with regards to FOPE zone. We have reviewed the demographic and clinical characteristics of the reported cases. With this report we aim to bring more awareness about this condition amongst orthopaedic surgeons.

**Keywords:** adolescent, knee pain, marrow edema, physis, MRI, sports medicine

In 2011 Zbojniec and Laor<sup>1</sup> described a distinct MRI finding characterized by a focal bone marrow edema pattern centered at the physis of bones around the knee of adolescent patients. The edema pattern extended to the adjacent metaphysis and epiphysis. They coined this finding focal peripheral edema (FOPE) zones, and proposed that it could be a manifestation of normal physeal fusion, but could also be a cause of adolescent knee pain when no other MRI abnormalities are present. Since their initial case series of 12 patients there have been several other reports.<sup>2-9</sup> We present a case with a FOPE zone finding on MRI scan in an adolescent male and reviewed published reports to find out what we know about this condition so far.

## Case report

**History:** A 15 year 7 month old caucasian boy presented with off and on pain in the right knee for almost a year. Pain occurs when he was doing any sport activities or just running. The pain made him feel weak in the knee and was unable to continue with the sports. He had never noticed any swelling in the knee. He was unable to locate the pain but described it as deep seated. His father had suffered from Osteochondritis dissecans in childhood.

**Physical examination:** Physical examination of the knee revealed no swelling of the knee, full range of motion, no gross instability, and no localized tenderness. Patella grinding revealed painless crepitus in both knees. The McMurray test revealed painless clicking.

**Investigation:** Considering his family history of Osteochondritis dissecans it was decided to get an MRI scan of his knee. MRI scan showed focal periphyseal edema (FOPE) zones of proximal tibia (Figure 1).

With no other lesions detected on the MRI scan we attributed his knee pain to the FOPE lesion. The child and his parents were advised about the nature of the condition and he was recommended to cut down on sports activities and take mild analgesics when needed. On a phone call follow-up six months later, he reported less frequent pain, probably from not doing as much sports due to the Covid-19 pandemic restrictions.

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**Figure:** Coronal fat suppressed PD weighted image (a), and Sagittal fat suppressed PD weighted image (b) showing focal periphyseal edema (FOPE) zone in proximal tibial physis.

*Literature review*

Zbojniewicz and Laor<sup>1</sup> retrospectively analyzed routine MRI examinations of knees performed for acute or chronic pain in adolescents collected over a five year period. They identified 15 FOPE zones in MRI of 12 patients (Table 1). Two patients had two separate FOPE zones and one patient developed a new FOPE zone on follow-up MRI evaluation. Half of the patients had other MRI findings that could explain the pain; such as Hoffa fat pad edema, partial discoid meniscus, meniscus tear etc, but the other half had no other MRI findings. They measured the size of the FOPE zone at its maximum

transverse diameter at the level of affected physis and also proposed a classification system based on the location of the FOPE zone on the cross-sectional map on the affected physis. Considering the narrow age range of the patients and consistent degree of skeletal maturation amongst the patients they postulated that FOPE zone could be a manifestation of early stages of physiologic physeal fusion and could be responsible for clinical symptoms of pain when no other imaging findings are present.

**Table 1:** Demographic data of reported cases of FOPE zone.

Author	Year Published	Number of FOPE zone	Number and Sex	Age range	Site	Sports Activities / Trauma
Zbojniewicz et al <sup>1</sup>	2011	15	7 F 5 M	11y9m - 15y3m 13y8m -15y8m	8 Femur 6 Tibia 1 Fibula	Runner, dancer, basketball, soccer, tennis, volleyball, track athletic, off road bicycling, baseball, football, horseback riding, golf.
Beckmann et al <sup>2</sup>	2015	4	3 F	13y3m -14y2m	1 Femur 3 Tibia	Softball, dancer, basketball.
Bochmann et al <sup>3</sup>	2016	1	1 F	13y	Femur	Fell from horse.
Bai et al <sup>4*</sup>	2016	28	7 F 21 M	11 - 15y 10 - 16y	Not reported	Not reported.
Sakamoto et al <sup>5</sup>	2017	1	1 M	11y	Proximal Femur	Gymnastics.
Giles et al <sup>6</sup>	2018	4	3 F 1 M	12y1m -13y 15y11m	Not reported	Soccer, basketball, cross country running.
Ueyama et al <sup>7</sup>	2018	3	2 F 1 M	12y6m - 14y4m 14y8m	1 Femur 2 Tibia	Baseball, Figure skater, Soccer
Spiers et al <sup>8</sup>	2019	3	3 F	13y-14y	3 Femur	Gymnastics, soccer, softball.
Frohlich et al <sup>9</sup>	2020	27	7 F 20 M	Not reported	Not reported	Alpine skiing.

\* Article in Chinese language, only abstract was available in English language.  
F = female; M = male; y = years; m = months.

Beckmann et al<sup>2</sup> reported four FOPE zones in three female patients. They also noted that one of their patients had partial closure of central physis of proximal tibia. Bockmann et al<sup>3</sup> reported a single case of a 13 year old female who developed a FOPE zone in her distal femur seen on MRI evaluation nine months after falling from a horse and twisting her knee. No other injuries were detected on the MRI scan. A follow up MRI scan four months later showed clear reduction in intensity of signal produced by the FOPE lesion. It was the first reported case with a follow up MRI evaluation.

Bai et al<sup>4</sup> compared the size of the FOPE zones of 12 patients with knee pain without a traumatic history to 16 patients with knee pain after a trauma. In the non traumatic cases the FOPE zone size range was  $14.5 \pm 6.6$  mm whereas in the traumatic cases the size range was  $26.2 \pm 8.8$  mm. There was a statistically significant difference between non traumatic and traumatic FOPE zone sizes.

Sakamoto et al<sup>5</sup> report the first and the only case so far of a FOPE zone occurring in a non-weight bearing growth plate of greater trochanter apophysis in a 11 year old boy with complaints of hip pain. The pain subsided after four weeks of the onset. Gilles et al<sup>6</sup> retrospectively identified four patients, three females and one male, with MRI findings consistent with FOPE. All 4 reported atraumatic, activity-related knee pain. Two clinical outcome instruments, Short Form 10 (SF-10) and Pediatric International Knee Documentation Committee (pedi-IKDC), were obtained from the patients. The analyzed scores were found to be markedly lower than age and sex-matched normal peers even over one year after initial presentation. They suggested that FOPE associated knee pain may not be clinically benign, with negative effects on the function and well-being of affected adolescents.

Ueyama et al<sup>7</sup> reported on three adolescent patients with knee pain and finding of FOPE zones. One of the patients was followed up for two years and three months, by which time the physis had closed and follow-up MRI showed that the FOPE had disappeared. The patient showed no limb length discrepancy. Spiers et al<sup>8</sup> reported on three female patients with FOPE zones in distal femur. Two of the three patients had a repeat MRI scan at one year and three years after the initial MRI scan. The second MRI scans showed incomplete resolution of the FOPE zones. All three patients experienced persistent pain after one year of conservative treatment. One patient even had residual pain three years after the initial diagnosis.

Frohlich et al<sup>9</sup> studied 108 youth competitive alpine skiers aged 13 - 15 years to describe the overuse-related knee complaints and MRI abnormalities. They found FOPE zones in MRI of 27 patients, making it the second most common finding (25%), second to findings of distal femoral cortical irregularities (63%). Of the 27 patients with FOPE zones findings, seven were female and 20 male. Thirteen of the 27 patients were asymptomatic.

## Discussion

Physal fusion mostly starts centrally and proceeds centrifugally. This causes decreased elasticity of the central physis relative to the periphery during early closure of the central physis. Zbojniewicz et al<sup>1</sup> suggested that this may cause more stress to the central physis in athletic teens resulting in localized microtrauma with possible vascular damage and bleeding manifesting as increased signal seen on fluid-sensitive MRI sequences. Pain may arise from tethering mechanism similar to that in tarsal coalitions. All the FOPE zones reported were in the central location in the region of expected initiation of physiologic physal fusion. The average age was about 12 years in females and 14 years in males.<sup>4</sup> Although in the sum of all the reported cases there has been more number of male (49) patients compared to female (33), the number of samples is too small to determine any gender predilection. The incidence is yet unknown. Though considered a rare condition, Frohlich's<sup>9</sup> report has shown that 25% of adolescent alpine skiers had findings of FOPE zone on MRI evaluation, of which half were asymptomatic.

The most common site for FOPE zone finding was around the knee. There was only one report of a case with FOPE zone in proximal femur trochanteric apophysis.<sup>5</sup> Majority of the cases were involved in some sports activities and did not report any particular incident of trauma, supporting the theory of localized microtrauma. In traumatic cases the FOPE zone was larger in size compared with non traumatic cases<sup>4</sup>. Follow-up MRI showed the FOPE zone to decrease in size and intensity of edema signal<sup>1,3</sup>, and in one case it had completely disappeared.<sup>7</sup> This decrease in size could not be correlated with decrease in symptoms.<sup>8</sup>

Some authors have raised concerns about differentiating FOPE zone from other bone conditions such as infiltrative bone tumor, osteomyelitis and chronic physal stress injury.<sup>2,7</sup> All reports suggest conservative treatment by activity restriction, physiotherapy and mild analgesics etc, and did not recommend any invasive intervention as in most cases the symptoms resolved over time. However some reports<sup>6,8</sup> have suggested that FOPE associated knee pain may not be clinically benign as shown by decreased pedi-IKDC scores compared to matched peers and persistent activity related knee pain greater than one year after diagnosis. In the case we presented the patient still has symptoms of pain six months after the initial diagnosis.

There is still a lot we need to learn about this condition. With greater awareness of this condition amongst orthopaedic surgeons we expect reports with more objective analysis with respect to clinical presentation, size and site of the FOPE lesion and long term clinical outcome. A well planned prospective study could help us determine whether FOPE zone on MRI finding is merely a physiologic phenomenon or pathologic condition, and identify risk factors for developing this condition, thus providing us with a basis for preventive measures.

## Conclusion

We have presented a case of a young male adolescent with persistent knee pain with no MRI findings except for the FOPE zone, and attributed it to be the cause of his pain. FOPE zone is an MRI finding seen in the early physeal fusion stage. It could be a normal manifestation of early physeal fusion but could also be a cause of pain by tethering mechanism. No sex

predilection can be concluded. In most cases the clinical manifestation is benign and resolves over time, but few cases continue to have residual pain for over a year. Orthopaedic surgeons, especially those involved in adolescent sports medicine, should be aware of FOPE as a probable cause of activity related knee pain in absence of other MRI findings.

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