Automatic Detection of Slipped Capital Femoral Epiphysis on Pediatric Pelvic Radiographs Using Machine Learning

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Background

- Slipped capital femoral epiphysis (SCFE) is the most common hip abnormality of adolescence where mechanical overload of the proximal femoral physis leads to displacement of the epiphysis *and secondary joint deformity*

- In patients with suspected SCFE, initial evaluation is ideally performed with frontal and frog leg lateral pelvic radiographs, with the frog leg lateral view significantly increasing the sensitivity

- Nonspecific symptoms often result in only frontal radiographs being performed and subtle cases are often missed

- *Missed cases can lead to poor long-term outcomes secondary to hip deformity, development of osseous/avascular necrosis, and early hip arthritis in adolescents and young adults*

- *The medical-legal consequences of missed, delayed diagnosis can be severe for health systems and practioners*

Objectives

- Develop a convolutional neural network (A.I.) to automatically evaluate frontal radiographs for subtle cases of SCFE

Methods

- Convolutional neural network created with two modules in series which classified 503 frontal pelvic radiographs (e.g. 1006 hips) as normal, mild SCFE or severe SCFE (Fig. 1)

- Module 1 classified each hip has "indeterminate" (either normal or mild SCFE) or "severe" (severe SCFE) by attempting to identify the lateral margin of the proximal femoral physis on the frontal view (Fig. 2)

- If a lateral margin was recognized, the hip was classified as "indeterminate" and if it was not recognized, the hip was classified as "severe"

- A.I. was trained on 136 annotated normal frontal pelvic radiographs (Fig. 3)

- Module 1 performance was then tested on 121 (non-annotated) abnormal frontal pelvic radiographs (e.g. 242 hips)

- Those cases classified as "indeterminate" were then evaluated in module 2
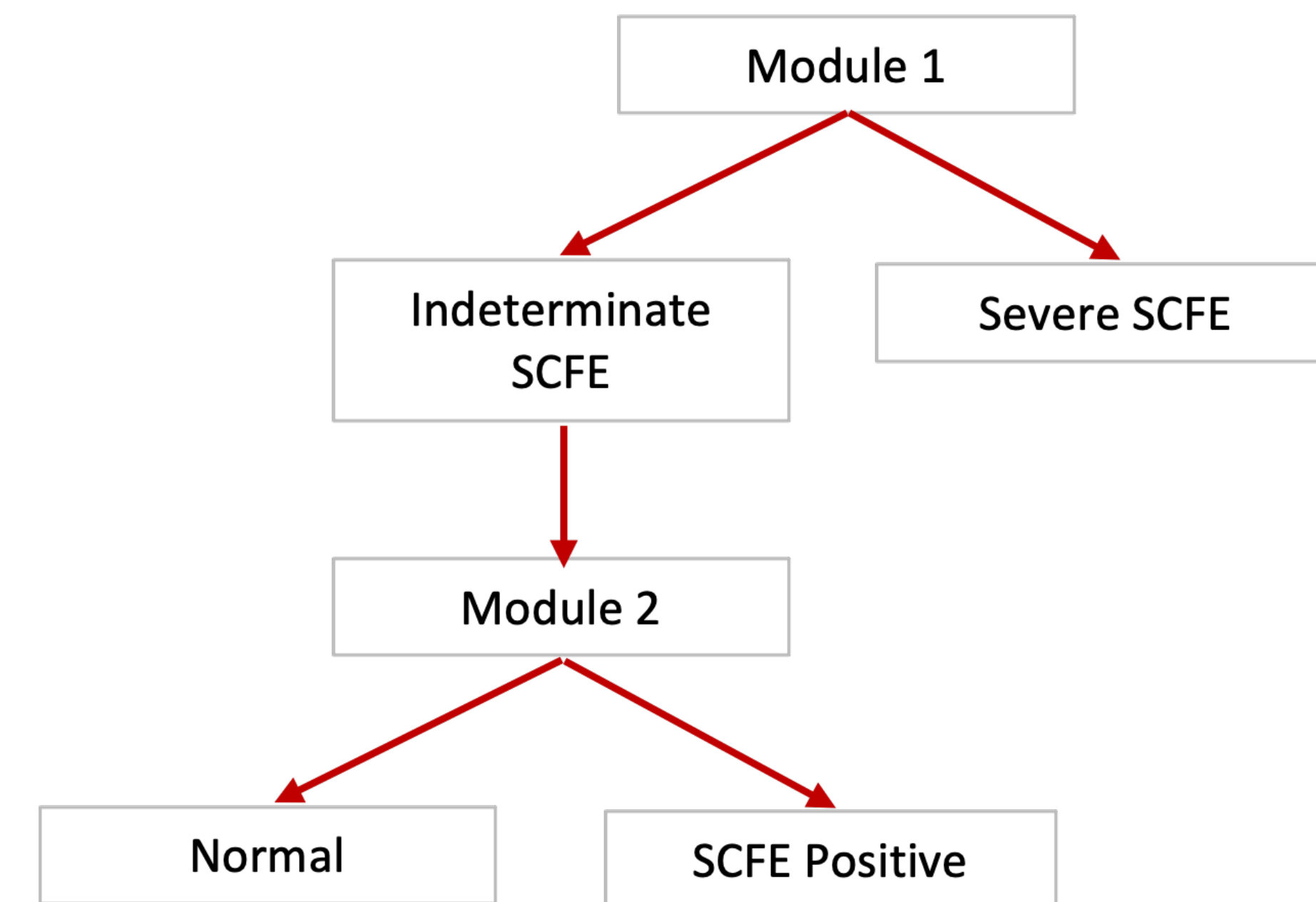
Results and Figures

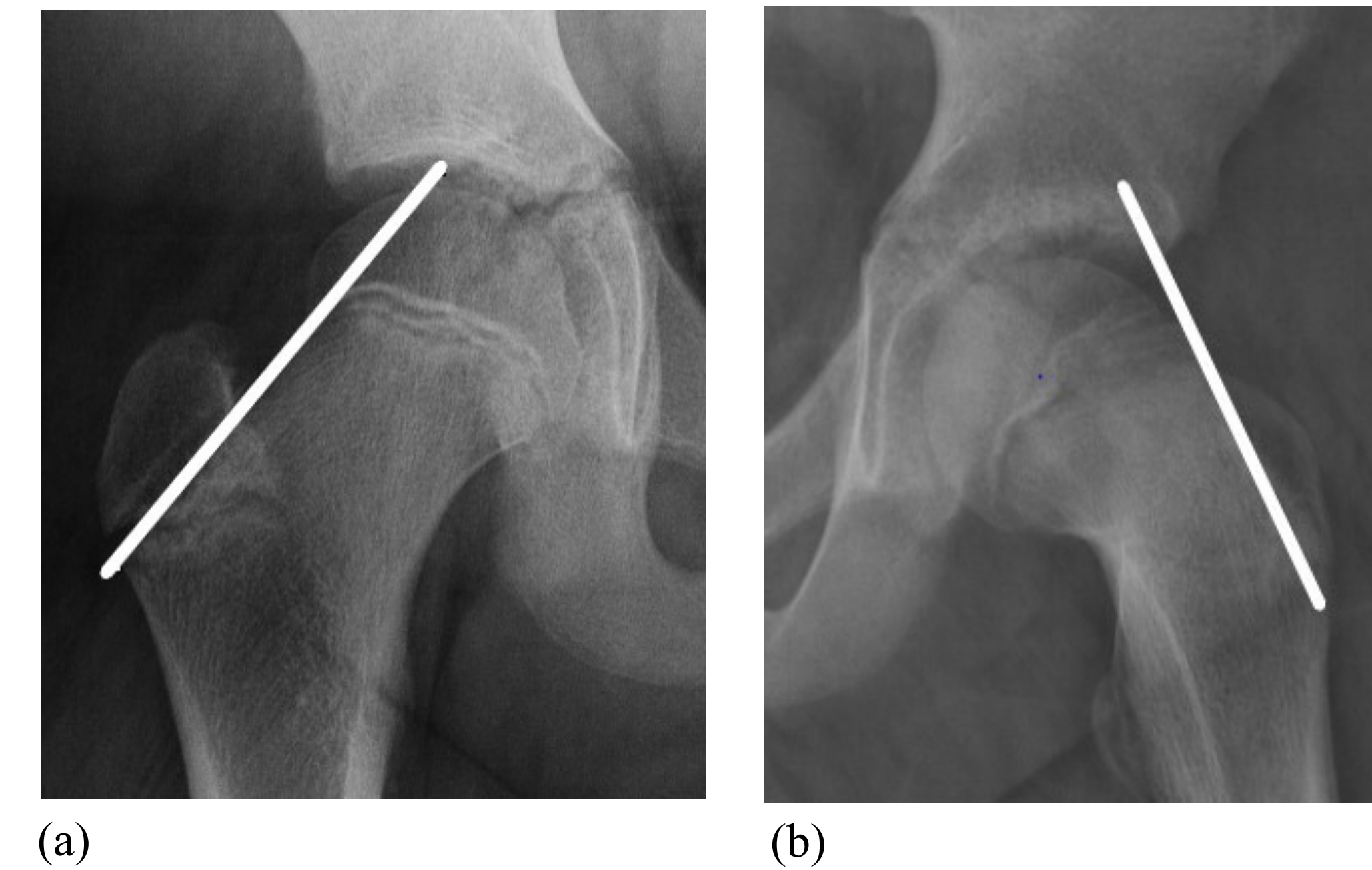Figure 1: Graphic representation of the convolutional neural network in series

Figure 2: Demarcation of the lateral margin of the femoral physis of the right and left hip in the same patient with (a) demonstrating a normal margin and (b) showing an abnormal lateral margin, which the A.I. was not able to detect
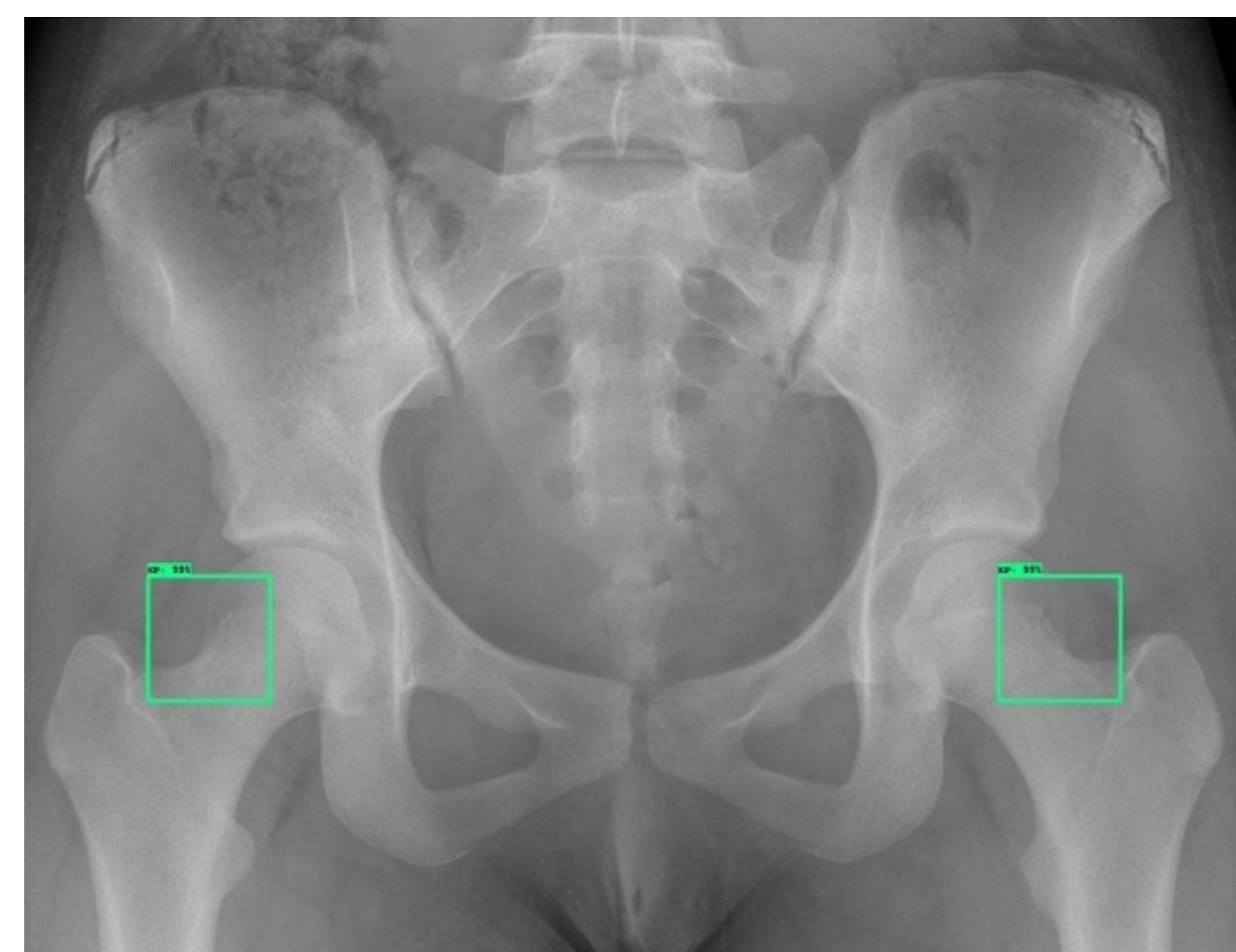

Figure 3: Automatic detection of the lateral physis region by A.I. If the normal lateral physis margin is not detected, the hip is classified as "severe"
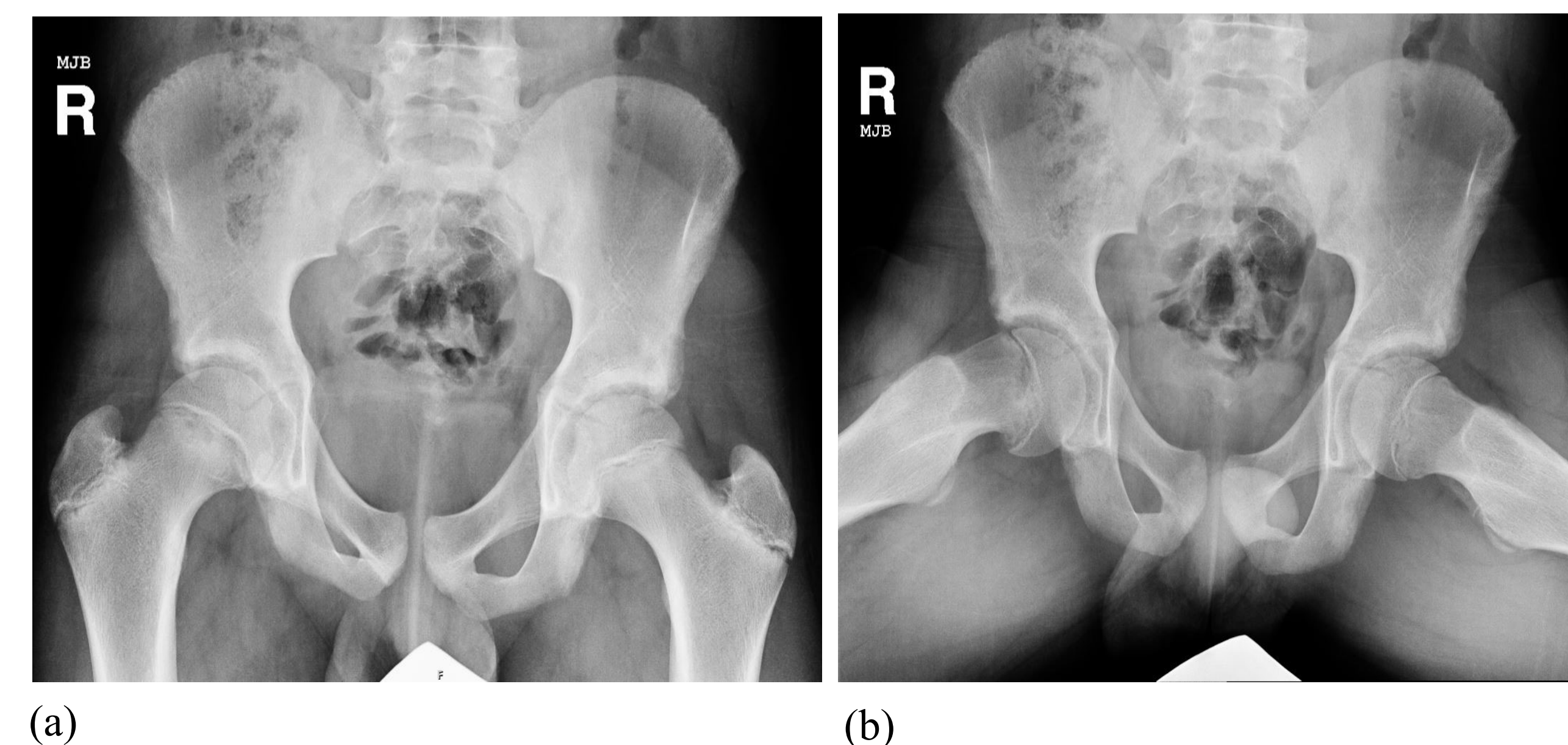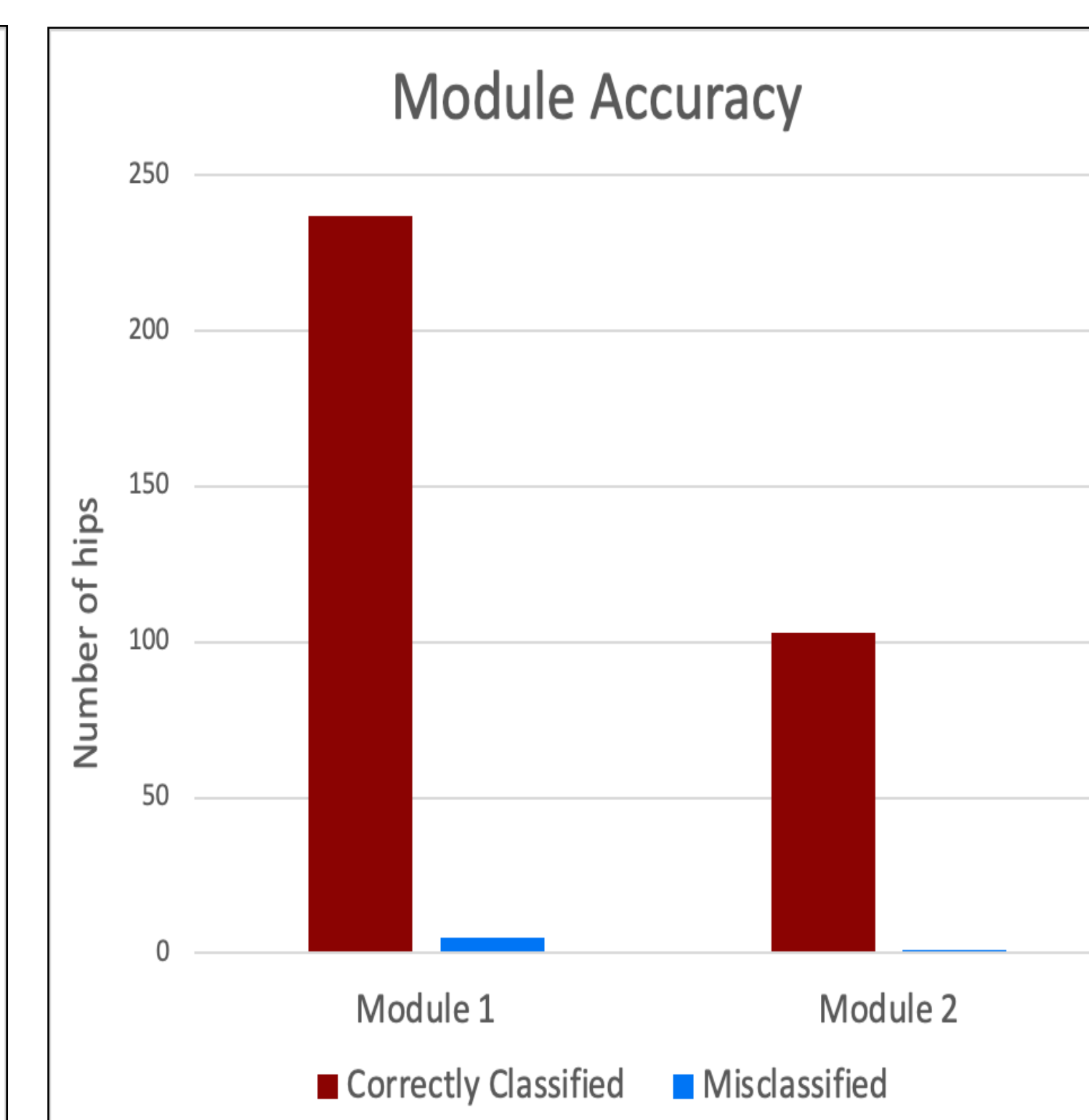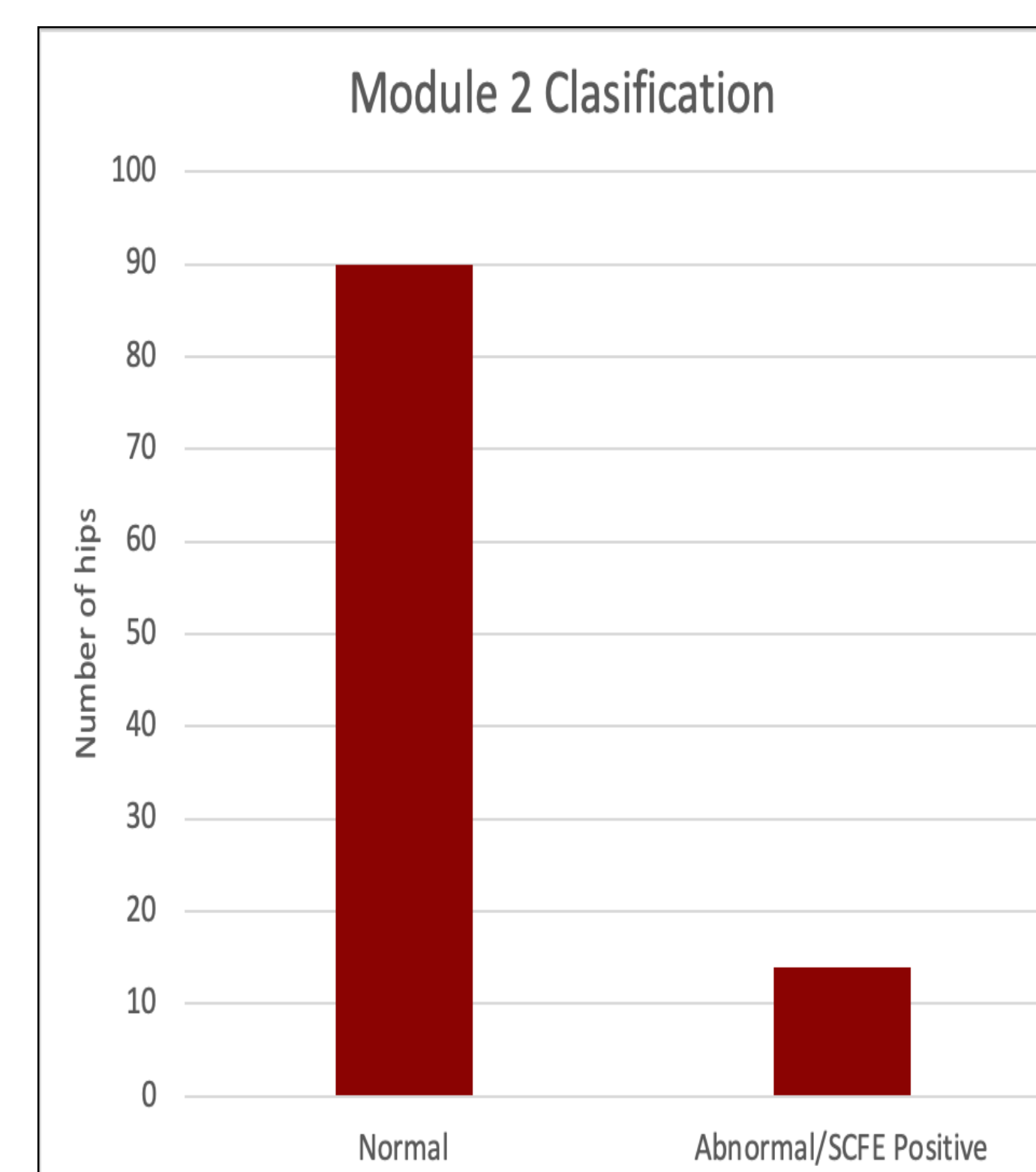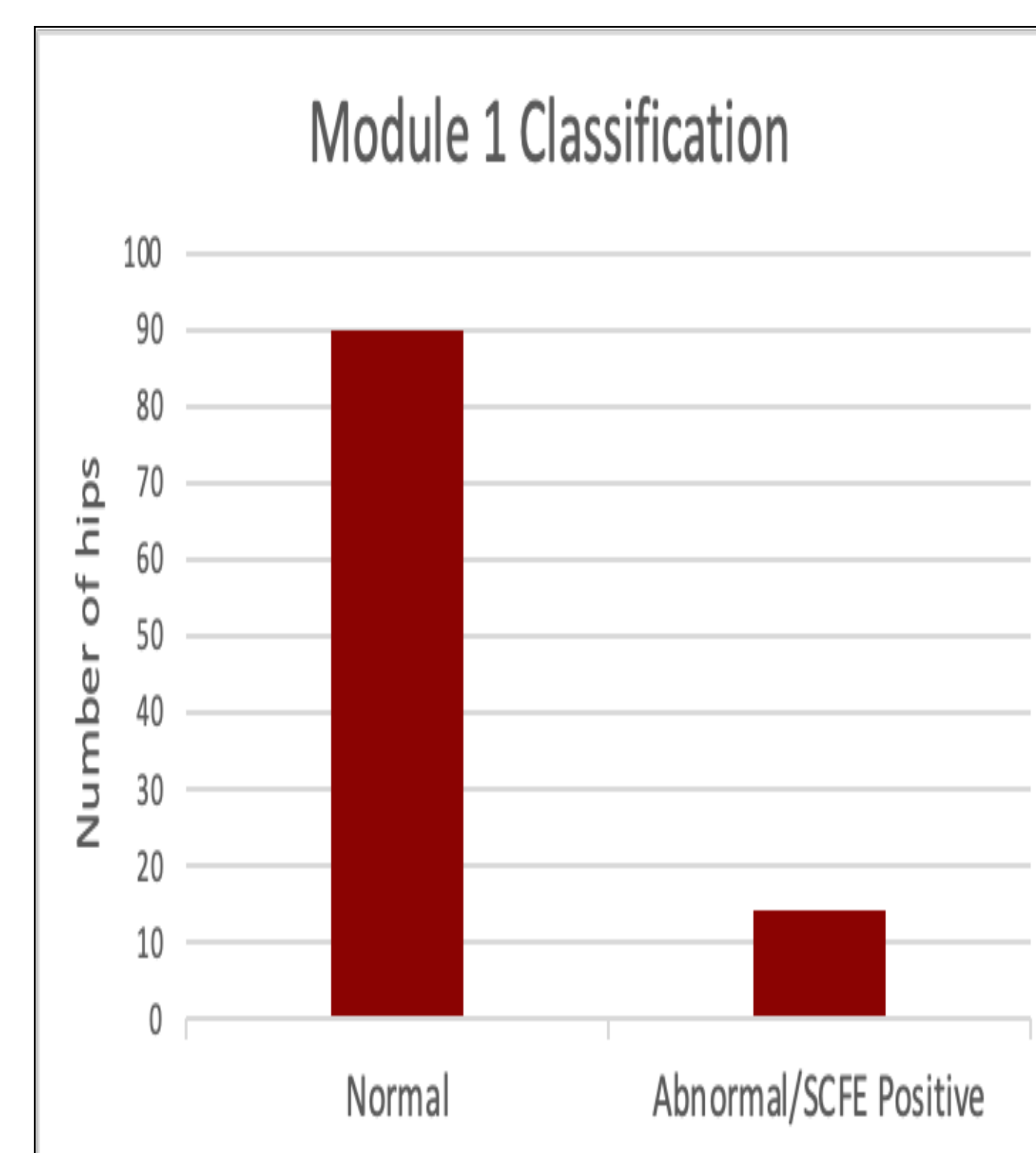

Figure 4: The gold standard is the frog leg lateral radiographic view, which makes subtle cases of SCFE on the frontal radiograph (a) more apparent (b)

Methods cont.

- Module 2 used image classification to distinguish cases of mild SCFE from normal

- The gold standard for diagnosis is the frog leg view, confirmed by an MSK-trained radiologist (Fig. 4)

Limitations

- Data from a single institution

- Relatively small dataset

Discussion

- Module 1 functions as a strong screening test with no false negative results and a low number of false positive results (2.1%)

- *Zero False negative rate is ideal for screening of conditions in which missed/delayed diagnosis increases the risk for complications, morbidity, poor outcomes*

- Module 2 has a high specificity, classifying all 90 normal hips as true "normals" and misclassifying a single subtle case of SCFE as "normal"

- Results hold promise for the automatic assessment of cases of SCFE on single view pelvic radiographs with the potential to improve detection of subtle cases of SCFE and reduce delays in care

Future Directions

- Current dataset used to train the A.I. was from a single institution, making the generalizability of this model unknown

- Public access to a larger volume of SCFE cases from multiple institutions is being made available to assess our model's performance outside of Stanford cases

References

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4. Boles CA, el-Khoury GY. Slipped capital femoral epiphysis. *RadioGraphics*. 1997;17(4):809-823.