Original Article

Detection of secondary ossification centers by sonography

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Abstract

Background: To assess the validity of ultrasonography (US) in detection of secondary ossification centers (SOC) of the hand. Radiography is the standard technique for estimating skeletal bone age with its unwanted harmful effects mostly undesirable in little children. If efficient enough, US could be an appropriate substitute.

Materials and Methods: Left hand US was performed on 6-60 months children ($n = 24$, with 29 SOCs for each child in his/her hand and a total of 696 SOCs) referred for wrist radiography and bone age determination during a 4 months period. The presence of SOCs was investigated by US and radiography by two radiologists under blind conditions.

Results: US was evaluated 696 SOCs, and 446 SOCs were detected, by US and 436 by radiography without statistically significant difference. The results of US and radiography in detection of SOCs of distal forearm (23 SOCs were detected by both US and radiography) and carpi (87 SOCs) were identical. However, in metacarpi (94 for US, 88 for radiography) and phalanges (242 for US, 238 for radiography) US appeared better.

Conclusion: On the base of our data, US is at least as effective as radiography in detection of SOCs and therefore can play a role in the skeletal age estimation.

Key Words: Bone age, radiography, secondary ossification center, sonography

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INTRODUCTION

Pediatric bone age assessment is very important and frequently used for medical and legal purposes. Conventional skeletal radiography is the standard technique for assessing bone age.[1] For evaluation of radiographic skeletal age, the Greulich-Pyle (GP) and Tanner-Whitehouse (TW) methods are generally used in clinical practice.[2] The GP atlas focuses on a number of maturational indicators, which represent stages of bone development or ossification events specific for each age, whereas TW composite scores are based on osseous stages and events at each level.[3] With these methods children are exposed to X-ray. The harmful effects of X-ray are especially, worrisome in young children. And hence, there have been attempts for replacing radiography by other safe methods. MRI has been used for this purpose.[4,5] However, despite its safety, it is expensive, not easily available, time consuming and finally not suitable for young children (because they are not cooperative). Ultrasonography (US) is a rapidly evolving technique without any harmful side- effect that is gaining popularity for the evaluation and treatment of joints and soft- tissue disease. Its inherent advantages include accessibility,

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quick scan time, low- cost, multiplanar capability, and the ability to perform real-time imaging with contralateral comparison.[3]

At birth, the bones of wrist are all cartilaginous and echolucent. Development of ossification centers occurs by a sequence as hyperechoic spots within these cartilages. And hence, US seem to be ideal for detection of these bright islands in the context of dark cartilage [Figure 1]. If US would be able to detect secondary ossification centers (SOCs) at least as soon as radiography, it can be a useful modality as an alternative method for detection of SOCs. The aim of this study is to evaluate the efficacy of US in detection of SOCs in young children, who are the most vulnerable to disadvantages of radiography.

MATERIALS AND METHODS

24 participants 6-60 months of age underwent left hand and wrist radiography and ultrasonographic examination for SOC detection from 22th Nov of 2011- to 18th March of 2012. (They were the children referred for taking left hand radiographs due to growth problems). Any radiographs indicating a disease process involving the hands were excluded. Radiographs of the left hand and wrist were taken according to the instructions of GP, with a tube-film distance of 91.4 cm. The results then were interpreted with the use of the GP atlas by a radiologist. Detected SOCs with radiography were noted on a separate "plain radiography chart.". Radiographic and ultrasonographic examinations of the left wrist and hand were performed within 5 days. Linear array real-time ultrasonographic equipment with a 7.5-MHz transducer (Siemens G50) was used by another radiologist who was unaware of the plain radiographic results. Ultrasonographic scans were targeted on the epiphyses of metacarpi, phalanges and distal end of radius and ulna and carpal cartilages, a total of 29 SOCs for each individual. Presence of an echogenic spot (with or without acoustic shadow) in center of these cartilages were considered as initial appearance of SOC. The results were recorded on the "hand and wrist US chart.". Then comparison between the sonographic and radiographic results was performed.

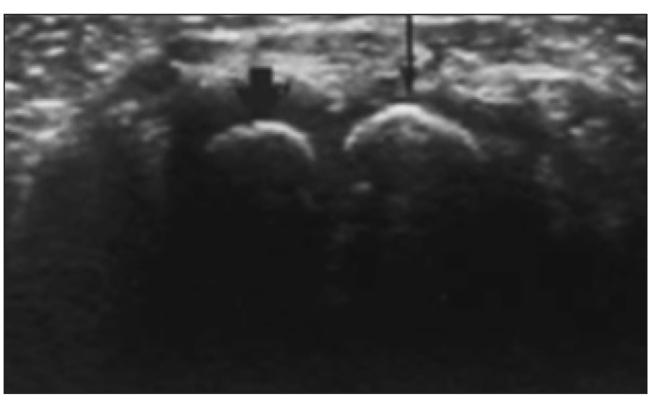

Figure 1: Ultrasonographic view of secondary ossification centers of wrist (arrows)

The 16th edition of SPSS software was used for statistical analysis.

This study was approved by "medical ethics committee" of "medical school" of "Isfahan University of medical sciences."

RESULTS

A total of 24 participants (50% males, 50% females) were examined. A total of 696 SOCs, 29 SOCs for each individual were evaluated, during a 4 months period. The mean chronological age was 35.3 ± 7.6 months with range of 16-60 months; the mean bone age was 32.62 ± 14.8 months. In total, 446 SOCs out of 696 were detected by US and 436 by radiography, without statistical significant difference (PV = 0.09). The results of US and radiography in detection of SOCs of distal forearm (23 SOCs were detected by each) and carpi (87 SOCs) were identical. In metacarpi (94 for US, 88 for radiography) and phalanges (242 US, 238 radiography) US appeared better but not significantly (P values of 0.25 and 0.1 respectively). There was no significant sex difference. The summary of results is illustrated in chart no. 1.

DISCUSSION

We have found no other study with exactly the same purposes as ours, but there were a few ones with the aim of evaluating US for investigating bone age in different ways and with different results: Castriota-Scanderberg concluded that ultrasonographic examination of the hip is a safe and cost-effective method for assessment of skeletal age, but its low accuracy makes it currently unsuitable for clinical use.[6] Another method (sunlight) using US is based on the differing conduction velocities of US through the various skeletal tissues. In cartilage, the reported velocity is about 1700 m/s, and it will double in calcified bone. With increasing volume and density of ossification of growth plates, there is a corresponding increase in velocity of sound waves.[7] with this method over prediction in delayed bone age and under prediction in advanced bone age was reported by "Khan."[2] So they concluded US yet should not be considered a valid replacement for radiographic bone age determination. An alternative approach to evaluation of ossification is US of the overlying

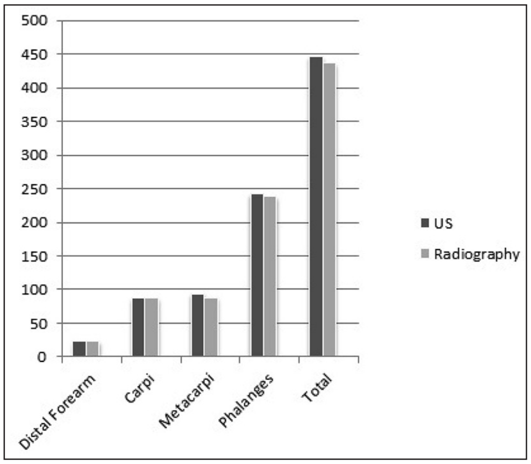

Figure 2: The number of secondary ossification centers detected by US in comparison with radiography

cartilage, with the thickness of the anterior femoral head cartilage being shown to be inversely related to chronological age. Although, the authors of this study cite a good correlation when compared with GP, there was much more variability of bone age estimates compared with the radiographic technique.[2]

According to our results, US was better than radiography in detection of SOCs of metacarpi and phalanges but not significantly (PV = 0.25 and 0.1 respectively). The minimal superiority of US in detecting metacarpal and phalangeal centers may be due to the shape, configuration and sizes of these centers and multiplanar capability of US. The shapes of carpal and metacarpal SOCs are more or less round before completely ossified but SOCs of phalanges are relatively flat. Furthermore, SOCs of metacarpi and phalanges appear relatively later and so they may be smaller than SOCs of carpi and radius at this age range (this is apart from smaller sizes of phalangeal SOCs inherently). However, the study shows sonography is a good alternative for radiography in detection of SOCs or even better [Figure 2].

With the current radiographic techniques using hand, both the shape and numbers of SOCs are important. One of the limitations of US is inability to determine the shape of SOCs as well as radiology but in small children the presence and size of SOCs are more important parameters than their shapes. SOCs appear as round foci and then with advancing age their shapes will change. Size can be accurately assessed by US in little children and as we showed in this study, US is an accurate method for detection of SOCs. Thus, it could be concluded that, if we prepare sonographic standards based on the number and sizes of SOCs then US can be used as a safe and cost-effective method for bone age assessment in young children, with the possibility of resulting in charts with standard deviations much smaller than that of radiographic ones.

CONCLUSION

According to this study, US is sensitive enough for detection of SOC of hand. We suggest that studies to find correlation between bone age and number and size of SOCs of hand with the aim of making acceptable standards be planned. Growth plates and cartilaginous parts of bones are the other subjects that may be investigated in this regard.

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