EOS Imaging: Insight Into This Emerging Musculoskeletal Imaging System

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Introduction

EOS 2D/3D imaging system (EOS imaging, Paris, France) is a multidimensional Xray imaging system that is able to acquire high quality images in two perpendicular planes with less radiation than standard imaging techniques.[1] EOS is currently used clinically in scoliosis and lower extremity deformities (leg length discrepancy, angulation deformities, *etc*). Although technically very promising, the available clinical data from the EOS imaging system are still limited, and its clinical benefits are under further investigation.

Background

EOS (EOS imaging, Paris, France) is a biplane, weight bearing, whole-body digital Xray imaging system that uses slot-scanning (an ultrasensitive Xray detection technology) as opposed to conic projection. The EOS system can produce images of comparable or better quality than computed radiography (CR) and digital radiography (DR) with 6-9 times less radiation dose and shorter examination time.[2,3] EOS image quality has been reported to be comparable or superior to film Xray imaging and CR. Two perpendicular Xray tubes and associated slot scanning detectors move simultaneously down the entire height of the patient up to 175 cm, or any desired subset of this length, and capture both frontal and lateral images simultaneously. Digital images are immediately available on the acquisition workstation and can be directly transferred to the picture archiving and communications system (PACS) (Figure 1). A whole body scan takes approximately 20 seconds and a spine scan approximately 4-6 seconds.[1,4] Patients must be able to stand or sit, and for spine Xrays specifically, they should be developmentally mature and physically able to hold their breath on command. In addition, the enclosed design of the EOS machine places a limit on the patient's size (Figure 2).

The main application of EOS is for pathology with a rotational component, which changes under load, and pathology that requires frequent and chronic follow-ups that pose a radiation exposure concern.[1,2,4] As a result, EOS imaging's main clinical indication is scoliosis/kyphoscoliosis, but it is also being used in lower extremity deformity and length discrepancy.

Methods for clinical diagnosis, evaluation, treatment planning, and follow-up monitoring of spine deformities are being continuously examined and reevaluated with numerous alternative techniques proposed throughout the years. The most commonly used Cobb angle method, the basis of scoliosis evaluation and treatment, relies on AP and lateral Xrays. Many have argued that this two-dimensional method oversimplifies and erroneously interprets a three-dimensional deformity.[5] EOS addresses the two main issues of traditional scoliosis imaging with methods of CR and DR: the dependence of the degree of curvature on the plane of radiographic projection and the concern for radiation exposure due to frequent and chronic radiographic follow-up of these patients.[5,6] The full-length EOS images eliminate the need for manual or digital stitching when there is an interest to study the relative spino-pelvic alignment in scoliosis.[1,4] Additionally, EOS addresses another major issue, the accuracy of the Cobb angle for the evaluation and monitoring of kyphoscoliotic deformities, by providing additional information on the axial rotation (Figure 3). The Ster-EOS 2D/3D software provides a quick method to generate a personalized 3D reconstruction of the spine and quantitatively deliver the rotational components of the spinal vertebrae to the PACS.[1,6] The 3D reconstruction procedure is semi-manual; hence, its accuracy depends on the user expertise. Three-dimensional reconstruction of the spine has not been developed for patients younger than 7 years old or for pathologies such as supernumerary vertebrae, congenital deformities, and spondylolisthesis. Three-dimensional reconstruction is not meant to detect bone fracture, osteophytes, fibrocartilage calluses, nor significant changes in the geometry of the bone. The 3D reconstruction of the lower extremities is still not available for patients younger than 15 years old. The 3D reconstructions of the cervical spine, ribcage and upper extremities are not still developed in this software.[1]

EOS system is an up-and-coming technology. Several 3D parameters of the spine and lower extremities are still being validated. Despite

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Figure 1. Preoperative (on the left) and postoperative (on the right) LAT and AP EOS spine views of a 70 degrees right thoracic adolescent idiopathic scoliosis treated with posterior spinal fusion with instrumentation of T1-L2 levels.

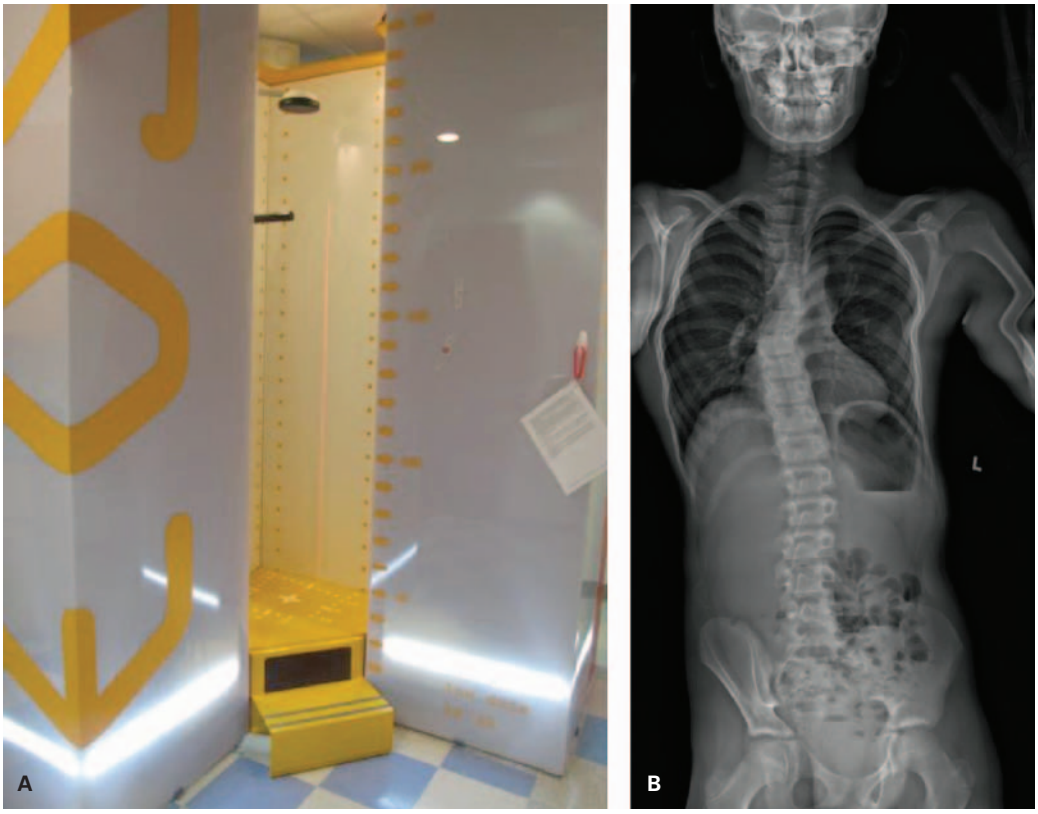

Figure 2. (A) EOS imaging system machine. (B) Artifacts due to patient motion during a spine scan.

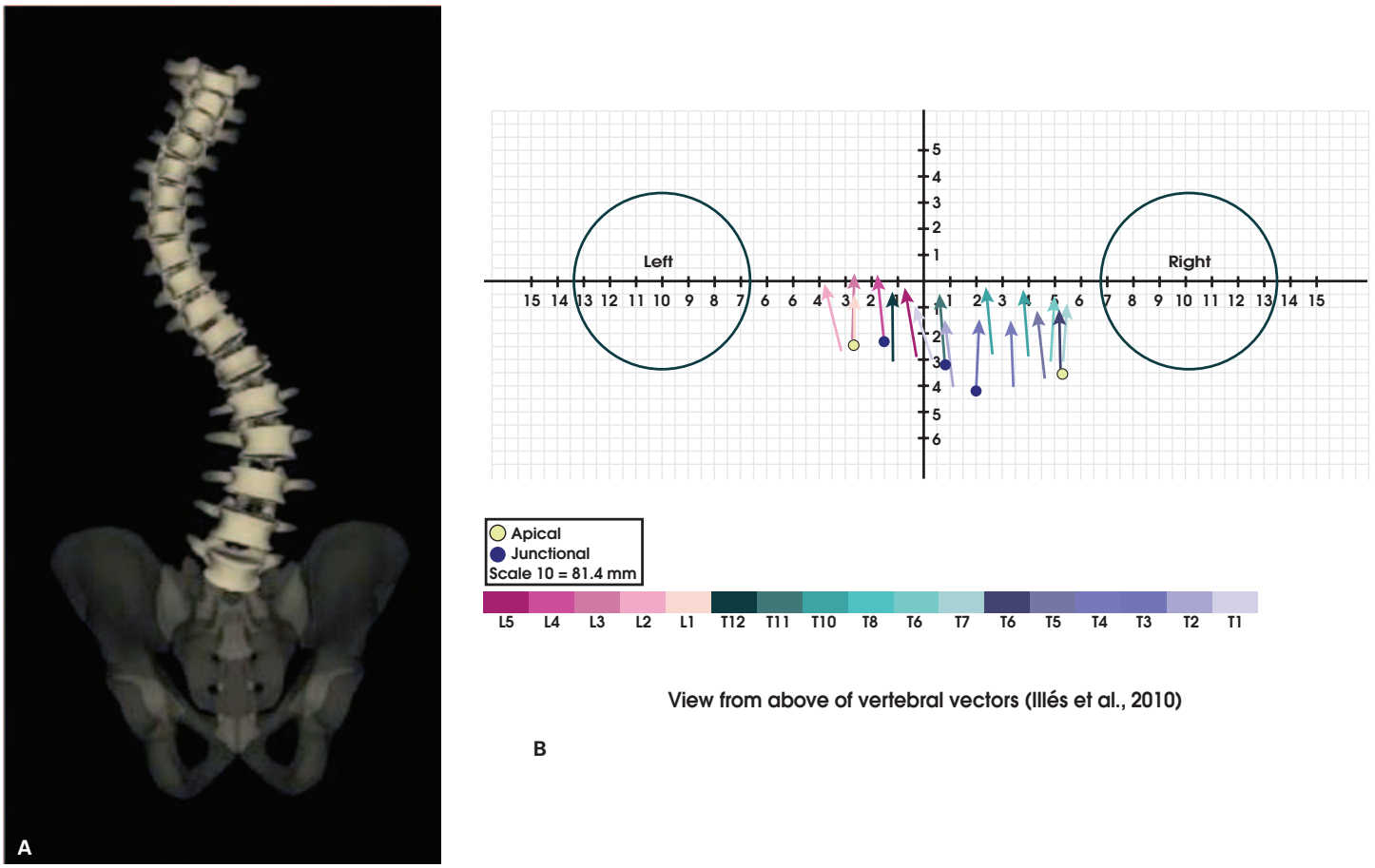

Figure 3. (A) EOS-generated 3D reconstruction of the spine of a patient with adolescent idiopathic scoliosis (AP view). (B) EOS-generated diagrams of vertebrae axial rotations shown by vertebral vectors (with respect to the femoral heads, top view).

the very promising features of the EOS imaging system the application of the 3D components of the skeletal deformities in the patient's clinical care is yet to be investigated and quantified.[2]

Question

What are the main advantages and disadvantages of the new EOS imaging system?

- Advantages:
  1. Low radiation
  2. Quick test (20 seconds for an adult full-body scan)
  3. Provides information on axial rotation
  4. More accurate representation of the deformity/spinal balance (plane of radiographic projection, weight bearing images)
  5. Less expensive than CT 3-D reconstruction for preoperative planning
  6. Full body imaging without the need for digital stitching/manual joining of images
- Disadvantages:
  1. Limited clinically validated outcomes
  2. Limited use in non-ambulatory patients and developmentally immature
  3. Not widely available
  4. Expensive equipment
  5. Narrow range of indications and applicability outside of the aforementioned uses

How can the EOS imaging system and 3D morphological parameters affect orthopedic clinical practice?

- 3D parameters permit visualization and evaluation of the true shape of the skeletal deformity. Quantitative parameters from the 3D reconstructions permit close monitoring of the progression of the deformity and surgical outcome.
- The full body Xray images allow more accurate assessment of progression of skeletal deformities and detection of abnormalities associated with a specific pathology.

Discussion

The main question that arises whenever a new device or method is introduced is if it can prove its superiority to existing methods or the standard of care. The main challenge associated with EOS is further clinical research to investigate and potentially prove whether the nature and quality of the produced images are better than the traditional imaging modalities and if the measured decline in radiation exposure translates to improved health outcomes of orthopaedic patients. Further research is needed to investigate its cost-effectiveness related to these potential health benefits.[3]

In conclusion, EOS 2D/3D imaging system is a very promising method that addresses several limitations of the current diagnostic means for various musculoskeletal disorders. However, at this time, EOS has limited clinical data and its ability to improve patient outcomes needs further investigation.[2,3] It is imperative that the orthopaedic community embraces the potential of this new imaging system and formally investigates its clinical effectiveness in patient management and long-term health outcomes.

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