Biplanar Full-Body X-Ray Imaging

- A new biplanar x-ray imaging system acquires simultaneous lateral and anteroposterior images while the patient is in a weight-bearing position.
- The imaging system uses novel slot-scanning technology that can acquire simultaneous orthogonal whole-body images at a fraction of the radiation dose of standard x-rays.
- Indications include pathologies that change under load:
  - Spinal problems such as scoliosis, kyphosis, and osteoporotic fractures.
  - Lower limb problems, including alignment evaluation prior to joint replacement surgery and monitoring leg-length discrepancies in children and adolescents.
- 3D images can be generated from the 2D views using statistical modeling.

The new biplanar imaging system (Figure 1) allows the simultaneous acquisition of orthogonal lateral (LAT) and anteroposterior (AP) images in a 1:1 scale while the patient is in an upright, weight-bearing position. The biplanar system achieves this with the aid of a novel detection system (a proportional multiwire chamber and a gaseous x-ray detector), which is not affected by scattered radiation.

Images are acquired using a slot scanning method that scans a horizontal line at a time during the synchronized vertical movement of orthogonal radiation sources and detectors to simultaneously create a pair of images, rather than acquiring multiple images one after another to produce compiled LAT and AP views as in standard x-ray imaging. The resulting biplanar images are up to 45 cm wide and 175 cm in height.

Images can be acquired of all or part of the body, depending on the clinical need. To achieve similar images with conventional x-ray imaging requires multiple exposures resulting in substantially longer examination times and higher radiation doses. Furthermore, conventional x-ray images must be aligned and combined (stitched) to create a view of the region of interest, a process that has the potential for distortion.

The detection method is highly sensitive and the radiation dose is one-third to one-tenth that of conventional x-ray imaging, depending on the study and body part imaged. For example, the mean entrance surface dose is five times lower than x-ray film for anteroposterior (AP) spine images and six times lower for LAT images. The detection system is insensitive to diffuse scattered radiation and the images are of high quality with a pixel resolution of 254 mm.

Figure 1. Biplanar system scanner.
The biplanar imaging system is likely to be most beneficial for patients with pathologies that change under load, especially those in which rotational movement is a factor. In addition, the low radiation exposure associated with the biplanar imaging system is likely to be beneficial for patients who need repeated x-ray examinations, especially children with scoliosis. For these reasons, biplanar imaging will be considered the standard of care at Mass General Hospital for outpatient imaging for weight-bearing lower limb joint surveys and full-spine imaging.

**Spine**
The principal indication for biplanar imaging is scoliosis (Figure 2), particularly in children, because of the need for repeated examinations. Potential indications for biplanar imaging in adults include degenerative diseases that lead to arthritis, kyphosis, or scoliosis.

**Lower Limb Alignment**
Biplanar imaging has advantages for joint surveys of hips, knees, and ankles (Figure 3) as well as measurements of leg-length discrepancies and alignment in children. It may also prove beneficial for planning surgical intervention, including joint replacement surgery.

For example, accurate correction of coronal alignment promotes good knee function and leads to better patient outcomes after knee replacement surgery. Biplanar imaging ensures that the LAT and AP images are acquired while the patient is in the same position, which could provide more precise measurements of lateral deformity. Similarly, biplanar imaging could provide benefits for hip replacement therapy since accurate models of patient anatomy are likely to promote the correct alignment of the acetabular component, which is essential to reduce wear and the risk of dislocation.

**Leg-Length Discrepancies**
Leg-length discrepancy in children and adolescents can be secondary to a variety of causes, including congenital deformity, infection, trauma, and metabolic disease. Whether the discrepancies are major or minor, they require early diagnosis and regular monitoring. Currently, conventional radiography of the full length of the extremities from hip to ankle is used to measure bone lengths and joint angles. However, the accuracy of the measurements depends on the ability of the patient to remain in one position during the acquisition of multiple images and the precise stitching together of the images for analysis. Biplanar imaging has the advantage of a single image acquisition, lower radiation dose, and the generation of 3D images.

**Patient Experience**
To be imaged by the biplanar system, a patient first steps up into a booth that resembles a shower stall (Figure 1). In most cases, images are acquired while the patient is standing but a stool can be made available to allow patients to sit during spinal imaging. A technologist aligns the patient in the AP/LAT position with the aid of two laser beams. A full-body scan from head to toe takes 20 seconds. Spine scans take four to six seconds, depending on the length of spine imaged. Although they can hold onto a bar to steady themselves, remaining still for the required length of time can be challenging for some patients.

![Figure 2. Biplanar PA and LAT images showing idiopathic S-shaped thoracolumbar scoliosis in a 12-year-old female.](image)
3D Imaging

Another potential benefit of biplanar imaging comes from the ability to generate 3D images from the 2D data. However, this function is not yet in clinical use and is only being used for research purposes.

Unlike CT, in which 3D images are generated from tomographic data, the biplanar system uses statistical modeling based on the expected shape of bones. Thus, resulting 3D images may not show the precise morphological details of the bones accurately although the mechanical axis alignment is accurate. However, 3D images based on weight-bearing biplanar imaging may have some clinical advantages.

For example, routine clinical evaluation and monitoring of scoliosis with LAT and AP planar radiographic imaging may not accurately demonstrate the severity of three-dimensional spinal deformity. The only established method to quantify vertebral rotation uses CT, in which images are acquired while the patient is lying down. As this can affect the geometry of the spine, the curvature may not reflect the situation when the patient is standing. Moreover, the radiation dose from CT is much greater than radiographic imaging and is not suitable for repeated assessments, particularly for childhood scoliosis. Recently, comparisons of 3D images reconstructed from CT images with those generated by the biplanar system showed only minor differences in vertebral body shape, position, and axial orientation.

It should be noted that the biplanar imaging system is still regarded as an emerging technology, and there is little information at present on the value of this method in terms of clinical outcomes. However, it is an active area of research with potential benefit in more accurate surgical planning as well as the ability to measure treatment outcomes.

Scheduling

Biplanar x-ray imaging is only performed in the Yawkey Center for Outpatient Care on the Mass General main campus in Boston and can be ordered by calling 617-724-XRAY (9729) or through the Radiology Order Entry system http://mghroe under the header Surveys.
Further Information

For more information about biplanar imaging, please contact Ambrose Huang, MD, Musculoskeletal Radiology, at 617-726-7717 or Michael S. Gee, MD, PhD, Pediatric Radiology, Massachusetts General Hospital, at 617-724-4207.

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References


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