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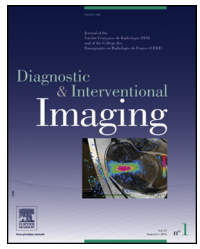

ORIGINAL ARTICLE / *Musculoskeletal imaging*

An evaluation of the EOS X-ray imaging system in pelvimetry

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Abstract
Objectives: To demonstrate the reliability of the EOS imaging system in measuring the internal diameters of the bony pelvis.
Materials and methods: A prospective study comparing the results of the pelvimetry of 18 dry pelvises carried out on the EOS imaging system to measurements taken manually and using the two current gold standard CT methods. Pelvimetric measurements of each pelvic bone were obtained using four methods and compared: direct manual measurements, spiral and sequential CT pelvimetry, and 2D-3D low-dose biplanar X-rays. The various obstetric diameters were measured to the millimetre and compared.
Results: There was no significant difference in the different diameters assessed, with the exception of the interspinous diameter. There was a highly significant correlation ($P < 0.001$) between the values measured manually and by EOS for the Magnin index (Pearson = 0.98), the obstetric conjugate diameter (Pearson = 0.99), and the median transverse diameter (Pearson = 0.87).
Conclusion: The EOS imaging system allows for an *ex vivo* determination of the obstetrical diameters that is reliable enough to estimate obstetric prognosis, producing comparable measurements to CT. In view of concerns about protection from radiation, this low-dose imaging technique could become, after *in vivo* prospective validation, the new gold standard for pelvimetry and therefore a good alternative to CT.

A vaginal delivery entails the foetus passing through the birth canal, which consists of the bony pelvis and associated soft tissues. The pelvic part of the canal is bordered by a bony frame, which means that foetal progression must

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follow a specific trajectory although there is some degree of flexibility between the different parts of the pelvis during parturition. Mechanical dystocia due to a small pelvis poses a significant risk during delivery but it can be prevented through an estimation of the diameters of the pelvic inlet, midpelvis and pelvic outlet, all of which need to be passed through. The shortcomings of clinical pelvimetry, especially in the assessment of the pelvic inlet, have given way to the use of imaging techniques. In fact, the use of imaging to prevent and control the risks during delivery has profoundly changed obstetric prognoses [1]. As part of this, traditional radiographic pelvimetry, which allows the overall shape of the pelvis to be assessed but is rather uncomfortable and uses indirect measurements, has been replaced by sequential followed by spiral CT pelvimetry, which provides an accurate estimate of the dimensions of the pelvic inlet, midpelvis, and pelvic outlet while reducing radiation exposure for mother and foetus [2]. This modality has become the gold standard and it is simple, reliable, and fast, although radiation remains a detrimental factor and 3D reconstructions are sometimes imprecise due to the constants of current and kilovoltage being reduced as far as possible. While MRI offers the advantage of being free from radiation and producing accurate measurements [3,4], it remains difficult to access.

In parallel, a few years ago a new medical imaging system called EOS appeared, which simultaneously acquires lateral and anteroposterior radiographic images and lowers the dose of X-rays absorbed by the patient. This system makes use of a high-sensitivity gaseous Charpak detector and its use is currently indicated for the assessment of deformities of the spine [5—8], and the upper [9] and lower limbs [10,11] especially in children [12]. Images are obtained in a 1:1 scale and it is accurate enough for preoperative planning, monitoring disease, or taking direct measurements, making this an attractive tool. Radiographs of a part or the full body can be taken while the patient is standing, in a single acquisition, without needing to stitch images together, and with no vertical distortion through simply choosing a reference plane to eliminate lengthening. The gaseous detectors with variable gain enable high contrast images to be acquired at an X-ray dose reduced by a factor of 8—10 compared to a traditional radiography system, thus significantly reducing the patient's radiation exposure [8,13].

The main objective of this study is to demonstrate *ex vivo* that the EOS imaging system is reliable for the measurement of the internal diameters of the bony pelvis through a comparison with the current gold standard computed tomography techniques and with direct manual measurements on the bony pelvis. The secondary objective is to compare irradiation for the various modalities tested.

Materials and methods

This prospective comparative study consisted of a comparison of the pelvimetric measurements of 18 bony pelvises obtained using the EOS system with measurements taken manually, and with those from the two computed tomography techniques that are currently gold standard. A single operator examined each pelvis independently and in a blinded manner, taking the manual measurements by using a thread that was then held against a millimetre graduated ruler, by standard and spiral CT, and then through simultaneous lateral and anteroposterior radiographic views using EOS imaging. The diameters measured were those that are usually used by obstetricians and are assessed by CT pelvimetry: the obstetric conjugate diameter (OCD), the true conjugate diameter (TCD), the median transverse and transverse diameters (MTD and TD), the intertuberous diameter (ITD), the interspinous diameter (ISD), and the anteroposterior diameter (APD) of the pelvic outlet. The Magnin index was also calculated by adding the OCD to the MTD.

For the CT examination, the bony pelvises were placed in a stand to keep them in a physiological position. On standard CT pelvimetry (Fig. 1), a lateral cross-section was used to measure the obstetric conjugate diameter, the true conjugate diameter, and the anteroposterior diameter of the outlet, and then two cross-sectional planes were combined: one passed through the ischial spines to measure the intertuberous diameter, and a second perpendicular plane through the middle of the obstetric conjugate diameter was obtained by tilting the stand, and this was used to measure the median transverse diameter of the inlet. The cross-sections were 5 mm thick and the constants were held at 120 kV and 50 mA (Siemens Somatom Sensation CT 64-channel scanner, Erlangen, Germany). Next, a spiral CT of each pelvis was carried out a using the following

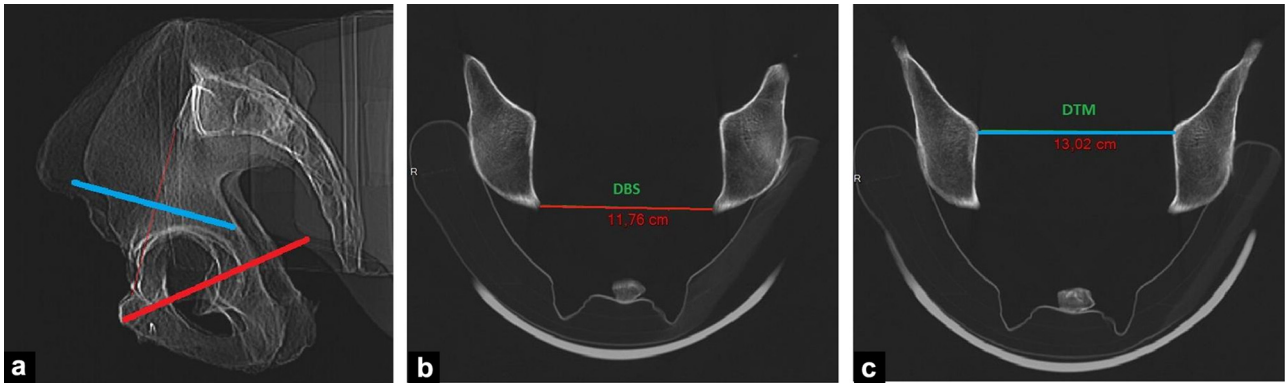

Figure 1. Principle of taking measurements using cross-sectional CT: a: orientation of the cross-sections on the lateral view; b: measurement of ISD using a cross-section passing through the ischial spines; c: measurement of MTD using a cross-section perpendicular to the middle of the OCD.

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