Reliability of two-dimensional computed tomography for measuring hip anatomy

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ABSTRACT

Purpose. To evaluate the reliability (inter- and intra-observer variability) of 4 hip anatomies using 2-dimensional pelvic computed tomography (CT).

Methods. Two-dimensional pelvic CT of 10 men and 10 women aged 33 to 89 (mean, 69) years presenting with non-orthopaedic conditions within one month were evaluated by 3 observers. The centre-edge angle of Wiberg, the Sharp angle, the acetabular depth ratio of Murray, and the acetabular anteversion angle of every hip were measured by each observer. After 6 weeks, these measurements were repeated. Reliability was evaluated using intraclass correlation coefficient (ICC), which represents the variation between patients as a percentage of the variation from all 3 sources (patients, inter-observers, and intra-observers). The ICC was classified as poor (<0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and excellent (0.81–1.00).

Results. Reliability was substantial for the Sharp angle (ICC=0.74), the acetabular anteversion angle (ICC=0.69), and the acetabular depth ratio of Murray (ICC=0.62), and was fair for the centre-edge angle of Wiberg (ICC=0.40).

Conclusion. The Sharp angle, the acetabular anteversion angle, and the acetabular depth ratio of Murray could be reliably measured using 2-dimensional CT. These measurements are appropriate for population-based studies of hip anatomy.

Key words: anatomy, cross-sectional; hip joint; reproducibility of results; tomography, X-ray computed

INTRODUCTION

Hip osteoarthritis is associated with bony malformations such as acetabular dysplasia,1,2 protrusio acetabuli, and acetabular retroversion.3,4 The prevalence of certain hip abnormalities in adult populations based on radiography has been reported.3 In certain patient groups, computed tomography (CT) has also been used to investigate hip anatomic variation.5 For future population-based CT studies,
we evaluated the reliability (inter- and intra-observer variability) of 4 hip anatomies using 2-dimensional pelvic CT.

**MATERIALS AND METHODS**

This study was approved by the ethics committee of our hospital. Two-dimensional pelvic CT of 10 men and 10 women aged 33 to 89 (mean, 69) years presenting with non-orthopaedic conditions between September and October 2010 were evaluated by 3 observers. Patients with pelvic tumours, infections, fractures, or metabolic bone disease were excluded. CT was performed in the standard supine position. Of these 20 scans, 9 were for the abdomen (portal venous phase), 6 were for the chest, abdomen, and pelvis (portal venous phase), and 5 were bi-phasic scans for abdominal aortic aneurysms (arterial phase). All the CT images were reformatted with 3-mm axial, sagittal, and coronal images.

For each hip, the scan representing the centre of the femoral head in the corresponding planes was selected. The centre-edge angle of Wiberg, the Sharp angle, and the acetabular depth ratio of Murray were measured for detection of acetabular dysplasia and protrusio acetabuli, whereas the acetabular anteversion angle was measured for detection of acetabular retroversion (Figs. 1 and 2).

The 3 observers (a junior orthopaedic resident, a senior orthopaedic resident, and an orthopaedic fellow) with varying levels of experience independently measured the 4 hip anatomies, using a standardised digitised computer system. After 6 weeks, these measurements were repeated.

The inter- and intra-observer variabilities were each summarised as corresponding coefficients of variation. The coefficients of variation of the 2 variabilities were summarised as intraclass correlation coefficients (ICCs), which represented the variation between patients as a percentage of the variation from all 3 sources (patients, inter-observers, and intra-observers). The ICC was classified as poor (<0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and excellent (0.81–1.00).

**RESULTS**

All 4 hip anatomies showed good reliability, having coefficients of variation (of both inter- and intra-observer variabilities) of <10%, except that the coefficient of variation (of intra-observer variability) of the acetabular version was 13.4%. ICCs of all hip anatomies were >60%, except for the centre-edge angle of Wiberg, for which the ICC was 40% (Table). Reliability was substantial for the Sharp angle (ICC=0.74), the acetabular anteversion angle (ICC=0.69), and the acetabular depth ratio of Murray (ICC=0.62), and was fair for the centre-edge angle of Wiberg (ICC=0.40). Most variation in the centre-edge angle of Wiberg was not due to inherent differences between patients, but rather inter- and intra-observer variations.

**DISCUSSION**

Certain anatomic abnormalities of the hip may predispose to degenerative change. The reliability
and validity of certain CT measurements of hip anatomy have been reported in the paediatric setting.\textsuperscript{13} Two-dimensional CT has been widely used to investigate abdominal and pelvic pathology. In a small group of patients with trauma or non-specific abdominal pain, pelvic CT was performed to evaluate the prevalence of hip abnormalities.\textsuperscript{7} CT for non-orthopaedic abdominal or renal pathology has been used for population-based anatomic studies of the lumbar spine, such as age-related spinous process anatomic variations\textsuperscript{14} and optimal placement of lumbar disc prostheses.\textsuperscript{15} Secondary use of CT data avoids unnecessary radiation exposure and enables population-based anatomic studies, and thus ensuring the reliability of such measurements is important.

In the current study, reliability was substantial for the Sharp angle, the acetabular anteversion angle, and the acetabular depth ratio of Murray (based on 2-dimensional CT). Therefore, these measurements were suitable for use in population-based studies of hip anatomy. The reliability of the centre-edge angle of Wiberg was fair. This may have been due to observer inexperience, although variations in inter-observer reliability did not correlate with years of experience. The centre edge angle of Wiberg could not be reliably and reproducibly measured using 2-dimensional CT.

Despite superior anatomic details, CT is associated with increased radiation exposure. The mean radiation dose of standard abdominal and pelvic CT scans without contrast is approximately 10 to 15 mSv.\textsuperscript{16,17} whereas the mean radiation dose for a radiograph of the pelvis is only 0.7 mSv.\textsuperscript{17} The clinical risk depends on the amount of radiation exposure and the susceptibility to radiation harm of exposed organ systems. Routine abdominal and pelvic CT carries an estimated lifetime risk of one radiation-induced cancer per 500 to 1330 patients, depending on the age at exposure.\textsuperscript{16} Radiography and CT for bony assessment carries substantially less risk owing to lower effective doses.

One limitation of our study was the small sample, which was similar to another CT reliability study of paediatric hip anatomy.\textsuperscript{8} In addition, our cohort was relatively old (mean age, 69 years) and may have influenced the generalisability of our results. Nonetheless, the age range (33 to 89 years) was reflective of a standard adult population. In most patients, radiographs of the pelvis were not available, and could not be used to validate CT measurements of hip anatomy. Moreover, the positioning of patients during CT was not standardised. Conditions such as hip flexion contracture, pelvic obliquity, and spinal malalignment may have prevented proper patient positioning and biased the results, although this problem can be solved with 3-dimensional reconstruction and multiplanar reformation.

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**DISCLOSURE**

No conflicts of interest were declared by the authors.
REFERENCES