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Evaluation of a Novel Method for Determining Transverse Plane Pelvic Obliquity

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Abstract

Study Design: This was a retrospective review of neuromuscular scoliosis radiographs evaluating interobserver and intra-observer error for a novel method of transverse plane pelvic obliquity.

Objectives: To evaluate the utility of a previously described method by Lucas et al. of determining transverse plane pelvic obliquity using standard radiographs in patients with cerebral palsy and neuromuscular scoliosis.

Summary of Background Data: Evaluation of pelvic obliquity in the transverse plane has not been thoroughly studied. The pelvis has been noted to function as intercalary vertebra in neuromuscular scoliosis, resulting in marked obliquity in all 3 planes.

Methods: Forty radiographs were chosen from 10 patients with cerebral palsy and neuromuscular scoliosis who had had a posterior spine arthrodesis and Galveston spino-pelvic fixation. Four observers independently examined the radiographs at different levels of training on 2 dates 1 week apart. Measurements recorded by each observer were described by Lucas et al.: E (the distance measured on lateral radiographs between the ilium at the inferior part of the sacro-iliac joint and the lateral edge of the anterior superior iliac spine), F_R and F_L (the coronal plane linear distance between the same 2 landmarks, measured from a posteroanterior radiograph, where F was measured for both the left (F_L) and right (F_R) sides of the pelvis, respectively), and β (the transverse plane rotation of the pelvis). Reproducibility of the measurements were analyzed using the concordance correlation coefficient (CCC). A CCC of 0.80 or higher was considered excellent agreement.

Results: The CCC between the first and second sets of measurements was lowest for E and highest for the calculated β, although none of the CCC calculations was statistically significant, demonstrating poor agreement.

Conclusions: The ability to reliably measure and calculate the degree of transverse plane rotation by radiographs in cerebral palsy patients with spino-pelvic deformity by the method described by Lucas et al. is poor, likely because of difficulty in consistently identify pelvic landmarks.

Keywords: Scoliosis; Radiographs; Pelvic obliquity

Introduction

In patients with neuromuscular scoliosis, pelvic obliquity is often associated with the spinal deformity. Complications from pelvic obliquity include unequal pressure distribution with sitting that can lead to decreased sitting tolerance, pain with sitting, truncal decompensation, hip dislocation on the high side, the development of ischial and sacral decubitus, rib crest impingement, skin maceration, and difficulty with adaptive seating [1,2].

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Pelvic obliquity becomes a clinical problem with greater degrees of pelvic obliquity, in particular in patients with insensate skin. In addition, patients with neuromuscular scoliosis and pelvic obliquity are forced to use their hands for support during sitting, which renders them functional quadriplegics [3].

These patients are traditionally managed with posterior spine fusions extending to the pelvis. The goal of surgery is to achieve a stable balanced spine over a level pelvis. The Galveston technique is a common method of spino-pelvic fixation used in this patient population [4].

The concept of pelvic obliquity has been evaluated primarily in the frontal plane, and only recently, the sagittal plane [5-9]. To the best of the authors' knowledge, the evaluation of pelvic rotation, or obliquity in the transverse plane, has not been thoroughly studied. Letts et al. [10] and Dubousset [5] believed that the pelvis functions as an intercalary vertebrae, and can participate in the severe rotation that accompanies neuromuscular scoliosis. The windswept pattern of lower extremity deformity in patients with cerebral palsy contributes to marked pelvic rotation in the seated child.

Lucas et al. [11] described a method to determine transverse plane pelvic rotation using posteroanterior (PA) radiographs. The authors used a pelvic model with radio-opaque markers to allow radiographic measurements to be performed, and compared the reliability of these measurements with the predetermined pelvis obliquity. They demonstrated that the determination of pelvis transverse plane rotation from anatomic landmarks readily visible on standard radiographs is possible. The authors concluded that although exact degrees of rotation require computed tomography scans and additional measurement, approximation of transverse plane rotation can be inferred from radiographs [11]. This method of evaluating pelvic rotational obliquity is not commonly used in clinical practice; however, other than computational tomography, there is no other practical method to determine this deformity.

The goal of the current study was to assess the utility of this method of estimating pelvis transverse plane rotation in a neuromuscular patient population. The authors chose to evaluate patients with cerebral palsy, for whom pelvic obliquity and transverse plane rotation is a common deformity and who frequently undergo spino-pelvic fixation using the Galveston technique [3,12,13]. The feasiblity of this method was to be assessed by having a number of observers with varying degrees of expertise in interpreting radiographs compare the reproducibility of the measurements. Assessing agreement both within and among observers would address the generalizability of the method for use by other practitioners.

Materials and Methods

Forty radiographs were chosen from 10 patients with cerebral palsy and neuromuscular scoliosis who had had a posterior spine arthrodesis and Galveston spino-pelvic fixation. One PA sitting radiograph and 1 lateral sitting radiograph of the thoracolumbar spine were chosen for each patient in both preoperative and postoperative conditions. Patients chosen were those with the best available radiographs, taken using a scoliosis seating chariot to ensure consistent patient position [14,15].

Four observers independently examined the radiographs on 2 dates at least 1 week apart. The observers included a pediatric orthopedic surgeon, an orthopedic spine fellow, an orthopedic chief resident, and a medical student. The measurements obtained by each observer were recorded and were not available for comparison during subsequent measurements by either the same observer or other observers. No marks were made on the radiographs, to avoid bias of later measurements.

The measurements recorded by each observer are described by Lucas et al. [11] (Fig. 1), using their analytical model. Briefly, E is the sagittal plane linear distance between the ilium at the inferior portion of the sacro-iliac (SI) joint and the lateral edge of the anterior superior iliac spine (ASIS), measured on a lateral radiograph. F is the coronal plane linear distance between the same 2 landmarks, measured from a posteroanterior radiograph. F was measured for both the left (F_L) and right (F_R) sides of the pelvis. B is the transverse plane rotation of the pelvis, calculated from the above measurements using the following equation derived by Lucas et al: $ß = \sin^{-1}(F_R - F_L)/2E$.

Statistical methods

Several methods of statistical analyses were used. Summary statistics for each measurement on each patient were calculated and box plots were constructed for graphical displays. Analysis of variance calculations were used to compare both interobserver and intra-observer variability among measurements.

The concordance correlation coefficient (CCC) was used to analyze the reproducibility of the measurements, as described by Lin [16]. The CCC is the best method to assess agreement between paired values of continuous measurements. Similar to the Pearson correlation coefficient, the CCC ranges between the values of −1 (perfect negative agreement) and +1 (perfect positive agreement). A CCC of 0.80 or higher was chosen to represent excellent agreement [17]. A graphical presentation of the first and second measurements was also used to visually illustrate perfect agreement using a line through the origin and a slope of +1.

Results

Figure 2 shows the pooled measurements of E, F_R, and F_L. Each single box plot represents the range of values for 1 measurement on 1 radiograph. The upper and lower borders of each gray box represent the 75th and 25th percentiles, respectively, for that measurement, whereas the middle line represents the median. Asterisks identify outliers. For example, from the ranges of measured values for E, the