A Scaled Pelvic Frame Of Reference For Hip Reconstructive Surgery

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Introduction: Accurate determination of the hip joint center is a crucial part of hip arthroplasty. Numerous studies in the literature have investigated acetabular inclination and anteversion but there are very few studies describing accurate methods of defining the acetabular center position in 3D space, although x-axis translation of just 1cm for instance has profound effects on the abductor moment. The stereophotogrammetric and other plain radiographic methods have been shown to have substantial errors. We propose a novel system that goes beyond the anterior pelvic plane to introduce a scaled frame of reference (FOR) which defines the hip centre coordinates in relation to easily identifiable pelvic anatomical landmarks.

Materials and Methods: Twenty-two hips in patients with other pathology were analysed using 3-dimensional CT reconstruction software. The anterior pelvic plane coordinate system was used with the origin at the right anterior superior iliac spine (ASIS). The x-axis pointed horizontally from left-to-right, the y-axis vertically upwards, and the z-axis posterior-to-anterior. The femoral head centre represented the hip centre and its coordinates (Cx,Cy,Cz) were measured. The pelvic horizontal dimension (Dx) was the distance between the most lateral points on the iliac crests, its vertical dimension (Dy) was the distance between the highest point on the iliac wing and the ischial tuberosity, and its depth (Dz) was the horizontal distance between the posterior superior iliac spine and its corresponding ASIS.

![Figure 1. An AP view showing the hip centre x- and y-coordinates (Cx and Cy) and the horizontal and vertical dimensions of the pelvis (Dx and Dy); and a lateral view showing the hip centre y- and z-coordinates (Cy and Cz) and depth of the pelvis (Dz).](image)

After noting the hip centre coordinates, the ratios of these coordinates to the pelvic dimensions were calculated. An independent observer then repeated the landmark acquisition and measurement of the ratios in order to test the method’s reliability.

Results: The position of the hip centre varies between individuals, but for a given individual its coordinates can be derived from known pelvic landmarks. We have found that the mean ratio of hip centre x-coordinate to pelvic horizontal dimension (Cx/Dx) was 0.09, the mean ratio of hip centre y-coordinate to pelvic vertical dimension (Cy/Dy) was 0.33, and the mean ratio of hip centre z-coordinate to pelvic depth (Cz/Dz) was 0.37. On the other hand, the mean ratios of the hip centre y- and z-coordinates to the pelvic horizontal dimension (Cy/Dx and Cz/Dx) were 0.25 and 0.20 respectively. The inter-observer variability was tested using SPSS statistical software, and a mean intra-class correlation coefficient of 0.95 was observed. Moreover, Bland-Altman plots showed good inter-observer agreement.

![Table 1. Mean hip-centre-coordinate-to-pelvic-dimension ratios with the 95% confidence intervals and the intra-class correlation coefficients.](image)

Discussion: The method we have described here relies on a small collection of anatomical points on the pelvis that are easily accessible using a tracking probe. These points allow the frame of reference (FOR) to be given a scale that is unique to the patient. This scaled FOR has significant reliability, and with it we have defined the relationship between the pelvic dimensions and the hip centre coordinates. We have found that the x-, y- and z-coordinates of the hip centre have a fairly constant relationship with their corresponding pelvic dimension. There was also a fairly constant relationship between the y- and z-coordinates of the hip centre with the horizontal dimension of the pelvis (Dx). As these dimensions are easy to measure, they can be used to accurately derive the x,y,z-coordinates of the hip centre. Without the need for detailed imaging, these points allow the surgeon to scale the patient’s pelvis and thereby know within a few millimetres the normal position and inclination of the acetabulum. This knowledge may be of significant benefit when planning or undertaking reconstructive hip surgery. This is especially true in patients with bilateral hip disease where there is no reference available for planning the surgery. Looking from another perspective, if the centre of the hip and the pelvic width are known one can then derive the position of the ASIS. This is particularly useful when working out CT scanning protocols based on a scout view where the ASIS’s cannot be easily identified.