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Effects of Spinopelvic Balance on Acetabular Version in Total Hip Arthroplasty

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Abstract

The orientation of acetabular component is influenced by pelvic tilt, body position and individual variation in pelvic parameters. Most adverse events attribute to improper positioning of the acetabular component in the functional position. There is evidence that the orientation of the pelvis changes from the supine to standing position, consequently changing the orientation of acetabular cup version. This article substantiates the influence of pelvic tilt, incurred from a sagittal deformity of spine, on the dynamic orientation of the acetabular cup which was positioned in accordance with the anatomic landmarks alone. If the reference is only the bony architecture and the dynamic positions of the pelvis are not taken into account, improper functional orientation of the acetabular cup can result in sitting and standing positions. These can induce instability even in anatomically appropriately oriented acetabular component. The sagittal position of pelvis being a key factor in impingement and dislocation after total hip arthroplasty, its tilting affects the position of acetabular component in the sagittal plane of the body as compared with its anatomic position in the pelvis. Therefore we suggest a preoperative lateral view of spine-pelvis, in upright and supine position for evaluation of a corrective adaptation of the acetabular cup accordingly with pelvic balance.

Keywords Impingement; Pelvic tilt; Surgical anteversion; Acetabular component; Dislocation

A basket full of literature is there to show a relationship between pelvic tilt and cup orientation in total hip arthropasty. McCollum and Gray proposed a standing lateral roentgenogram for direct measurement of the cup flexion [1]. Lazennec et al. expressed the sagittal inclination of the cup by a morphological angle, the sacro-acetabular angle (between the sagittal axis of the prosthetic cup and the upper sacral plate) which was the geometric sum of the positional angle sacral slope and the sagittal acetabular tilt [2]. A mathematical model on a "Sawbone", by Chen et al. elucidated a variation of the cup position from 15° anteversion in 0° pelvic inclination to 0.5° retroversion in 15° forwards sagittal pelvic tilting [3]. The influence of the spine on the sagittal pelvic tilt and on the cup orientation was pointed out by Tang et al. for patients with ankylosing spondylitis [4]. They advised adapting the usual positioning of the cup by reducing the inclination and ante version by 5° for each 10° of sagittal mal-rotation beyond 20°. But they advised using only the shape of the obdurate for men to assess this sagittal mal-rotation on antero-posterior radiographic imaging.

Acetabular cup angles associated with THA vary between the standing and lying positions [5]. Lewinnek et al. described a "safe zone" of cup ante version and abduction (50—250 anteversion with 300-500 abduction), in which the dislocation rate was demonstrated to be low [6]. However, even when the acetabular cup is positioned in this "safezone" at the time of surgery, the acetabular cup angle can change and move away from the "safe zone" because of pelvic rotation after THA. Accordingly, an increased understanding of postoperative chronological changes in pelvic tilt and of individual variations during these changes is important for accurate preoperative planning of acetabular cup angles. A precise assessment of the change in pelvic tilting from supine to standing position leading to change in acetabular cup orientation due to improper sagittal balance can have impingements with future dislocations.

Our case impresses upon the influence of pelvic tilt, incurred from a sagittal deformity of spine, on the dynamic orientation of the acetabular cup which was positioned in accordance with the anatomic landmarks alone. Improper functional orientation of the acetabular cup can result in supine and standing positions if the reference is only the bony architecture and the dynamic positions of the pelvis are not taken into account. These can induce instability even in anatomically appropriately oriented acetabular component (Figure 1).

Impingement was prevalent even when components were implanted in the anatomic safe zone in a study of 162 retrieved acetabular components [7]. With increased trend of using hard on hard bearing surfaces, minimizing the risk of impingement, which leads to catastrophic events like chip fracture, metallosis, and loosening in these bearing surfaces, should be considered. When faced with this disappointing outcome, it is worth reckoning that component orientation is made in static lying position, whereas prosthesis dislocates out of the result of a dynamic phenomenon which occurs during change in position during the movements of daily life [8]. This is a reasonable explanation, as to why an anatomically oriented cup, placed in supine position may functionally prove to be wrongly oriented, so favoring subsequent dislocations.

The rotation of pelvis leads to anterior tilt (where the upper portion of the pelvis tips forward) and posterior tilt (upper portion of the pelvis tips backward) [9]. The aging process and spinal deformities may lead to an altered sagittal balance. The sacrum and pelvis therefore forms a rigid structure (sacropelvis), which translates and rotates around the bicoxofemoralaxis for the necessary compensatory balance [8]. The sagittal position of pelvis is not vertical nor is it static [9]. In supine position, the pelvis tilts anteriorly, which decreases anteversion of the acetabular component and in the standing and supine position, the reverse happens and anteversion is increased [5].

Optimal adjustment of the acetabular cup is of utmost importance for ensuring stability and maximum range of motion of the prosthetic joint, without causing impingement on the femoral neck [9]. After total hip arthroplasty increased anterior tilt of acetabular component can cause posterior impingement and anterior dislocation, similarly, posterior tilt or retroversion can cause anterior impingement and posterior dislocation [10].

Of importance is the fact that each individual possess a pelvic equilibrium which is specific and is different in standing and lying positions; however there are variations in the position of pelvis from the lying to the standing position even though Legaye recommended a routine pre-operative lateral radiogram of total vertebral column in upright position to assess the global balance which could show only static pelvic position not dynamic variance of pelvic tilting [8]. Consequently the orientation of the acetabular cup version changes dynamically from supine to standing position. In the presence of a normal range of motion of the spine, the pelvis rotates around the transverse axis giving some room for adjustment during movements of the prosthetic hip.

Sacral tilt (ST) and measured acetabular tilt (MAT) should be calculated on lateral radiographs to note for any pelvic tilt. Sagittal sacral tilt is defined as the angle between the horizontal plane and a line tangent to the upper endplate of S1. Acetabular tilt or surgical ante version is the angle formed by the line tangent to the anterior and posterior edges of the acetabular cup and ahorizontal line. There is significant inter-subject and intra-subject variation in ST and MAT values from supine to standing position which is directly influenced by the mechanics of lumbosacral junction and result in a dynamic functional ante version that is high outside the safe zone. These require unique adjustment in acetabular cup alignment to maximize stability and avoid impingement and, or dislocation after total hip arthroplasty [11]. ST and MAT are functional angles and the orientation of acetabulum in supine and standing positions can be accurately extrapolated from the correlation between pelvic parameters.

In our case we are insisting upon patients having fixed kyphoscoliotic deformity, have more vertical position of the sacrum which is often masked in supine position due to compensated pelvis, tilted posteriorly. This verticalizes the cup and places the hip in hyperextension while changing from supine to standing position [11]. A retroverted pelvis leads to functional ante version that is more than the normal range, causing uncovering of the femoral head anteriorly. Even though the cup is placed appropriately in accordance with the pelvic bony landmarks, posterior impingement and anterior dislocation cannot be avoided.

These patients have constant low values of ST in supine and standing position, signifying posterior tilt of the pelvis. ST shows a variation from supine to standing position, which is much more than normal variation [10-12].

Conclusion

Majority of the patients are considered being the normal variant in pelvic tilting. Small subsets of patients, 5-7%, are outliers, who demonstrate a more flexed or extended pelvic, these require unique adjustment in acetabular cup alignment to maximize stability and avoid impingement and, or dislocation after total hip arthroplasty [9]. A detailed analysis of individual sagittal balance allows a precise evaluation of the amount of sagittal pelvic imbalance, which influences acetabular cup orientation and allows preventive or prospective adjustment of the cup and identifies the outliers, especially in THA with hard bearing. Therefore we intend in future to request a pre-operative lateral x-ray view of the spine-pelvis in the upright and supine position to evaluate the global sagittal balance, it's probable future evaluation, and to plan corrective adaptation of pelvic balance.

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