A challenge on orthopedic sciences: The Influence of Spinal Disease and Deformities on Total Hip Arthroplasty: A review on literature

Abstract:

Purpose: Adult degenerative disorders of the hip and spine are common. The recent studies inconsistently have discussed about the influence of spinal disorders on total hip arthroplasty (THA). In this review we discussed clearly about these relationships and their effects on the most appropriate position of the acetabular component.

Methods: We searched on databases and evaluated the articles about spinopelvic parameters in patients with spinal disorders who need total hip arthroplasty.

Results: A review in literature, at a glance, showed a prevalence of 21.2 % to 60.4% of LBP in patients, who are candidates for primary total hip arthroplasty (THA).The coexistence of degenerative disease of hip and spine or other diseases can significantly alter spinopelvic alignment. Accordingly, pain management or any other treatment in these patients requires knowing about biomechanics of the hip and spinal parameters and consideration of the relative contribution of each region. In this review article we discussed about these relationships and finally their effects on the most appropriate position of the acetabular component.

Conclusion: We concluded that Counseling sessions among patients, orthopedic surgeons and spine surgeons can result the best outcome for these individuals.

Key words: Hip Arthroplasty, Spinopelvic Alignment, Spinal Parameters, Spinal Disorders

Background:

Today, we cannot evaluate any region of body separately, because each of the mechanism in the body is coordinated with the rest. So, just a tunnel vision to the site of pathology without evaluating other related origins is not accepted and may result to mismanagement. It is therefore possible as orthopedic surgeons,we do the best in the pathologic site but patient's symptoms still remain.

Adult degenerative disorders of the hip and spine are common (1). Studies reported up to 12% of degenerative hip joint disease of the patients over age 80 (2). Also, the prevalence of spondylosis has ranged from 9.7% to 90.1% according to age and sex in the general population (78.2% in women and 90.1% in men older than 80) (3, 4). A review in literature, at a glance, showed a prevalence of 21.2 % to 60.4% of LBP in patients, who, are candidates for primary total hip arthroplasty (THA) (5, 6).

Due to this high association of osteoarthritis in hip and spinal joints, hip-spinal syndrome has been introduced first bye Offierski and MacNab (7) in 1983. They categorized this syndrome into four groups: one) Simple hip spine syndrome with pathologic changes in the hip and spine with a clear source of pain and disability. Two) Secondary hip-spine syndrome. It is defined as aggravated spine syndrome by the hip deformity. Three) Complex hip-spine syndrome, a condition that in, both spine and hip were symptomatic and there was no clear source for the pain and disability. Four) Misdiagnosis syndrome. In this category the source of pain was not identified properly.

The coexistence of degenerative disease of hip and spine or other diseases can significantly alter spinopelvic alignment (8-10). Accordingly, pain management or any treatment in these patients

requires knowing about biomechanics of hip and spinal parameters and consideration of the relative contribution of each region. We, in this review, try to discuss about these relationships and finally their effects on the most appropriate position of the acetabular component.

Biomechanics and Parameters

Human bipedalism is an exclusive and ergonomic position which requires excellent coordination between the hip and the spine (11). The normal spine is vertical having a midline axis that passes through the central of the sacrum (central sacral vertical line). On the other hand the normal pelvis is horizontal, with symmetrical points at equal height (12). However, the spatial perception of the sagittal pelvic position is more complex. Understanding of sagittal balance of the pelvis requires the definition of certain parameters. Pelvic incidence (PI), introduced first bye Beaupere and colleagues (13, 14), is defined as angle between the line perpendicular to the sacral plate at its midpoint and the line connecting this point to the axis of the femoral heads on a lateral radiograph (Fig 1). On a lateral view, the width of the pelvis is quantified by the PI. It is a constant angle that becomes set at the end of growth, regardless of its position. It is specific for each person and differs in various individual. Pelvic tilt (PT) and sacral slope (SS) are two angles directly correlated with the PI. Actually; PI is the algebraic sum of PT and SS. The pelvis can rotate around the femoral heads up to a certain limit. This rotation is regarded as the PT. PT defined by the angle between the vertical reference line and the line connecting the midpoint of the sacral plate and the axis of the femoral heads. Another parameter is SS, the angle between a line parallel to the S1 end plate and a horizontal line. This angle is variable during spinopelvic motion, decreasing from lying position to standing and from standing to sitting (15, 16). Also,

there is a proved relationship between SS and lumbar lordosis (LL), as LL decreases, SS concurrently decreases and PT increases, so the pelvis is getting retroverted (17-19).

Spinal diseases and deformity can lead to sagittal and coronal imbalance. These patients, to continue their complete activity of daily living (CADL) have to increase motion in hip joints due to lumbar pain or fear from lumbar motion pain (20). Many investigations showed that SS and PT changes in various position (16, 21, 22). When someone is lying, SS and LL are at their peak (usually above 45 degrees) and pelvis is tilted forward and also acetabular version and abduction are in the lowest to give high maneuverability to hip for full extension. In standing position the PT slightly backward and SS decreases slightly (35° to 45°), and acetabular version and abduction increase. Finally, As the patient goes to a seated position, the pelvis is completely backward, SS decreases to less than 25° and for full hip flexion, acetabular version and abduction further increase (23). Patients who have undergone THA and have a balanced spine will show a similar adjustment in spin pelvis alignment in different position (24). Patients suffered from lumbar disease with limited lumbar range of motion (ROM) show slight change in pelvis orientation in different position. That is, there is little change in SS, PT, or acetabular version or abduction with body positioning, inherently limiting the ability to accommodate additional hip flexion or extension in sitting and standing position, respectively (16, 21). Degenerative spine disease or other spine pathologies which are showed in LBP lead to reduction in LL and SS and a significant increase in PT (25, 26). The compensatory mechanisms in these patients with lumbar hypolordosis are: thoracic hyperextension, forwarded trunk tilt, knee flexion , hip extension, posterior PT and acetabular anteversion (AA) (10, 22, 27, 28).

SPINAL DISEASE AND ACETABULAR COMPONENT

Many studies evaluated the changes in pelvic parameters during various positions in patients undergoing THA (29-32). Lazennec *et al* (29) detected that when patients with previous THA changed their position from standing to sitting, would show a mild increase of 15.6° in AA and concluded that lumbosacral mobility was crucial for this physiological change to limit post-operative impingement. Kanawade *et al* (31) showed a mean verticality increase of 25° in acetabular component in patients with THA and normal spinal mobility, in the position of standing to sitting, and also recommended adjusting placement of the components to avoid instability, especially in patients with a hyper-mobile pelvis (33). There are also some researches (32, 34) in which investigators tried to anticipate amount of change. For example Lembeck *et al* (34) determined that for every 1° increase in pelvic retroversion, AA increases 0.7°.

Recently, the role of spinal disease and deformity in acetabular component orientation during THA has been mentioned by some investigators. This is because of studies which showed a significant high rate of complication in patients who were undergone THA with concurrent spinal disease and deformity, specially dislocation and impingement. Prather *et al* (35) showed a greater improvement in CADL and pain relief in patients who were undergone THA without spinal disease and deformity when compared to those who have spinal disease and deformity.. Tang *et al* (36) evaluated 95 primary THA in 58 patients with ankylosing spondylitis and detected the higher incidence of complications such as dislocation on top of them. In 2014, Zheng *et al* (37) conducted a study on 28 patients with ankylosing spondylitis and detected a high rate of dislocation , given that, they first underwent THA and then had a corrective spinal osteotomy. Also, Nilsdotter *et a*l (38) reported that patients with post-operative LBP have less

long term functional improvement after THA. Conversely, some investigators showed THA in patients with severe osteoarthritis of hip can significantly relief LBP (39, 40).

This subject remains as a challenge on orthopedic sciences and some procedure should be done first: THA or spinal procedure. Can we candidate patients with coexistence hip and spinal osteoarthritis just for THA without any procedure on spine? Does spinal malalignment have no influence on acetabular cup in THA? Some authors recommended THA can relief both hip and LBP (39, 40). There are some notes on this recommendation: First; remaining hip pain or LBP after THA result in less improvement in patient's outcome (38). Second; THA alone without considering spinal disease and deformity lead to increase rate of complication. Third; The most important diagnostic method for coexistence of osteoarthritis in hip and spinal joints are the remaining pain after THA, so we think LBP relief after THA have been due to a referral pain from hip, as we know there is low compliance between osteoarthritis clinical symptoms and radiographic signs. Therefore, a LBP with spine origin will not relief after THA. Some surgeons recommend to treat the most symptomatic disease first, but there is an important criticism on this recommendation: pelvic parameters have a significant influence on position of acetabular cup which changed significantly after spinal procedures (41). In overall, most surgeons recommended correcting spinal mal-alignment before THA. In case of impossibility to correct spinal mal-alignment, acetabular cup orientation should be adjusted (42).

The definition of safe zone for acetabular cup was mentioned first by Lewinnek and his colleagues (43) in 1978. They showed that dislocation rate after THA was lowest in 15±10° antevertion and 40±10° inclination of acetabular cup. A big problem on their definition was that they did not consider lumbar spine parameters and it's dynamic. In case of spine disease and deformity, hypolordosis lead to increase posterior PT (44) (retroversion). In the standing position

and for compensating this position, acetabulum should be anteverted and abducted, so pelvis is forced to hyperextended position and finally result in posterior hip impingement and anterior instability. On the other hand, in the seated position, hip joints are hyperflexed because of a rigid lumbar spine which cannot flex spinopelvic complex as much as needed, so leading to potential posterior instability (20). In fact, the compensatory mechanisms to restore postural balance in patients with lumbar hypolordosis include thoracic hyperextension (or loss of kyphosis), forward tilt of the trunk, knee flexion, hip extension, and increased or posterior PT (10, 27, 28). The net compensatory outcome is positive sagittal balance and relative pelvis retroversion, subsequent in excessive AA (22). Zhu and coworkers (45) in 2010 determined that only 6.1% of patients have zero PT. Most patients (83.9%) fell in a narrow range close to neutral PT (PT<10°). However, the outlier patients would have been a cup implanted correctly according to anterior pelvic plane, but functionally, it would be malposition and lead to a high risk in extreme position for dislocation and impingement.

Studies have quantified the impact of PT on acetabular inclination as approximately each degree of posterior tilt (retroversion) leads to a 0.7° increase in acetabular inclination (32, 46). Anatomic version progressively increases with a mean of 7.1° with changing position from standing to sitting in relation to a 14.5° increase in posterior tilt (29). Attention to pelvis and acetabulum position for lumbar rigidity and deformity compensation lead to set off the most (58%) dislocated THAs and have cups placed in the safe zone. This trigger point prompt the investigators to find the relationship between different spinopelvic parameters and cup orientation and recommend various models (47, 48). In 2009 Legaye (49) described a detailed chart base on exact calculation formulas for adjusting AA and inclination (Fig 2). They also noted that the difference between the observed and theoretical values of the SS allows a precise

assessment of the pelvic sagittal mal-rotation (49). If a backward mal-rotation is detected, the corrective angle has to be detracted from the target angle. The recommended corrections were in agreement with those described by Tang *et al* (50) who suggested reduction of the inclination and ante version by 5° for each 10° of sagittal mal-rotation beyond 20°. Other investigators recommended a correction of 0.5 to 0.7° for 1° of pelvic sagittal rotation (20, 51)

At present, many surgeons recommended to place acetabular cup in a 'safe zone' of 5° to 25° of anteversion (43, 52) to minimize the complications such as impingement and dislocation and make the maximum ROM available. Authors using synthetic special models of hip joint revealed that cup positioning placement in the safe zone can provide the greatest ROM in flexion and extension (53, 54). Practical movement is greatly sensitive to placing the acetabular cup, with limits to CADL happening through changes of anteversion as little as 10° to 15° (53). Recently, a functional study by Phan and coworkers (33) has done according to a history of spinal surgery, clinical postural imbalance and also based on pre-operative standing and sitting lateral radiography views, and has divided Patients considered for THA to four category. They could somewhat propone an algorithm based on flexible or rigid spinopelvic junctions and also with appropriate sagittal spinal balance (PT < 25°; PI–LL < 10°) or persistent imbalance (PT > 25°; PI–LL > 10°) to explain the role of spinal deformity and disease on THA.

In Group one (Flexible and balanced patients have no previous spinal diseases with a fully movement of spinopelvic junction. Most of them have a balanced spinal sagittal and full recompense of the spine to accommodate positional changes of the pelvis. Exact AA in this group will be dictated by surgeon precedence, but should be in the acetabular safe zone of 5° to 25° of anteversion to allow a functional ROM and minimize the risk of impingement.

They also defined patients with rigid spinopelvic junction and sagittal spinal balance (balance Rigid and balance) in Group two. In these patients AA will not indigenously increase during sitting, potentially causing a loss of functional range of flexion of the hip. They recommended that the orientation of the acetabular cup for this group should be more anteverted to help correct the relative acetabular retroversion in the sitting position. Nevertheless, because of a normal ROM in standing position, an extreme anteverted acetabular cup can limit ROM in this position. Therefore, Phan and colleagues recommended placement of the acetabular component in the higher end of the traditional safe zone, with AA of 15° to 25°, to provide an ideal balance in providing the best ROM in both the standing and sitting position (33).

The authors mentioned that there are two possible treatment pathways for Group three (Flexible and unbalance) with Flexible spinopelvic junction and sagittal spinal imbalance (PT > 25°; PI–LL > 10°): The first option is to correct the spinal deformity surgically before THA and then patients were treated according Group one. For patients unwilling or unable to undergo major spinal surgery, or with overriding pain in the hip, the second possible option is to proceed with THA with placement of the acetabular component in a position more fully replicating that of the balanced patient (33).

As Phan and colleagues described there are two possible treatments, based on the probability of future spinal surgery for patients Group four (rigid and unbalance): The first is correction of spinal mal-alignment and then placement of the patient into the group two. The second would be to proceed with THA, placing the acetabular component in a position where more fully replicates that in the balanced patient. However, it is important to note that spinal surgery after THA, may require revision of the acetabular cup to accommodate the pelvic re-orientation following spinal re-alignment if there is impingement of the hip and instability (33).

Finally, it seems that except of AA and inclination other factors such as age, Developmental dysplasia, prior hip fracture, and female gender are associated with increase in hip dislocation after THA (55, 56). Esposito *et al* (48)mentioned in their study on 7040 patients undergone primary THA that cup position alone did not predict risk of dislocation. Abdel *et al* (47) also detected that the vast majority of dislocated THAs are within the Lewinnek safe zone for acetabular component position. It is require to conduct studies to evaluate these factors in patients with spinal disease and deformity undergone THA.

Conclusion:

In this study, we tried to discuss all possible methods for THA in patients with coexisting spinal disease and deformity. These patients are in a high risk for post-operation complications such as dislocation, remaining pain and reducing daily activity. It is obvious that Counseling sessions between patient, orthopedic surgeon and spine surgeon can result the best outcome for these patients.

Conflict of interest: The authors declare no conflict of interest

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Fig 1: Spinopelvic parameters
VRL; vertical reference line, HRL; horizontal reference line, SS; sacral slope, PT; pelvic tilt, PI; pelvic incidence

Fig 2: Relation between the pelvic tilt and the angle of inclination and anteversion of the acetabular cup for an aimed 45° inclination according to Legaye's study