The Impact of Lumbar Spine Disease and Deformity on Total Hip Arthroplasty Outcomes

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KEYWORDS

- Spinal deformity • Scoliosis • Kyphosis • Lumbar • THA • Total hip arthroplasty • Pelvic tilt
- Sagittal balance

KEY POINTS

- Spinal deformities can significantly restrict lumbar range of motion and lumbar lordosis, leading to pelvic obliquity and increased pelvic tilt.
- A comprehensive preoperative workup and component templating are essential to ensure appropriate compensation for altered pelvic parameters for implantation of components according to functional positioning.
- Pelvic obliquity from scoliosis must be measured to calculate appropriate leg length.
- Cup positioning should be templated on standing radiograph to limit potential impingement from cup malposition.
- In cases of spinal deformity, the optimal position of the cup that accommodates pelvic parameters and limits impingement may lie outside the classic parameters of the safe zone.

INTRODUCTION

Osteoarthritis (OA) is a systemic and inevitable disease of aging that can affect the hip and spine concurrently, producing substantial pain and disability.[1–11] The degenerative changes of end-stage arthritis in the hip and spine can significantly alter body kinematics and spinopelvic alignment.[5,12–18] Accordingly, the diagnosis and treatment of patients with simultaneous hip and spine disease require consideration of the relative contributions of each region to clinical symptoms, postural balance, and locomotion.

LUMBAR RANGE OF MOTION

Lumbar disease, low back pain (LBP), and guarding from fear of LBP cause a significant reduction in lumbar range of motion (ROM).[12–16] In addition, McGregor and colleagues[19] showed that patients with disk prolapse, degenerative disk disease, and stenosis have a predictable reduction in lumbar ROM in flexion/extension, lateral bending, and rotation compared with age-matched controls. In more obvious cases, patients with ankylosing spondylitis and those undergoing multilevel spinal fusion procedures

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can have profound, fixed reductions in lumbar ROM.

To complete activities of daily living (ADLs) that demand spinopelvic motion, patients with lumbar disease compensate for decreased lumbar motion from stiffness or fusion by increasing motion through the hip joints.

SPINOPELVIC MOTION AND PELVIC PARAMETERS

Spinopelvic flexion and extension are the sum of intrinsic motion from the hip joints and extrinsic motion from the lumbosacral joints.[18] Duval-Beaupere and colleagues[20,21] introduced the concept of pelvic incidence (PI) to describe the anatomic relationship between the alignment and motion of the spine and pelvis.[22] PI, defined by the angle between a line drawn from the center of the femoral head to the midpoint of the S1 end plate on a lateral radiograph (**Fig. 1**), can vary significantly from person to person but remains an anatomic constant for each individual after puberty throughout all pelvic ROM. Sacral slope (SS), defined by the angle between a line parallel to the S1 end plate and a horizontal line, is a measure of the inclination of the pelvis base and is variable throughout spinopelvic motion, increasing from the sitting position to standing and from standing to lying supine.[5,18,23] Pelvic tilt (PT), defined by the angle between a line drawn from the midpoint of the S1 end plate and a vertical line, is a measure of the position of the pelvis relative to the acetabulum and varies reciprocally with SS, decreasing, or becoming less posterior, from the sitting position to standing and further decreasing from standing to lying supine. The relationship between the geometric measures is PI = SS + PT.

Pelvic parameters and spine measures are connected by a linear relationship between SS and lumbar lordosis. This relationship was initially described by Stagnara and colleagues[24] in 1982 and subsequently confirmed by other investigators showing a correlation of $r = 0.84$ to 0.86 between the measures.[22,25] The implication of this relationship is that as lumbar lordosis decreases, SS concurrently decreases and PT increases, retroverting the pelvis.

INFLUENCE OF BODY POSITION ON PELVIC PARAMETERS

Although PI remains constant throughout spinopelvic motion, SS and PT significantly vary with body position.[5,18,23,26] While lying supine, lumbar lordosis and SS (often exceeding 45°) are accentuated, the pelvis is tilted forward, and acetabular version and abduction are low to permit maximal hip extension. Moving from lying supine to standing, the pelvis tilts slightly backward and SS decreases slightly (between 35° and 45°), and acetabular version and abduction increase. Moving from standing to sitting, the pelvis is further tilted backward and the SS decreases to 25° or less, and acetabular version and abduction further increase to permit further hip flexion.[18,27]

In multiple studies, Lazennec and colleagues[5,18,23,27] documented the variable radiographic position of total hip arthroplasty (THA) cups on anteroposterior (AP) and lateral films in the sitting and standing positions. These investigators reported changes in the AP inclination of the cup from 49° to 52° in the standing position to 57° to 64° in the seated position and changes in the sagittal inclination of the cup from 36° to 47° standing to 51° to 58° in the seated position. Patients with limited lumbar ROM from lumbar disease or resultant fusion show little variation in pelvic orientation based on position.[5,18,23] 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 when seated or extension when standing or lying supine.

CORONAL AND SAGITTAL ALIGNMENT AND SPINOPELVIC MECHANICS

Coronal imbalance is governed by scoliosis and pelvic obliquity. Although idiopathic adolescent scoliosis and degenerative scoliosis arise de novo,

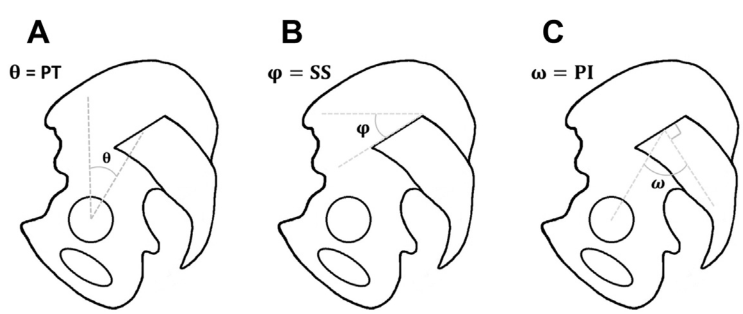

Fig. 1. (*A*) PT. Defined by the angle (θ) between a line drawn from the center of the femoral head to the midpoint of the S1 end plate on a lateral radiograph. (*B*) SS. Defined by the angle (φ) between a line parallel to the S1 end plate and a horizontal line. (*C*) PI. Defined by the angle (ω) between a line drawn from the midpoint of the S1 end plate and a vertical line.