A Novel Biplanar Functional Total Hip Replacement Planning Algorithm Including Age and Predictive Postoperative Changes

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INTRODUCTION:

Total Hip Arthroplasty (THA) planning has evolved away from the Lewinnek zone to include functional planning including the standing and sitting positions. Research has shown that besides component position, aberrant non-modifiable mechanics such as standing sagittal imbalance and lumbar/pelvic stiffness must be accounted for to minimize construct impingement and instability. It has shown that restoring hip function through THA changes the preoperative mechanics, normalizing the integrated mobilities of the hip and spine. The purpose of this paper is to introduce a biplanar functional algorithm that measures preoperative parameters to determine a safe Combined Sagittal Index (CSI), a validated measure for THA stability, then applies adaptation for predicted changes in cup position and combined component mobilities to account for 1 year postoperative changes.

METHODS:

A previously described geometric construct was used to determine optimal Anteinclination (AI) based on standing and sitting Sacral Slope (SS) angles and added to the preoperatively measured Pelvic Femoral Angle (PFA) to determine optimal CSI status. AI position is modified for femoral version (FV) outliers <10 and >25 on a sliding scale, 1°AI:1°FV preserving combined Anteversion concerns. Postoperative changes are based on published data 1 year after surgery, revised standing, sitting SS mobility is used to input formulas to recalculate predicted AI and PFA and CSI correcting for the adjusted mechanics at the later time point. The preoperative conditions addressed include; normal mechanics, loss of hip extension (flexion contracture), loss of hip flexion, and spinal stiffness.

RESULTS:

Normal preoperative mechanics subtracts 2° standing and 3° sitting SS mobilities, the delta PFA increasing 7°, this increases AI standing 2.5° and coronal anteversion 2°. Loss of hip extension affects primarily the standing position, subtracting 5° from standing SS and 3° sitting SS, the delta PFA increasing 12°, this increases standing AI 4° and coronal anteversion 3°. Loss of hip flexion affects primarily the sitting position, subtracting 3° standing and 7° sitting, this increases delta PFA 15°, increasing standing AI 5° and coronal anteversion 4°. Lumbar stiffness is unaffected by THA, the standing SS decreases 2°, sitting changes marginally with outliers driven by thoracic kyphosis and body habitus, delta PFA changes 3°, standing AI changes 1° and coronal anteversion 1°.

DISCUSSION AND CONCLUSION: Sagittal plane mechanics have been found to drive cup positioning algorithms, however matching preoperative values does not consider the biomechanical changes that occur when hip function is restored by THA. Research has shown that the equilibration between spine and hip function requires longer than the traditional six week follow up films to determine. One year studies show that mechanics become normalized with improved upright posture and more hip flexion sitting, these changes decrease the functional excursion of the cup and may significantly alter functional planning based on preoperative measurements of pelvic tilt and mobility. Planning must account for these temporal changes and become predictive in nature, current data places the 1 year postoperative studies as the best time point to base these predictions on. The loss of hip function can be adjusted for in algorithms with greater variability in younger patients whose spines remain flexible and also adapt, the elderly and those with stiff spines remain dependent on the hip for mobility, their mechanics may change less with greater risks of bony impingement not well addressed by CSI management. Predictive age related sagittal to coronal algorithms hold great promise for future planning with the benefit of allowing incorporation of the effects of spinal fusion surgery on anticipated or existing hip component positioning.