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Review article

The influence of spine-hip relations on total hip replacement: A systematic review

C. Rivière [a,*], J.-Y. Lazennec [b], C. Van Der Straeten [a], E. Auvinet [a], J. Cobb [a], S. Muirhead-Allwood [c]

[a] MSK Lab, 7, Laboratory Block, Charing Cross Campus, Imperial college of London, W6 8RP London, UK
[b] Service de chirurgie orthopédique, hôpital Pitié-Salpêtrière, université Pierre-et-Marie-Curie, 47–83, boulevard de l'Hôpital, 75634 Paris cedex 13, France
[c] London hip unit, 30, Devonshire St, W1G 6PU London, UK

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ABSTRACT

Sagittal pelvic kinematics along with spino-pelvic angular parameters have recently been studied by numerous investigators for their effect on total hip replacement (THR) clinical outcomes, but many issue of spine-hip relations (SHR) are currently unexplored. Therefore, our review aims at clarifying the following questions: is there any evidence of a relationship between articular impingement/dislocation risk in primary THR and (1) certain sagittal pelvic kinematics patterns, (2) pelvic incidence, and (3) types of SHRs? A systematic review of the existing literature utilising PubMed and Google search engines was performed in January 2017. Only clinical or computational studies published in peer-reviewed journals over the last five years in either English or French were reviewed. We identified 769 reports, of which 12 met our eligibility criteria. A review of literature shows that sagittal pelvic kinematics, but not the pelvic incidence, influences the risk of prosthetic impingement/dislocation. We found no study having assessed the relationship between this risk and the types of SHRs. Sagittal pelvic kinematics is highly variable among individuals and certain kinematic patterns substantially influences the risk of prosthetic impingement/dislocation. Recommendations for cup positioning are therefore switching from a systematic to a patient-specific approach, with the standing cup orientation Lewinneck safe zone progressively giving way to a new parameter of interest: the functional orientation of the cup. Based on a recently published classification for SHRs, We propose a new concept of "kinematically aligned THR" for the purposes of THR planning. Further studies are needed to investigate the relevance of such a classification towards the assumptions and hypothesis we have made.
Level of evidence,- Level IV, systematic review of level III and IV studies.

1. Introduction

In total hip replacement (THR), achieving ideal orientation of the cup is crucial in reducing edge loading and articular impingement, which would otherwise lead to accelerated wear [1], squeaking [2], and increased dislocation risk. Proper standing cup positioning, as measured on AP pelvic X-ray, has long been considered a predictive factor for dislocation risk (Lewinneck safe zone) [3] and edge loading (Grammatopoulos safe zone) [4]; however, this is now regarded as highly controversial [5–8]. In fact, many other improvements either technical (less invasive approach, capsular repair) or technological (modern more tolerant implants with notably larger head-neck ratio and jumping distance) [9–12] have significantly, but not entirely, reduced the dislocation rate after THR [5,13–15].

It is likely that most of the atraumatic dislocations that happen with modern implants are the result of atypical pelvic kinematics that lead to aberrant functional acetabular orientation [12,16]. This new parameter, namely functional acetabular orientation, enables us to refine the understanding of the pathophysiology of prosthetic dislocation and is likely to explain why patients with normal standing cup orientation sometime dislocate, while other patients with abnormal ones do not [17]. The fact that functional cup orientation is likely related to pelvic kinematics, which in turn is mostly influenced by lumbar mobility [18], highlights the close relationship between spine and hip biomechanics. This is presently defined in the literature as spine-hip relations (SHRs). Impairment of one body segment (spine or hip) is likely to affect the other, leading to what is known as spine-hip syndrome (SHS) [10] or in consequentially reverse form, hip-spine syndrome (HSS) [19,20].

* Corresponding author.
E-mail address: rivierech@gmail.com (C. Rivière).

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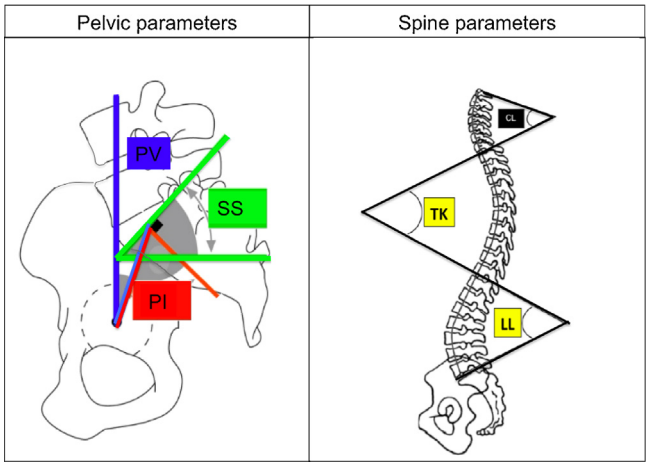

Fig. 1. Spino-pelvic parameters. PI: pelvic incidence; SS: sacral slope; PV: pelvic version; LL: lumbar lordosis; TK: thoracic kyphosis; CL: cervical lordosis.

Parameters such as pelvic incidence (PI), pelvic kinematics and sagittal balance enable a more complete picture of an individual's SHR. Spino-pelvic angular parameters (Fig. 1) define the shape and behaviour of the spino-pelvic complex [21,22]. The PI is a constant morphologic parameter that grossly enables us to predict the physiologic individual sagittal range of pelvis motion [23]. In contrast, sacral slope (SS), pelvic version (PV) and lumbar lordosis (LL) are functional parameters, with values dependent on body position. The spino-pelvic parameters can be measured on lateral lumbo-pelvic radiographs and with the EOS™ imaging system (Biospace, Paris, France) [10,24]. By utilising these imaging methods to compare spino-pelvic orientation during different body postures (e.g. standing, sitting, squatting), it is possible to obtain some measure of an individual's sagittal pelvic kinematic pattern [19]. Sagittal pelvic kinematics and spino-pelvic angular parameters have recently been studied for their relationship with clinical outcomes in THR (dislocation, articular impingement, edge loading, etc.) [25]. Therefore, our review subsequently aims to clarify the following questions: is there any evidence of a relationship between articular impingement/dislocation risk in primary THR and:

- certain sagittal pelvic kinematics patterns;
- pelvic incidence;
- types of SHRs?

2. Search strategy and criteria

A literature search was performed on 16th January 2017 with PubMed and Google scholar by one author (CR). The search parameters used were: ("total hip replacement" or "THR" or "THA" or "total hip arthroplasty" or "hip replacement") and ("dislocation" or "hip instability" or "instability" or "edge loading" or "impingement" or "hip impingement" or "articular impingement") and ("spine-hip relations" or "spine-hip relation" or "pelvic tilt" or "pelvic version" or "pelvic incidence" or "sacral slope" or "pelvic parameters" or "spino-pelvic parameters" or "pelvic retroversion" or "pelvic kinematics" or "spine ageing" or "lumbar ageing" or "spine deformity" or "spine stiffness" or "spine flexibility" or "lumbar flexibility") for the search on PubMed, and (dislocation or "edge loading") and ("pelvic tilt" or "pelvic incidence" or "spine-hip relation") and "edge loading" or dislocation or instability "pelvic tilt" or "pelvic incidence" or "spine deformity" or "spine flexibility" or "spine-hip relation" or "pelvic kinematics" "hip replacement" or "total hip arthroplasty" for the one on Google Scholar. Only articles from peer reviewed journals published over the last five years in either English or French were reviewed. Among the studies that were identified, those eligible were clinical or computational studies that reported the influence of pelvic kinematics or spino-pelvic parameters (pelvic incidence, etc.) on the risks of prosthetic impingement or dislocation (inclusion criteria). References were excluded if they were review articles, case reports, commentary, editorial, insights articles, proceedings or if they focused on revision hip prosthesis (exclusion criteria). The Newcastle Ottawa scale [26] was used to assess the quality of the eligible articles relating to nonrandomized clinical studies.

3. Results

Fig. 2 illustrates the flow chart of our methodology. Twelve studies were eligible for this review and are summarised in Table 1. Table 2 shows the quality assessment of the eligible clinical studies.

3.1. Answer to question 1

There is a high variability among individuals with regards to pelvic kinematics parameters as observed during various tasks (squatting, low-chair rising and picking up objects), which result in a smaller margin of error than anticipated for cup placement in order to avoid impingement ("the safe zone") [8,17]. Also, standing pelvic retroversion has been shown to progressively aggravate over the years after a THR is performed [36], with more than 20° of tilt shown to increase the risk of superior edge loading [16] and posterior articular impingement [16,35]. Therefore, the risk of THR dislocation for elderly patients with non-instrumented spine disease is very high (7.1%) and also related to the extent of spine stiffening: PI-LL mismatch [31], higher posterior standing PT [31,33], reduced course of posterior pelvic tilt [33]. After lumbar fusion, this risk was reported to be even higher (with the exception of one report [32]) [27–31,37], was proportional to the length of the fusion [30] and whether THR was performed prior to [28,30] or after [27–30,37] the spine procedure.

3.2. Answer to question 2

Delsole et al. [31] and Sariali et al. [34] found no difference in PI between dislocators and non-dislocators (64.6° [10 patients] vs. 52.4° [97 patients] [$P = 0.121$] and 54.1° [12 patients] vs. 56.5° [12 patients] [$P = 0.4$], respectively). However, Delsole et al. [31] assessed 139 THRs in a cohort of 107 patients having spine disease and they did not differentiate between patients with or without lumbar instrumentation in their "dislocated group" (11 THRs in 10 patients). It is important to distinguish between these two groups when assessing the relationship between PI and hip instability:

- since PI influences the outcome and progression of spine disease, a blanket inclusion of all patients with spine disease could inadvertently combine two separate groups of dysmorphic PI ranges, hence confounding any results;
- as the lumbo-pelvic complex (LPC) becomes stiff after fusion and is likely to generate similar sagittal range of motion (ROM) between fused patients, this reduces the clinical influence of the PI and therefore affects the assessment of the relationship between PI and hip instability.

3.3. Answer to question 3

We found no study having assessed the relationship between this risk and the types of SHRs. Therefore, we used a classification summarised in Table 3 and Fig. 3 to assess the relationship between