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Acetabular Component Positioning and Risk of Dislocation in Hip Arthroplasty: Is Lewinnek's Safe Zone Truly Safe?

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Abstract

Objective: The present research aims to determine if adherence to the Lewinnek safe zone, when exclusively considered, constitutes a pivotal element for ensuring stability in the context of total hip arthroplasty. This is done by examining the acetabular placement in instances of hip dislocation after total hip arthroplasty (THA). **Methodology:** The authors searched 2653 patient records from 2015 to 2022 looking for patients who had total hip arthroplasty at our facility. For the analysis, 23 patients were culled from 64 individuals who exhibited post-THA dislocations, employing a stringent exclusion criterion, and the resultant acetabular angulation and anteversion were quantified utilizing PEEKMED software (Peek Health S.A., Portugal) upon radiographic evidence. **Results:** Within the operational timeframe, from the cohort of 2653 subjects, 64 presented with at least a singular incident of displacement. Post-exclusion criterion enforcement, 23 patients were eligible for inclusion. Of these, 10 patients conformed to the safe zone demarcated by Lewinnek for both inclination and anteversion angles, while 13 exhibited deviations from the prescribed anteversion and/or inclination benchmarks. **Conclusion:** Analysis of the 23 patients reveals that 13 did not confirm to be in the safe zone parameters for anteversion and/or inclination, whereas 10 were within the safe zone as per Lewinnek's guidelines. This investigative review, corroborated by extant literature, suggests that the isolated consideration of the Lewinnek safe zone does not suffice as a solitary protective factor. It further posits that additional variables are equally critical as acetabular positioning and mandate individual assessment.

Keywords

Acetabular Component Positioning, Dislocation, Hip Arthroplasty, Lewinnek's Safe Zone

1. Introduction

Currently, beyond one million total hip arthroplasties are performed worldwide each year [1]. The most common surgical indications are severe osteoarthritis, fractures of the femoral neck or head, and femoral head osteonecrosis. Among the most feared postoperative complications, dislocation stands out, both for its severity and the added cost to the procedure. According to literature data, dislocation occurs at 1% - 3% and ranks as the leading reason for revision surgery [2] [3]. Different factors have been studied as potential contributors to postoperative instability, with acetabular positioning being of particular interest [4]-[11].

In 1978, Lewinnek *et al.* studied a series of postoperative radiographs and found that patients predisposed to dislocation had their acetabulum positioned outside a predefined range of angles. The author concluded that the safest zone for acetabular positioning would be within 40˚ ± 10˚ of inclination and 15˚ ± 10˚ of anteversion. This concept, known as Lewinnek's SAFE ZONE, has been widely disseminated and remained an absolute truth for decades [11].

Recent studies have questioned the concept of the safe zone described by Lewinnek, finding no absolute correlation between acetabular positioning and the occurrence of dislocation [4]-[10]. Seagrave *et al.* conducted a systematic review, analyzing 11 articles related to acetabular positioning. In only 2 of the 11 articles, it was statistically significant that the majority of patients experiencing dislocations were outside the safe zone. In 7 of the evaluated articles, patients with prosthesis dislocations were primarily located within the safe zone [10].

The present study aims to assess the relationship between acetabular positioning and the occurrence of dislocation in patients treated at our institution by measuring acetabular anteversion and inclination. It also aims to determine whether the safe zone genuinely reduces the risk of postoperative dislocation.

2. Materials and Methods

This study was submitted and approved by the Ethics Committee Board of our institution and performed in accordance with the Declaration of Helsinki. We reviewed medical records and radiographs of patients who underwent hip arthroplasty between 2015 and 2022 at our institution and experienced at least one episode of postoperative dislocation.

Patients who experienced dislocation in revision or partial prostheses were excluded, as were those with unavailable or poorly executed imaging examinations that prevented anteversion and inclination measurements, and patients with dis-

locations associated with periprosthetic fractures.

The measurements of acetabular component anteversion and inclination angles were performed using Peekmed software (Peek Health S.A., Portugal) on plain radiographs. This software is FDA-certified in the United States. Statistical analysis was conducted using SPSS 26, considering mean values, standard deviation, and percentages.

3. Results

Between 2015 and 2022, 2653 hip arthroplasties were performed at our institution, and 64 patients experienced at least one episode of prosthesis dislocation. After applying the exclusion criteria, 23 patients remained to be evaluated.

Of these patients, 9 were male, and 14 were female. The mean age at the time of dislocation was 66 years, ranging from 51 to 82 years. The time between surgery and the first episode of dislocation ranged from 1 day to 7 years.

Anteversion measurements of the acetabular component ranged from 1.8˚ to 39.5˚, with a mean of 14.9˚. Inclination measurements of the acetabular cup ranged from 23.3˚ to 67.1˚, with a mean of 44.7˚, as shown in Table 1.

Out of the 23 patients evaluated, only 5 had anteversion measurements outside the safe zone (15˚ ± 10˚), and 10 had inclination measurements outside the safe zone (40˚ ± 10˚), as indicated in Table 2. Among the 23 patients, 10 had both anteversion and inclination measurements within Lewinnek's established limits (Figure 1).

4. Discussion

Lewinnek *et al.*'s original article published in 1978 continues to be widely cited and debated in orthopedic literature, despite its evident limitations. The authors relied on a small sample, analyzing only 9 cases of dislocation, with 6 of these

Table 1. Angle values found in the 23 evaluated patients.

	Anteversion	Inclination
Mean Value	14.9	44.7
Standard Deviation	10.0	12.5
Minimum Value	1.8	23.3
Maximum Value	39.5	67.1

Table 2. Anteversion and inclination values found versus number of samples.

	Angle	N	%
Anteversion	5 - 25 degrees	17	73.9
	<5 or >25 degrees	6	26.1
Inclination	30 - 50 degrees	13	56.5
	<30 or >50 degrees	10	43.5

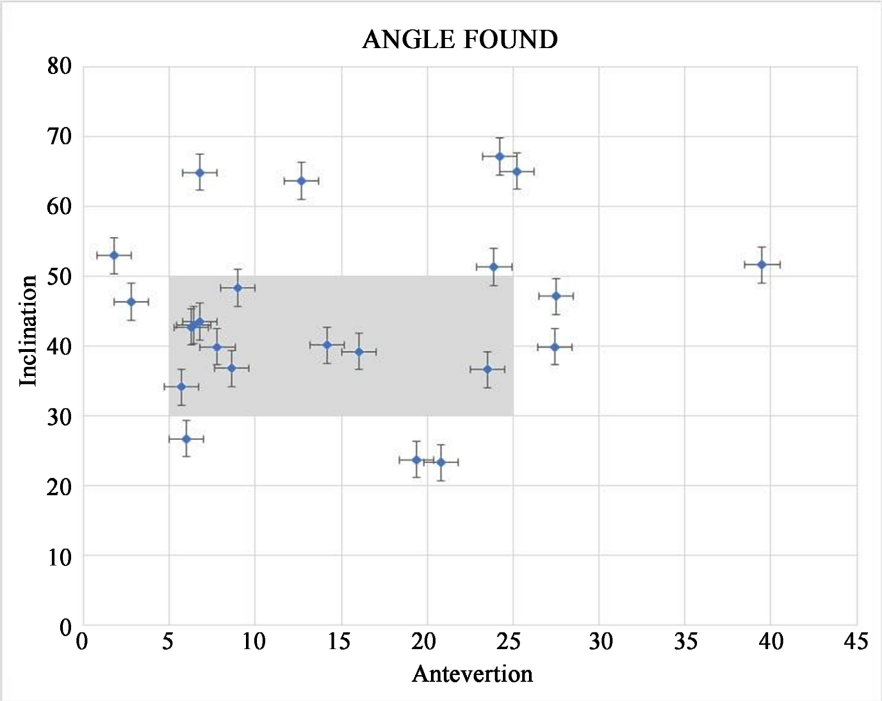

Figure 1. Graph demonstrating the values of inclination and anteversion found in the 23 evaluated cases with a highlight on the safety values according to Lewinnek *et al.*

involving revision prostheses, which are considered an independent risk factor for dislocation. In this study, we evaluated the relationship between acetabular positioning and dislocation occurrence in patients treated at our institution by measuring acetabular anteversion and inclination to determine whether the safe zone genuinely reduces the risk of postoperative dislocation [1]-[3] [11].

Several recent articles have questioned the efficiency of Lewinnek's safe zone in preventing acetabular dislocation. These authors are unable to pinpoint a single factor to explain cases of dislocation following hip arthroplasty, suggesting a possible multifactorial cause. Other factors may, therefore, explain postoperative instability in patients with the acetabulum positioned within the safe zone, such as femoral head size, femoral anteversion, femoral offset, and others [4]-[10].

The ideal positioning remains a topic of discussion. Incorrect acetabular positioning could result in femoral neck impingement with the acetabular rim or the polyethylene or ceramic insert. Such impingement can act as a fulcrum, causing femoral head displacement or even causing microtrauma in the polyethylene, ceramic, or metal, releasing abrasive debris that accelerates wear and aseptic loosening [12]-[14].

In a study involving prostheses removed from patients during revision, Yamaguchi *et al.* observed that patients with excessive anteversion of the acetabular component in radiographs exhibited signs of anterior acetabular rim impingement. These impingement episodes would occur when the patient flexed and internally rotated the hip while sitting and were related to episodes of posterior dislocation [13]. Greater acetabular inclinations were associated with increased

polyethylene wear and a higher risk of dislocation. However, smaller inclinations are associated with a loss of range of motion [14] [15].

The ideal positioning is likely one that allows for maximum range of motion without the consequence of femoroacetabular impingement and instability. Kummer *et al.* conducted a study on synthetic models and suggested that this positioning would be between 35 and 45 degrees of inclination and 0 to 10 degrees of anteversion [12]. Subsequent studies on three-dimensional models demonstrated that this depends not only on acetabular anteversion but also on the combined anteversion of the acetabulum and femoral neck [14] [16]-[18]. According to some authors, the combined anteversion value with the lowest dislocation risk is between 40 and 60 degrees [16] [18].

Another concept currently under debate is the so-called functional acetabular positioning. It is based on the fact that the pelvis is not static throughout the day. When assuming a seated position, for example, the patient tilts the pelvis approximately 20 degrees posteriorly, reducing lumbar lordosis and tilting the acetabulum. For every degree of pelvic tilt, it is estimated that the acetabulum undergoes 0.7 to 0.8 degrees of anteversion, allowing the femur to flex freely over the acetabulum without impacting its anterior rim. Therefore, in patients with reduced spine-pelvic movement due to previous arthrodesis or degenerative disease, the acetabulum should theoretically be positioned with more anteversion to compensate for this loss of mobility and avoid anterior femoroacetabular impingement and potential dislocations when sitting [19]-[21]. Similarly, patients with reduced lumbar lordosis require less acetabular anteversion [14] [20]. Some authors advocate the use of sagittal radiographs of the spine and pelvis for preoperative planning as a standardized approach.

In this study, it was demonstrated that out of the 23 patients who experienced dislocation after total hip arthroplasty, only 13 had acetabular angles outside the recommended safe zone. Analyzing articles in the literature and the results obtained in our study, it is evident that acetabular positioning does not constitute an isolated risk factor. It should be considered alongside other patient characteristics, such as age, muscular condition, ligament laxity, spine-pelvic balance, surgical approach, and femoral head size, among others. When determining acetabular positioning, the orthopedic surgeon must carefully evaluate each patient individually to arrive at an angle that allows for better mobility and lower dislocation risk for each case.

Further studies encompassing a larger case volume and incorporating instances where dislocation did not occur post-THA, while individually addressing other potential causes for the occurrence of dislocation, may elucidate the emergence of this undesirable outcome more clearly.

5. Conclusion

Of the 23 patients analyzed who experienced dislocation after total hip arthroplasty, 13 had anteversion and inclination angles outside Lewinnek's safe zone. The

current understanding found in the literature and corroborated by the results of this study is that acetabular positioning cannot be seen in isolation as a determining factor for the occurrence of dislocation. The ideal angle is likely different for each patient, and the surgeon should personalize the planning based on the numerous variables that can influence the risk of postoperative dislocation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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