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Research Article

Acetabular Component Inclination and Anteversion: A Comparative Study of the Supercapsular and Posterolateral Approaches

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ABSTRACT

Background: The Supercapsular Percutaneously-Assisted Total Hip (SuperPATH) technique is a muscle-preserving approach to Total Hip Arthroplasty (THA). However, whether the limited surgical exposure inherent to this technique affects acetabular component positioning remains a concern.

Objective: To evaluate the effect of the SuperPATH technique on acetabular component positioning and compare the results with those obtained using the traditional Posterolateral Approach (PLA).

Methods: This retrospective cohort study assessed acetabular component positioning using standardized anteroposterior digital hip radiographs from 86 randomly selected patients equally distributed between the two groups. Radiographic measurements used to calculate acetabular anteversion and inclination were independently obtained by two orthopedic surgeons, and interobserver reliability was assessed using the Intraclass Correlation Coefficient (ICC) with 95% confidence intervals. Differences between the surgical approaches were evaluated using the Mann-Whitney U test, with statistical significance set at $p<0.05$. Statistical analyses were performed using IBM® Statistical Package for the Social Sciences (SPSS) Statistics, version 22.

Results: Interobserver agreement was excellent (ICC>0.9). Mean acetabular inclination was similar between the SuperPATH and PLA groups (38.57 ± 7.15° and 40.76 ± 7.90°, respectively). In contrast, mean anteversion differed significantly between the groups (30.26 ± 5.86° and 25.61 ± 7.56°, respectively). The Mann-Whitney U test showed a significant difference in anteversion between the surgical approaches ($U=569.000$; $p<0.01$), but not in inclination ($U=1066.000$; $p>0.05$). One dislocation occurred in the PLA group, in a hip with an acetabular component inclination of less than 30°.

Conclusion: Acetabular components implanted using the SuperPATH technique were more anteverted than those implanted using the conventional posterolateral approach, whereas inclination did not differ significantly between the groups. An inclination angle below 30° was present in the only case of dislocation, which occurred in the PLA group.

Keywords: Total Hip Arthroplasty (THA); Hip prosthesis; Posterolateral approach; Supercapsular Percutaneously-Assisted Total Hip Arthroplasty (SuperPATH); Component positioning.

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INTRODUCTION

Total Hip Arthroplasty (THA) is one of the most successful procedures in orthopedic surgery and has undergone substantial advances in recent decades, driven by the development of new surgical techniques, a broader range of prosthetic components, and improvements in preoperative planning [1-6]. These advances have contributed to improve functional outcomes and quality of life, as well as reduced pain, in patients with severe degenerative hip disease [5-7].

Despite these favorable outcomes, dislocation remains a major complication after THA, occurring in 0.3% to 10% of primary procedures and in up to 28% of revision procedures [8]. Malposition of the acetabular component is an important predisposing factor, particularly with regard to anteversion and inclination [9]. Traditionally, the Lewinnek safe zone has been defined as 15° ± 10° of anteversion and 40° ± 10° of inclination/abduction, and these parameters remain widely used for the radiographic assessment of acetabular component positioning [10-19].

Minimally invasive approaches have been developed to reduce soft-tissue injury and facilitate early functional recovery [20-23]. The Supercapsular Percutaneously-Assisted Total Hip (SuperPATH) technique represents an evolution of micro-posterior approaches, using a surgical interval superior to the hip capsule between the gluteus minimus and piriformis muscles while preserving the posterior musculotendinous structures [24].

Recent evidence, however, indicates that no single surgical approach is universally superior across all THA outcomes. In a systematic review and meta-analysis of 85 randomized clinical trials involving 6,575 patients, SuperPATH was associated with favorable early functional recovery and ranked highest for the physical component of quality of life, although it was also associated with longer operative times and intermediate outcomes for gait and safety [25]. Magnetic resonance imaging studies have further demonstrated that SuperPATH does not completely eliminate periarticular muscle injury, despite greater preservation of selected posterior structures and more pronounced clinical benefits during the early postoperative period [26,27].

Previous comparative studies have also reported shorter hospital stays and favorable early recovery with SuperPATH, although the technique is frequently associated with longer operative times than conventional posterior approaches [28-32]. Nevertheless, the more limited surgical exposure inherent to minimally invasive techniques may make component orientation more challenging, and accurate acetabular cup positioning remains technically demanding even for experienced surgeons [3,4,32,33].

Given the need to balance soft-tissue preservation, functional recovery, and accurate prosthetic component positioning, this study aimed to evaluate the effect of the SuperPATH technique on acetabular component inclination and anteversion and to compare these parameters with those obtained using the traditional Posterolateral Approach (PLA).

METHODS

A retrospective cohort study was conducted to assess acetabular component positioning following primary Total Hip Arthroplasty (THA) performed between 2017 and 2019 for severe hip osteoarthritis at an orthopedic referral hospital in the state of São Paulo, Brazil. The study was approved by the research ethics committee and conducted in accordance with the ethical principles of the Declaration of Helsinki. All participants provided written informed consent.

Acetabular component positioning was assessed using standardized, full-scale anteroposterior digital pelvic radiographs. All procedures were performed by a single orthopedic surgeon. Radiographic measurements used to calculate acetabular anteversion and inclination were independently obtained in millimeters by two additional orthopedic surgeons. Measurements were performed in a blinded manner: The operating surgeon was not involved in the measurements, and the two examiners were blinded to each other's measurements. Statistical analyses were performed independently by a third examiner.

Exclusion criteria were THA's requiring component revision, procedures performed for fractures, and cases in which radiographic quality was insufficient to clearly delineate the acetabular cup margins for two-dimensional radiographic analysis.

Surgical techniques

Posterolateral approach

The conventional posterolateral approach consisted of a posterolateral hip incision, detachment of the external rotator muscles, followed by hip dislocation, femoral head osteotomy, acetabular and femoral preparation, and component implantation.

Supercapsular Percutaneously-Assisted Total Hip Surgery (SuperPATH)

This approach preserves the insertions of the hip external rotator muscles and involves femoral broaching through the piriformis fossa without hip dislocation, percutaneously assisted acetabular preparation, and component implantation. Hybrid fixation was used with the conventional posterolateral approach, whereas cementless fixation was used with the SuperPATH technique.

Standardization of radiographic examination

Standardized, full-scale digital radiographs were obtained according to the following protocol: An Anteroposterior (AP) projection with the patient in the supine position; the X-ray beam oriented perpendicular to the acetabular component; a source-to-image distance of 1 m; and manual adjustment of patient positioning to correct for pelvic anteversion or retroversion.

Radiographic assessments

Radiographic assessment of acetabular component anteversion and inclination was performed using Pixeon® image-viewing software. The inclination angle was measured as the angle formed by the intersection of two lines: One drawn along the base of the ischia and the other through the center of the acetabular cup face (Figure 1A).

The Pixeon® luminescence imaging feature was applied to enhance visualization of the acetabular cup margins. The distance from the posterior to the anterior margin of the cup (S) and the distance from the posterior margin to the deepest point of the cup Total Length (TL) were measured in millimeters.

The S/TL ratio represents the coefficient of rotation about the cup axis and was used in the trigonometric calculation [$\arcsin=(S/TL) \times (180/\pi)$] to determine the radiographic acetabular anteversion angle [16] (Figure 1B). Data were tabulated, and means and corresponding standard deviations were calculated for subsequent statistical analysis.

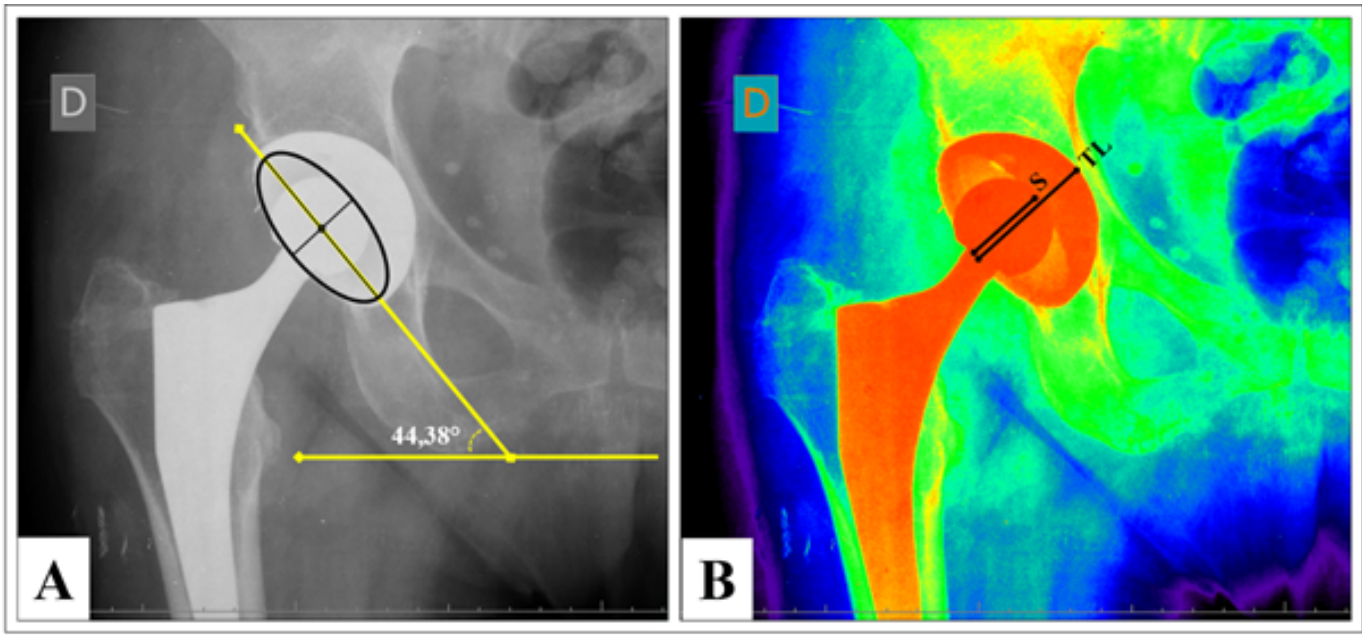


Figure 1: Assessment of acetabular component positioning: (A) Method used to assess the radiographic inclination angle; (B) Measurement of S and TL distances for subsequent calculation of the radiographic anteversion angle.

Statistical analysis

Interobserver reliability of the radiographic assessment method was evaluated using the Intraclass Correlation Coefficient (ICC) for absolute agreement, with 95% confidence intervals. ICC values were interpreted as follows: <0.40, poor; 0.40-0.60, fair; 0.60-0.75, good; and 0.75-1.00, excellent.

Mean radiographic inclination and anteversion angles of the acetabular components were compared between the two surgical approaches using the Mann-Whitney U test. Statistical significance was set at $p<0.05$. All statistical analyses were performed using IBM® Statistical Package for the Social Sciences (SPSS) Statistics, version 22.

RESULTS

A total of 162 arthroplasties were identified during the study period. Of these, 47 patients were excluded because the primary THA had been performed for a femoral fracture, 18 were excluded because they had undergone revision arthroplasty after a mean component implantation duration of more than 7.4 years, and 11 were excluded because radiographic quality was insufficient for two-dimensional assessment of the acetabular component.

A total of 43 hips treated using the PLA and 43 treated using SuperPATH were included in the analysis. Patients in the conventional PLA group had a mean age of 68.5 ± 9.3 years and a mean Body Mass Index (BMI) of 30.2%, and 51.2% were men. Patients in the SuperPATH group had mean age of 63.7 ± 6.5 years and a mean BMI of 28.4% and, 67.4% were men. Postoperative follow-up ranged from 6 to 24 months.

measurements was excellent (ICC>0.75). Radiographic inclination was similar between the two approaches, whereas acetabular anteversion differed significantly. The Mann-Whitney U test showed no significant difference in acetabular inclination between the surgical approaches ($U=1066.000$; $p>0.05$), whereas anteversion differed significantly between the groups ($U=569.000$; $p<0.01$) (Table 1). The distributions of acetabular component positioning angles are shown in (Figure 2).

Table 1: Mean and standard deviation of acetabular inclination and anteversion according to surgical approach (PLA and SuperPATH), with corresponding statistical results.

	Position of the acetabular cup	
Surgical approach	**Mean inclincation (°)**	**Mean anteversion (°)**
SuperPATH®	38.57° ± 7.15	30.26° ± 5.86
Posterolateral Approach (PLA)	40.76° ± 7.90	25.61° ± 7.56
Intraclass correlation coefficient (ICC)	0.991	0.987
Man-whitney U test (p-value)	0.222	0.002

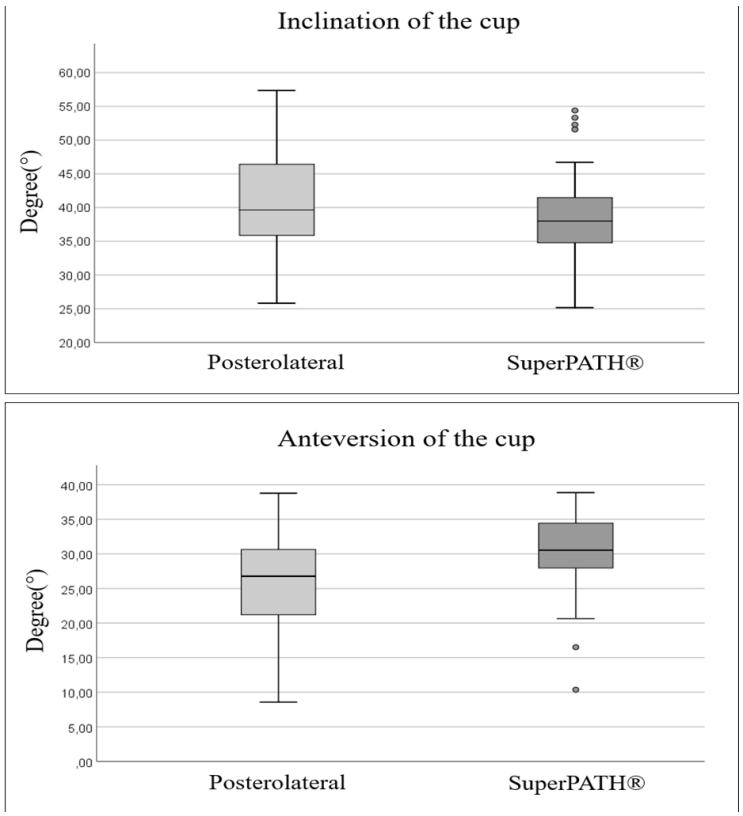


Figure 2: Distribution of radiographic inclination and anteversion angles according to surgical approach.

Regarding acetabular component positioning, 72.09% of SuperPATH cases and 83.72% of PLA cases had inclination angles between 30° and 50°. Anteversion angles between 5° and 25° were observed in 13.95% of acetabular components implanted using SuperPATH and 39.53% of those implanted using the PLA.

Both inclination and anteversion were simultaneously within the target ranges in 11.63% of SuperPATH cases and 34.88% of PLA cases. One dislocation occurred in the PLA group and was successfully treated with closed reduction in the operating room. No other complications were observed (Figure 3).

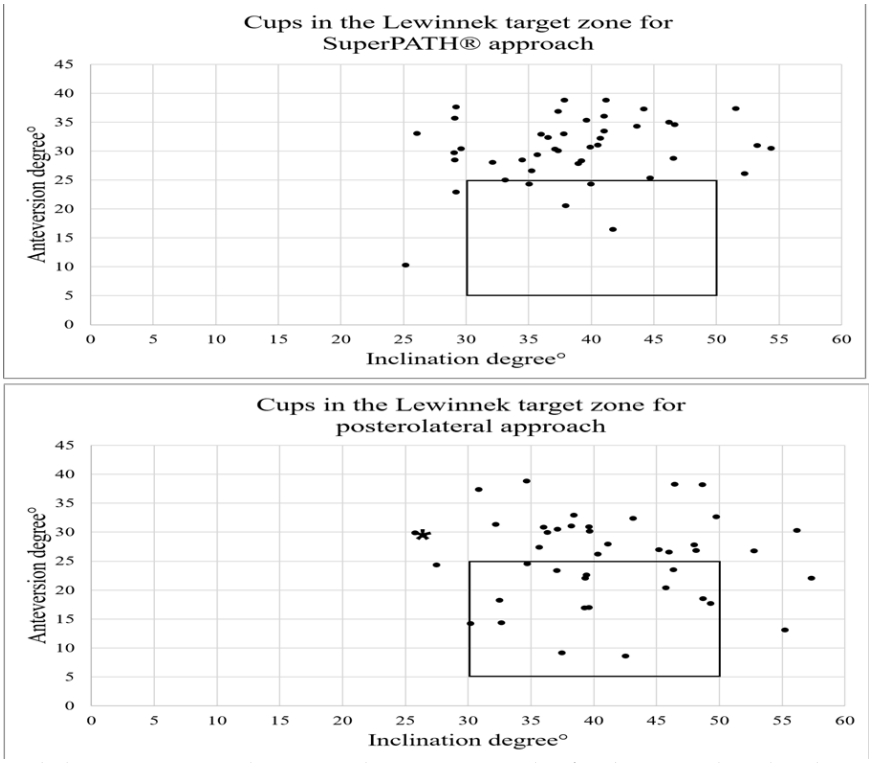


Figure 3: Distribution of acetabular component inclination and anteversion angles for the posterolateral and minimally invasive SuperPATH approaches according to the Lewinnek safe-zone criteria. (*) Postoperative dislocation.

DISCUSSION

The concept of a "safe zone," defined as 15°±10° of anteversion and 40° ± 10° of inclination/abduction, provides a widely used criterion for assessing acetabular component positioning [10,34]. However, there is no consensus regarding the optimal implant position or its relationship with the risk of complications [35-37].

Dislocation remains an important complication after THA and may occur even when the acetabular component is positioned within the recommended ranges. One study identified 206 dislocations among 9,784 primary procedures; among these cases, 84% and 69% had acceptable inclination and anteversion, respectively [34]. McLawhorn, et al. reported that 83% of dislocated hips had components positioned within the safe zone [35]. Therefore, acetabular component orientation alone does not determine the risk of dislocation, and other factors, including spinopelvic malalignment, individual anatomy, surgical approach, and instrumentation, should also be considered [33,40,41].

In the present study, 72.09% of acetabular cups in the SuperPATH group and 83.72% in the PLA group had inclination angles between 30° and 50°. Components implanted using the soft-tissue-preserving approach were significantly more anteverted; only 13.95% were within the safe range, compared with 39.53% of those implanted using the conventional approach. These findings are consistent with previous reports suggesting that posterior surgical approaches may result in greater anteversion angles [42]. The mean anteversion exceeded the recommended upper limit of 25° in both groups, particularly in the SuperPATH group, in which it exceeded this threshold by 5.26°. This finding differs from the more retroverted positioning reported in another study comparing the same techniques [32].

Despite the greater acetabular component anteversion, no complications were identified in the SuperPATH group during the 6- to 24-month postoperative follow-up period, supporting previous evidence that anteversion angles greater than 30° may not necessarily be associated with adverse outcomes in tissue-preserving posterior THA [38,39]. Similarly, in a series of 250 PATH procedures, a mean anteversion angle of 31° was not associated with dislocation [44]. Fujishiro, et al. also reported that anteversion angles of up to 30° were associated with a lower risk of dislocation [45].

No complications were identified among the 43 SuperPATH arthroplasties in this series [24,32,46]. Consistent with these findings, favorable outcomes have been reported in other case series using the same surgical technique, whereas other studies have reported subluxation, periprosthetic fractures, loss of implant position, and limb-length discrepancy [43,44,47-49].

The PLA may facilitate accurate acetabular cup positioning, as suggested by the simultaneous achievement of the Lewinnek inclination and anteversion criteria in 34.88% of PLA cases compared with 11.63% of SuperPATH cases in the present study [50,51]. Nevertheless, this finding differs from that of Barrack, et al, who reported that 88% of components were within the target ranges for both parameters. However, those authors used a broader inclination range (30°-55°), whereas the present study used an upper limit of 50°, a threshold traditionally associated with clinical safety in the literature [10,52,53]. No adverse outcomes were observed in cases with components positioned above this limit.

An inclination angle below 30° was present in the only case of dislocation, which occurred in a hip treated using the conventional approach and had an acetabular component inclination of 25.82°. Insufficient inclination reduces posteroinferior coverage, thereby increasing the risk of dislocation during hip flexion [9,33]. To reduce the risk of adverse outcomes, intraoperative patient positioning should be adjusted so that the sagittal pelvic axis is appropriately aligned relative to the floor [2].

In this cohort, pelvic and operating-table positioning were adjusted to provide the surgeon with an accurate reference for acetabular inclination. Radiographs were also standardized at full scale, with correction for potential pelvic anteversion or retroversion resulting from variations in patient positioning. A radiographic assessment method previously described in the literature was used [14,16]. To minimize potential measurement subjectivity, measurements obtained by experienced surgeons were statistically evaluated and demonstrated excellent interobserver agreement (ICC>0.9) [54].

Standardization of the surgical procedures and radiographic assessments may have contributed to the similar acetabular inclination observed between the groups. The significant difference in anteversion may be related to the SuperPATH technique, possibly because of differences in surgeon positioning during acetabular component insertion. With SuperPATH, the surgeon is positioned more superiorly relative to the acetabulum than with the conventional approach. Furthermore, because these were the first 43 hips treated using SuperPATH, the potential effect of the learning curve should be considered [20,32,43].

According to Rasuli and Gofton, 44% of the first 25 procedures achieved the safe-zone criteria for inclination and anteversion, increasing to 56% among the subsequent 25 procedures [43]. The authors evaluated acetabular component positioning in arthroplasties performed using SuperPATH and PATH. Similar to the findings of the present cohort, acetabular components implanted using SuperPATH were significantly more anteverted (23.5° *vs* 13.1°) and less abducted (39.0° *vs* 42.9°), and only 50% of cases met the angular criteria for clinical safety.

Restricted intraoperative visualization has also been shown to affect the radiographic inclination of components implanted using the SuperPATH approach [32]. The mean inclination of 38.57° observed in the present study was slightly lower than the values of 40.13° and 40° reported by other authors. However, the acetabular cups in the present study were more abducted than those reported by Qurashi, et al, who observed a mean angle of 34.4° [24,48,49].

Comparative studies directly evaluating acetabular component positioning after SuperPATH and posterior approaches have reported heterogeneous findings. In previously published cohorts, mean inclination ranged from 38.8° to 43.6° with SuperPATH and was approximately 45° with the posterolateral approach, whereas mean anteversion ranged from 15° to 17.4° and from 14.2° to 18.5°, respectively [32,55].

A randomized clinical trial reported significantly lower inclination with SuperPATH than with the mini-incision posterolateral approach (36.94 ± 6.37° *vs* 42.66 ± 3.58°; p=0.004), but no significant difference in anteversion (13.94 ± 4.73° *vs* 15.11 ± 4.06°; p=0.501) [56]. These findings differ in part from those of the present study, in which inclination did not differ significantly between the groups, whereas anteversion was significantly greater in the SuperPATH group. In contrast, another randomized clinical trial found no significant differences between SuperPATH and the conventional posterior approach in either inclination (42 ± 8° in both groups; p=0.96) or acetabular anteversion (22 ± 12° *vs* 23 ± 11°; p=0.78) [57]. Similarly, Hagio, et al. reported inclination angles of 39.9 ± 4.1° with SuperPATH and 38.9 ± 3.5° with the posterior approach (p=0.20), and anteversion angles of 24.4 ± 5.7° and 23.4 ± 6.5°, respectively (p=0.51) [58]. In the

latter study, however, intraoperative navigation was used in 22 of 30 SuperPATH cases, which may have reduced variability in component positioning and should be considered when comparing these findings with those of series performed without navigation.

An updated meta-analysis of randomized clinical trials published in 2025 reported potential differences between SuperPATH and traditional techniques in perioperative and functional outcomes but did not include acetabular inclination or anteversion among the outcomes analyzed [59]. Thus, although recent literature has broadened the clinical comparison of these approaches, primary evidence specifically addressing radiographic acetabular cup positioning remains relatively limited. Overall, the available studies more consistently report no significant difference in anteversion between approaches, making the greater anteversion observed in the present cohort a relevant finding that differs from part of the existing comparative literature.

The present study has several limitations, including its nonrandomized design and the lack of data on participants' functional outcomes. The modest sample size should also be considered, as it may have contributed to the low number of complications and limited the ability to detect differences between the surgical approaches [1]. Further studies are needed to determine whether greater acetabular component anteversion influences the long-term risk of complications after THA performed using this soft-tissue-preserving technique.

CONCLUSION

Acetabular components in hips treated using the SuperPATH® technique were more anteverted and less inclined than those implanted using the posterolateral approach. The minimally invasive approach was associated with a significant difference in acetabular component anteversion but not in inclination. Greater radiographic acetabular cup anteversion was not associated with complications during the follow-up period. An inclination angle below 30° was present in the only case of dislocation.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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REFERENCES

1. Debi R, Slamowicz E, Cohen O, Elbaz A, Lubovsky O, Lakstein D, et al. Acetabular cup orientation and postoperative leg length discrepancy in patients undergoing elective total hip arthroplasty via a direct anterior and anterolateral approaches. BMC Musculoskelet Disord. 2018;19(1):188.
2. Bhaskar D, Rajpura A, Board T. Current concepts in acetabular positioning in total hip arthroplasty. Indian J Orthop. 2017;51(4):386-396.
3. Alexandrov T, Ahlmann ER, Menendez LR. Early clinical and radiographic results of minimally invasive anterior approach hip arthroplasty. Adv Orthop. 2014;2014(1):954208.
4. Goyal P, Lau A, McCalden R, Teeter MG, Howard JL, Lanting BA. Accuracy of the modified Hardinge approach in acetabular positioning. Can J Surg. 2016;59(4):247.
5. Wang XD, Lan H, Hu ZX, Li KN, Wang ZH, Luo J, et al. SuperPATH minimally invasive approach to total hip arthroplasty of femoral neck fractures in the elderly: Preliminary clinical results. Orthop Surg. 2020;12(1):74-85.
6. Miashiro EH, Fujikib EN, Yamaguchi EN, Chikude T, Rodrigues LH, Fontes GM, et al. Preoperative planning of primary total hip arthroplasty using conventional radiographs. Rev Bras Ortop. 2014;49(02):140-148.
7. Zagra L. Advances in hip arthroplasty surgery: What is justified? EFORT Open Rev. 2017;2(5):171-178.
8. Falez F, Papalia M, Favetti F, Panegrossi G, Casella F, Mazzotta G. Total hip arthroplasty instability in Italy. Int Orthop. 2017;41(3):635-644.
9. Seagrave KG, Troelsen A, Malchau H, Husted H, Gromov K. Acetabular cup position and risk of dislocation in primary total hip arthroplasty: A systematic review of the literature. Acta Orthop. 2017;88(1):10-17.
10. Lewinnek GE, Lewis JL, Tarr RI, Compere CL, Zimmerman JR. Dislocations after total hip-replacement arthroplasties. J Bone Joint Surg Am. 1978;60(2):217-220.
11. Ackland MK, Bourne WB, Uhthoff HK. Anteversion of the acetabular cup. Measurement of angle after total hip replacement. J Bone Joint Surg Br. 1986;68(3):409-413.
12. Hassan DM, Johnston GH, Dust WN, Watson LG, Cassidy D. Radiographic calculation of anteversion in acetabular prostheses. J Arthroplasty. 1995;10(3):369-372.
13. Pradhan R. Planar anteversion of the acetabular cup as determined from plain anteroposterior radiographs. J Bone Joint Surg Br. 1999;81(3):431-435.
14. Widmer KH. A simplified method to determine acetabular cup anteversion from plain radiographs. J Arthroplasty. 2004;19(3):387-90.
15. Liaw CK, Hou SM, Yang RS, Wu TY, Fuh CS. A new tool for measuring cup orientation in total hip arthroplasties from plain radiographs. Clin Orthop Relat Res. 2006;451:134-139.
16. Casagrande RM, da Silva AE, Novelli C, Machado EG, Vieira FS, Costa FT, et al. Determining the three-dimensional position of the acetabular cup in total hip arthroplasty patients. Rev. CPAQV. 2015;7(3).
17. Murray DW. The definition and measurement of acetabular orientation. J Bone Joint Surg Br. 1993;75(2):228-232.
18. Hill JC, Gibson DP, Pagoti R, Beverland DE. Photographic measurement of the inclination of the acetabular component in total hip replacement using the posterior approach. J Bone Joint Surg Br. 2010;92(9):1209-1214.
19. Labronici PJ, Motta RL, Esteves BB, Franco JS, Hoffmann R, Ferreira LA, et al. Positioning of the acetabular component in cemented prostheses-radiographic calculation. Rev Bras Ortop. 2013;48(1):62-68.
20. Chow J, Penenberg B, Murphy S. Modified micro-superior percutaneously-assisted total hip: Early experiences & case reports. Curr Rev Musculoskelet Med. 2011 Sep;4(3):146-150.
21. Murphy SB. Technique of tissue-preserving, minimally-invasive total hip arthroplasty using a superior capsulotomy. Oper Tech Orthop. 2004;14(2):94-101.
22. Penenberg BL, Bolling WS, Riley M. Percutaneously Assisted Total Hip Arthroplasty (PATH): A preliminary report. J Bone Joint Surg Am. 2008 ;90(4):209-220.
23. Roger DJ, Hill D. Minimally invasive total hip arthroplasty using a transpiriformis approach: A preliminary report. Clin Orthop Relat Res. 2012;470(8):2227-2234.
24. Della Torre PK, Fitch DA, Chow JC. Supercapsular percutaneously-assisted total hip arthroplasty: Radiographic outcomes and surgical technique. Ann Transl Med. 2015;3(13):180.
25. Wang X, Zhou L, Shi T, Meng X, Tang Y, Guo C, et al. Early clinical efficacy and safety of different surgical approaches in total hip arthroplasty: A systematic review and network meta-analysis. BMC

Musculoskelet Disord. 2026.

26. Gan F, Zhang Q, Luo H, Li L, Lin X, Qin H. MRI assessment of muscle damage in total hip arthroplasty via SuperPATH approach. Orthop Traumatol Surg Res. 2026:104772.

27. Gan F, Zhang Q, Luo H, Li L, Lin X, Qin H. MRI assessment of muscle damage after posterolateral versus SuperPATH approach for total hip arthroplasty. Sci Rep. 2026.

28. Branco CB, Sousa RM, Sousa D, Reis J, Guimaraes A, et al. Comparison of short-term outcomes between minimal invasive superpath approach and conventional posterior approach in total hip arthroplasty: A randomized controlled trial. Int J Res Orthop. 2021: 431-437

29. Flevas DA, Tsakotos GA, Benakis LN, Sasalos GG, Tokis AV. The supercapsular percutaneously assisted total hip (SuperPATH) approach revisited: technique improvements after the perioperative experience of 344 cases. Life (Basel). 2022;12(7):981.

30. Ramadanov N, Bueschges S, Liu K, Lazaru P, Marintschev I. Direct and indirect comparisons in network meta-analysis of SuperPATH, direct anterior and posterior approaches in total hip arthroplasty. Sci Rep. 2022;12(1):16778.

31. Jiang H, Wang LH, Jin YX, Liu ZM, Xu LF, Chen XY. Supercapsular percutaneously assisted total hip arthroplasty versus conventional posterior approach: Comparison of early functional results. Acta Orthop Traumatol Turc. 2020;54(5):511.

32. Meng W, Huang Z, Wang H, Wang D, Luo Z, Bai Y, et al. Supercapsular percutaneously-assisted total hip (SuperPath) versus posterolateral total hip arthroplasty in bilateral osteonecrosis of the femoral head: A pilot clinical trial. BMC Musculoskelet Disord. 2019;21(1):2.

33. Scheerlinck T. Cup positioning in total hip arthroplasty. Acta Orthop Belg. 2014;80(3):336-347.

34. Hananouchi T, Saito M, Koyama T, Sugano N, Yoshikawa H. Tailor-made surgical guide reduces incidence of outliers of cup placement. Clin Orthop Relat Res. 2010;468(4):1088-1095.

35. Leichtle UG, Leichtle CI, Taslaci F, Reize P, Wünschel M. Dislocation after total hip arthroplasty: Risk factors and treatment options. Acta Orthop Traumatol Turc. 2013;47(2):96-103.

36. Grammatopoulos G, Thomas GE, Pandit H, Beard DJ, Gill HS, Murray DW. The effect of orientation of the acetabular component on outcome following total hip arthroplasty with small diameter hard-on-soft bearings. Bone Joint J. 2015;97(2):164-172.

37. Opperer M, Lee YY, Nally F, Blanes Perez A, Goudarz-Mehdikhani K, Gonzalez Della Valle A. A critical analysis of radiographic factors in patients who develop dislocation after elective primary total hip arthroplasty. Int Orthop. 2016;40(4):703-708.

38. Esposito CI, Gladnick BP, Lee YY, Lyman S, Wright TM, Mayman DJ, et al. Cup position alone does not predict risk of dislocation after hip arthroplasty. J Arthroplasty. 2015;30(1):109-113.

39. Tezuka T, Heckmann ND, Bodner RJ, Dorr LD. Functional safe zone is superior to the Lewinnek safe zone for total hip arthroplasty: Why the Lewinnek safe zone is not always predictive of stability. J Arthroplasty. 2019;34(1):3-8.

40. Austin MS, Rothman RH. Acetabular orientation: Anterolateral approach in the supine position. Clin Orthop Relat Res. 2009;467(1):112-118.

41. Abdel MP, von Roth P, Jennings MT, Hanssen AD, Pagnano MW. What safe zone? The vast majority of dislocated THAs are within the Lewinnek safe zone for acetabular component position. Clin Orthop Relat Res. 2016;474(2):386-391.

42. McLawhorn AS, Sculco PK, Weeks KD, Nam D, Mayman DJ. Targeting a new safe zone: A step in the development of patient-specific component positioning in hip arthroplasty. Orthop Proc. 2014;96:43.

43. Penenberg BL, Bolling WS, Riley M. Percutaneously Assisted Total Hip Arthroplasty (PATH): A preliminary report. J Bone Joint Surg Am. 2008;90(4):209-220.

44. Fujishiro T, Hiranaka T, Hashimoto S, Hayashi S, Kurosaka M, Kanno T, et al. The effect of acetabular and femoral component version on dislocation in primary total hip arthroplasty. Int Orthop. 2016;40(4):697-702.

45. Mitchell RJ, Kay AB, Smith KM, Murphy SB, Le DT. Early results of displaced femoral neck fragility fractures treated with supercapsular percutaneous-assisted total hip arthroplasty. Arthroplast Today. 2019;5(2):193-196.

46. Rasuli KJ, Gofton W. Percutaneously Assisted Total Hip (PATH) and Supercapsular Percutaneously Assisted Total Hip (SuperPATH) arthroplasty: Learning curves and early outcomes. Ann Transl Med. 2015;3(13):179.

47. Quitmann H. Supercapsular Percutaneously Assisted Total Hip (SuperPath) approach in total hip arthroplasty: Surgical technique and preliminary results. Oper Orthop Traumatol. 2019;31(6):536-546.

48. Qurashi S, Chinnappa J, Rositano P, Asha S. SuperPATH® minimally invasive total hip arthroplasty-an Australian experience. Reconstr Rev. 2016;6(2).

49. Hagio K, Akiyama K, Aikawa K, Saito M. Radiograph evaluation of total hip arthroplasty with superpath approach. Orthop Proc. 2020;102(1):94. Bone & Joint.

50. Callanan MC, Jarrett B, Bragdon CR, Zurakowski D, Rubash HE, Freiberg AA, Malchau H. The John Charnley Award: Risk factors for cup malpositioning: Quality improvement through a joint registry at a tertiary hospital. Clin Orthop Relat Res. 2011;469(2):319-329.

51. Barrack RL, Krempec JA, Clohisy JC, McDonald DJ, Ricci WM, Ruh EL, et al. Accuracy of acetabular component position in hip arthroplasty. J Bone Joint Surg Am. 2013;95(19):1760-1768.

52. Danoff JR, Bobman JT, Cunn G, Murtaugh T, Gorroochurn P, Geller JA, et al. Redefining the acetabular component safe zone for posterior approach total hip arthroplasty. J Arthroplasty. 2016;31(2):506-511.

53. García-Rey E, García-Cimbrelo E. Abductor biomechanics clinically impact the total hip arthroplasty dislocation rate: A prospective long-term study. J Arthroplasty. 2016;31(2):484-90.

54. Biedermann R, Tonin A, Krismer M, Rachbauer F, Eibl G, Stöckl B. Reducing the risk of dislocation after total hip arthroplasty: The effect of orientation of the acetabular component. J Bone Joint Surg Br. 2005;87(6):762-769.

55. Xie J, Zhang H, Wang L, Yao X, Pan Z, Jiang Q. Comparison of supercapsular percutaneously assisted approach total hip versus conventional posterior approach for total hip arthroplasty: A prospective, randomized controlled trial. J Orthop Surg Res. 2017;12(1):138.

56. Meng W, Gao L, Huang Z, Wang H, Wang D, Luo Z, et al. Supercapsular percutaneously-assisted total hip (SuperPath) versus mini-incision posterolateral total hip arthroplasty for hip osteoarthritis: A prospective randomized controlled trial. Ann Transl Med. 2021;9(5):392.

57. Khoja YT, Habis AA, Wood GC. The supercapsular percutaneously assisted total hip approach does not provide any clinical advantage over the conventional posterior approach for THA in a randomized clinical trial. Clin Orthop Relat Res. 2022;481(6):1116.

58. Hagio K, Aikawa K, Akiyama K. Comparison of short-term results in THA patients with SuperPath® and the conventional approach for dysplastic OA of the hip. Acta Biomed. 2025;96: 16935.

59. Huang L, Deng S, Fu D, Yang F. SuperPATH versus traditional hip replacement in efficacy and safety: An updated systematic review and meta-analysis. BMC Musculoskelet Disord. 2025;26(1):248.