

Orthopäde 2021 · 50:664–673

<https://doi.org/10.1007/s00132-021-04069-w>

Accepted: 13 November 2020

Published online: 12 February 2021

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Kaiwei Shen^{1,2} · Liqiong Lin¹ · Eryou Feng^{1,2} · Yiyuan Zhang¹ · Lili Xiao¹ · Feitai Lin¹ · Zhanglai Li¹¹ Department of Arthroscopy Surgery, Fuzhou Second Hospital Affiliated to Xiamen University, Fuzhou, China² Fujian University of Traditional Chinese Medicine, Fuzhou, China

Influence of sagittal degenerative spondylolisthesis on anteversion of the acetabular component in total hip arthroplasty

Introduction

Sagittal spinal deformity has been proven to affect the function of acetabular components [1], increasing the risk of dislocation [2] and burden on the quality of life after THA [3]. Recently, orthopedic surgeons are becoming increasingly aware of the association between spinal factors and hip joint dislocation. The safe zone was defined by Lewinnek et al.'s seminal work [4] in 1978, and Delsole et al. [5] found that there was still potential instability even in the traditional safe zone. Other research showed that acetabulum cups implanted in what is considered a safe coronal position but not a safe sagittal zone may cause impingement [6]. Therefore, the exact mechanism of lumbar-pelvic-femoral dislocation after THA has not been fully elucidated. The accurate analysis of sagittal balance parameters is necessary for evaluating hip stability.

Kaiwei Shen and Liqiong Lin are first co-authors, they contributed equally to the work.

Study design

Retrospective comparative case series (nonrandomized clinical study design).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request; please contact the corresponding author Dr. Feng. Administrative permission was received from Fuzhou Second Hospital affiliated to Xiamen University (No. 47, Shangteng Road, Cangshan District, Fuzhou, China) to access the medical records.

A large sample screening [7] of older Chinese patients (>65 years) shows that according to the Meyerding grading system, the incidence of lumbar spondylolisthesis is 24.84%, of which grade I or above is 22.03%, and 2.80% with grade II or higher level of slippage. The progression of osteoarthritis of the hip increases degenerative lumbar spondylolisthesis (DSPL) leading to lumbar kyphosis and pelvic retroversion [8]. The prevalence of degenerative spondylolisthesis associated with osteoarthritis of the hip joint in Japanese patients is as high as 31–36% [9]. In another study [10] comparing four degenerative lumbar spine conditions, the average complication risk ratios for spondylolisthesis were highest at 90 days after primary THA. At present, compared with the focus on lumbar spinal fusion [11, 12] or lumbar degenerative disc disease [13, 14], there are few studies of postoperative complications of THA in patients with DSPL. Therefore, we researched the effect, in the sagittal plane, of patients with lumbar spondylolisthesis, when changing from standing to sitting, on acetabular anteversion before and af-

ter THA, analyzed the risk of lumbar spondylolisthesis on postoperative dislocation.

Material and methods

Study population

Approved by IRB of the authors' affiliated institutions, the cross-sectional study recruited 91 patients between January 2018 and November 2019, all of whom met these inclusion criteria: (1) older than 18 years, no previous history of lower limb surgery; (2) diagnosed with primary end-stage hip osteoarthritis. A flow diagram is presented as **Fig. 1**. We excluded 26 patients who had a high risk of dislocation and factors affecting lumbar mobility as well as the spinopelvic kinematics [15]. These included three patients with a history of spinal surgery [16], four patients with scoliosis, which was defined as an abnormal lateral curvature of the spine greater than 10° in the coronal plane, two patients with vertebral compression fractures (stable fracture of the fourth and third lumbar, respectively), four pa-

Table 1 Demographic characteristics of the patients included in the study

Parameters	Control (n = 34) Mean ± SD	DSPL (n = 31) Mean ± SD	P-Value	Total (n = 65) Mean ± SD
Gender (male/female)	18/16	16/15	0.67	34/31
BMI (kg/m ²)	27 ± 10	28 ± 9	0.31	28 ± 10
Age (years)	62 ± 11	67 ± 10	0.45	65 ± 8

BMI body mass index, DSPL degenerative lumbar spondylolisthesis

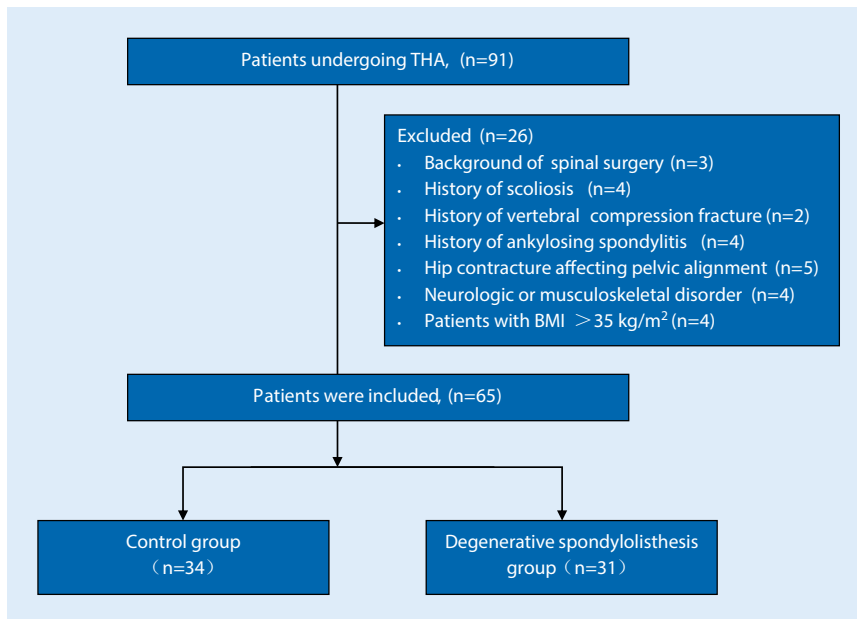


Fig. 1 ▲ Flow diagram showing the selection process for the study. *THA* total hip arthroplasty, *BMI* body mass index

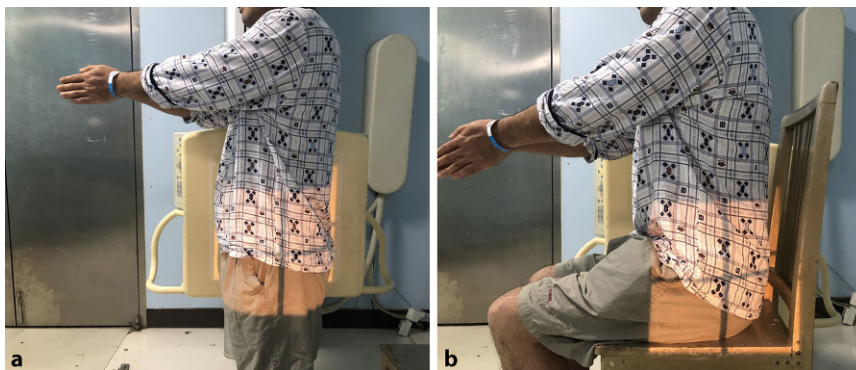


Fig. 2 ▲ Lateral radiographs of the spine and pelvis were made with the subject in a controlled standing (a) and sitting position (b)

tients with spinal ankylosis (with complete bridging osteophytes, ankylosing spondylitis, or diffuse idiopathic skeletal hyperostosis), five patients with hip contracture, four patients with neurologic or musculoskeletal disorders [17] and four patients with a BMI > 35 kg/m² [18]. The main characteristics of the population are shown in [Table 1](#).

Defining lumbar spine diseases

All surgeries were performed under the standardized protocol of a THA procedure at our institution so that the only variable during the study period was the change of DSPL. Patients whose vertebral bodies moved forward less than

50% relative to the lower vertebral bodies were included in the DSPL group by the Meyerding classification [19], which was used for grading as follows: grade 0, no slip; grade 1, translation up to 25%; grade 2, translation of 26–50%. The mean (±SD) Meyerding grades were 1.3 (±0.6) for patients with DSPL. The interobserver kappa coefficient between the two observers, who were spine surgeons with more than 10 years of experience with classifying the grade of patients with DSPL was 0.80 (95% confidence interval, CI 0.61–0.94); the intraobserver kappa coefficient was 0.91 (95% CI, 0.82–0.99), which were considered substantial for interobserver and intraobserver variability.

Biplanar imaging and spine parameters

A total of 65 patients underwent standing and sitting biplanar frontal and lateral plane two-dimensional radiographs from thoracolumbar junction (T12–L1) to the distal femur before and 6 months after THA, using the Star-PACS imaging system (YiLianZhong, Xiamen, China). The positions of all patients in the imaging system were adjusted by the same musculoskeletal radiologist (F. Lin) to ensure image quality and quantify the hip–spine relationship ([Fig. 2](#)). Patients were asked to keep their arms held parallel to the floor in front of their chest with horizontal gaze to minimize the effect of torso posture changes of the mobility of the spinopelvic complex [20]. Patients were then positioned consistently in a relaxed seated position on the wooden stool with the torso not exerting pressure on the back of the chair. We adjusted the height of chairs so that the femora were aligned parallel to the floor to achieve 90° of apparent hip flexion with the aim of achieving a natural and significant motion trajectory of the spine–pelvis–femur.

For each patient, six alignment parameters ([Fig. 3](#)) of standing and sitting postures were measured independently by two observers (K. Shen and L. Lin), using digital imaging analysis software (Materialise interactive medical image control system, ©2014 Materialise NV, Leuven, Belgium): (1) pelvic incidence (PI) is the angle formed between a line perpendicular to the upper end plate at its midpoint of S1 and a line connecting this point to the femoral head axis; (2) sacral slope (SS) is the angle between the upper plate of S1 and a horizontal line; (3) pelvic tilt (PT) is the angle between the vertical and the line joining the midpoint of the S1 endplate as well as the axis of the femoral heads [21]; (4) it has been shown that overall lumbar lordosis (LL), as a Cobb angle from the superior end plate of L1 to the upper endplate of S1 [22]; (5) pelvic–femoral angle (PFA) is the angle of femoral extension when standing (range from 170° to 190°) and of flexion when sitting (range from 120° to 144°) in relationship to the sacrum and can be used to define femoral motion [23];

K. Shen · L. Lin · E. Feng · Y. Zhang · L. Xiao · F. Lin · Z. Li

Influence of sagittal degenerative spondylolisthesis on anteversion of the acetabular component in total hip arthroplasty

Abstract

Background. Degenerative lumbar spondylolisthesis (DSPL), as opposed to other degenerative spinal conditions, is disregarded in the assessment of hip stability after total hip arthroplasty (THA). This study aimed to determine whether patients with DSPL have different acetabular anteversion compared to patients with normal spine before and following THA.

Methods. Preoperative and postoperative 6-month lateral pelvic radiographs in standing and sitting positions from 91 patients who underwent primary THA were retrospectively compared for spinopelvic parameters between patients with DSPL ($n = 31$) and with normal spine ($n = 34$).

Results. Compared to control patients in the standing position, patients with DSPL had

significantly increased preoperative pelvic tilt (24° in DSPL vs. 8° in controls; $p < 0.01$), pelvic–femoral angle (194° in DSPL vs. 174° in controls; $p < 0.05$), decreased lumbar lordosis (35° in DSPL vs. 43° in controls; $p < 0.05$), increased postoperative pelvic tilt (22° in DSPL vs. 7° in controls; $p < 0.01$), pelvic–femoral angle (187° in DSPL vs. 179° in controls; $p < 0.05$), and acetabular anteversion (31° in DSPL vs. 23° in controls; $p < 0.05$). Preoperative ($p = 0.181$) and postoperative ($p = 0.201$) sitting pelvic tilt did not differ. There were positive correlations between preoperative standing pelvic tilt and postoperative standing acetabular anteversion, pelvic–femoral angle, and combined sagittal index (CSI) in DSPL ($R^2 = 0.8416$; $R^2 = 0.9180$; $R^2 = 0.9459$, respec-

tively, $p < 0.01$) and in controls ($R^2 = 0.6872$; $R^2 = 0.6176$; $R^2 = 0.7129$, respectively, $p < 0.01$).

Conclusion. While the imbalance of seated sagittal plane is usually insignificant and compensable, the mechanism by which DSPL patients achieve a standing posture is different from control patients, with more hip extension and posterior tilt of the pelvis. Special attention should be paid to the risk of impingement caused by the increase of acetabular anteversion in the postoperative standing position.

Keywords

Retrospective study · Spinopelvic alignment · Imbalance · Sitting position · Standing position

Einfluss der sagittalen degenerativen Spondylolisthese auf die Anteversion der Azetabulum-Komponente bei Hüfttotalendoprothese

Zusammenfassung

Hintergrund. Die degenerative lumbale Spondylolisthese (DSPL) wird im Gegensatz zu anderen degenerativen Wirbelsäulenerkrankungen bei der Beurteilung der Hüftstabilität nach Hüfttotalendoprothese (HTEP) vernachlässigt. Ziel dieser Studie war es, festzustellen, ob Patienten mit DSPL im Vergleich zu Patienten mit normaler Wirbelsäule vor und nach der HTEP eine andere azetabuläre Anteversion aufweisen.

Methoden. Präoperative und postoperative 6-Monats-Röntgenaufnahmen des lateralen Beckens in stehender und sitzender Position von 91 Patienten, die sich einer primären HTEP unterzogen, wurden retrospektiv hinsichtlich spinopelviner Parameter zwischen Patienten mit DSPL ($n = 31$) und normaler Wirbelsäule ($n = 34$) verglichen.

Ergebnisse. Im Vergleich zu den Kontrollpatienten in stehender Position wiesen Patienten mit DSPL eine signifikant erhöhte

präoperative Beckenkippung (24° bei DSPL vs. 8° bei der Kontrollgruppe; $p < 0,01$), einen Becken-Oberschenkel-Winkel (194° bei DSPL vs. 174° bei der Kontrollgruppe; $p < 0,05$), eine verringerte Lendenlordose (35° bei DSPL vs. 43° bei der Kontrollgruppe; $p < 0,05$) sowie eine erhöhte postoperative Beckenkippung (22° bei DSPL vs. 7° bei der Kontrollgruppe; $p < 0,01$), Becken-Oberschenkel-Winkel (187° bei DSPL vs. 179° bei der Kontrollgruppe; $p < 0,05$) und Azetabulum-Anteversion (31° bei DSPL vs. 23° bei der Kontrollgruppe; $p < 0,05$). Die präoperative ($p = 0,181$) und postoperative ($p = 0,201$) Beckenkippung im Sitzen unterschied sich nicht. Es gab positive Korrelationen zwischen der präoperativen Beckenkippung im Stehen und der postoperativen Azetabulum-Anteversion im Stehen, dem Becken-Oberschenkel-Winkel und dem kombinierten Sagittal-Index (CSI) bei DSPL ($R^2 = 0,8416$; $R^2 = 0,9180$; $R^2 = 0,9459$;

jeweils $p < 0,01$) und bei der Kontrollgruppe ($R^2 = 0,6872$; $R^2 = 0,6176$; $R^2 = 0,7129$; jeweils $p < 0,01$).

Schlussfolgerung. Während die Dysbalance der Sagittalebene im Sitzen in der Regel unbedeutend und kompensierbar ist, unterscheidet sich der Mechanismus, durch den DSPL-Patienten eine stehende Haltung erreichen, von Kontrollpatienten, durch mehr Hüftextension und eine posteriorere Kippung des Beckens. Besonderes Augenmerk sollte auf das Impingement-Risiko gelegt werden, das durch die Zunahme der azetabulären Anteversion in der postoperativen Stehposition entsteht.

Schlüsselwörter

Retrospektive Studie · Spinopelvines Alignment · Ungleichgewicht · Sitzende Position · Stehende Position

(6) the method of combined anteversion, which we name in our study acetabular anteversion (AA), is a combination of both the anteversion and inclination of the acetabular component. The AA is a dynamic angle between a line tangent to the anterior and posterior edges of the ac-

etabular cup and a horizontal line parallel to the margin of the lateral radiograph and is considered an appropriate method for assessing sagittal imbalance [24]. The change of AA in standing and sitting positions in the patient reflects the vertical and the anteroposterior synergistic re-

lationship between the opening of the inclination and anteversion of acetabular components and the two-dimensional femoral head coverage in concert as the pelvis tilts [25].

To assess the sagittal functional hip motion to predict impingement and dis-

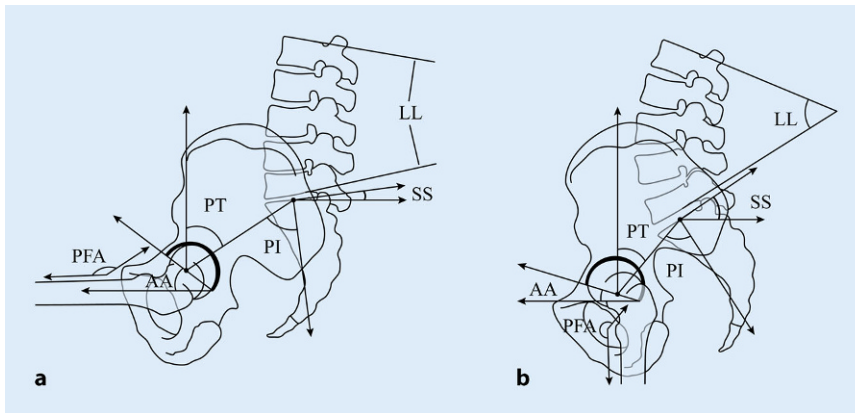


Fig. 3 ▲ Diagram showing the method of measurement of spinopelvic relationship in a sitting and b standing positions. SS sacral slope, PT pelvic tilt, PI pelvic incidence, AA acetabular anteversion, PFA pelvic-femoral angle, LL lumbar lordosis

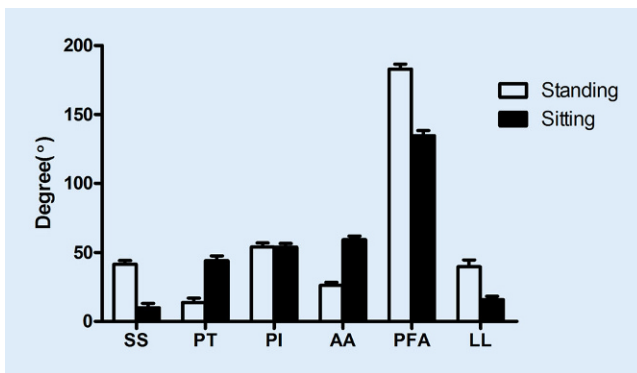


Fig. 4 ▲ Graph showing the differences from standing to sitting position preoperative lumbar-pelvic-femoral alignment measurements in patients undergoing THA. SS sacral slope, PT pelvic tilt, PI pelvic incidence, AA acetabular anteversion, PFA pelvic-femoral angle, LL lumbar lordosis

location, the functional safe zone was first proposed in 2019 by Tezuka et al. using the combined sagittal index (CSI), which is a new value for standing and sitting X-rays [6]. The CSI outliers are confirmed to be at risk of impingement and defined as follows: standing outliers have a standing CSI > 243° (upper range of standing ante-inclination (AI) 45° + upper range of standing PFA 197°); sitting outliers have a sitting CSI < 151° (lower range of sitting AI 41° + lower range of sitting PFA 110°).

Statistical methods

The reliability of the spinopelvic complex alignment parameters was estimated using the intraclass correlation coefficient (ICC) [26]. Reliability of both intrarater and interrater values were interpreted as excellent (≥ 0.75) in all parameters eval-

uated, with ICC values of 0.809–0.965. Although few studies have concerned the analysis of the sagittal balance in patients with DSPL in definite populations, we chose 5° in the approximate difference of preoperative pelvic movement. This is similar to a previous report [13] comparing control and degenerative disc disease patients because variations of sagittal balance are performed in the same way by patients with degenerative disc disease and DSPL [27]. At the least, 60 patients in our study (control and patients with DSPL) were required to achieve 80% power to detect a difference of 5° in sacral slope angle from standing to sitting between preoperative and postoperative measurements with an estimated group mean of 30°.

The two-sample and paired-sample *t*-test, Pearson correlation coefficients as well as multiple linear regression analysis were used to examine whether demo-

graphics, radiographic parameters, and correlations differed significantly among the two groups. *P* values less than 0.05 were considered significant with a 95% confidence interval. All statistical analyses were performed using SPSS Statistics, version 20.0 (IBM Corp, Armonk, NY, USA).

Result

There were differences between standing to sitting position in preoperative lumbar-pelvic-femoral alignment measurements in patients undergoing THA (■ Fig. 4). Lumbar-pelvic-femoral alignment parameters' change before and 6 months after THA appear in ■ Table 2. After controlling for age, sex, and BMI, we found that patients with DSPL before THA had 16° more posterior PT (24° DSPL patients versus 8° control; $p < 0.01$), 8° less LL (35° DSPL patients versus 43° control; $p < 0.05$), and 20° more PFA (194° DSPL patients versus 174° control; $p < 0.05$) when standing than patients with normal spine. For example, as shown in ■ Fig. 5, increased PT and decreased LL of patient 2 may be explained by the differences in lumbar-pelvic-femoral alignment in patients with DSPL; however, there was no difference in sitting PT before ($p = 0.181$) or after ($p = 0.201$) THA. Postoperatively, DSPL patients stood with a mean 15° more posterior PT (22° DSPL patients versus 7° control; $p < 0.01$), 8° more AA (31° DSPL patients versus 23° control; $p < 0.05$), and 8° more PFA (187° DSPL patients versus 179° control; $p < 0.05$).

Preoperative standing PT revealed a significant correlation with postoperative standing PFA in patients with DSPL ($R^2 = 0.9180$; $p < 0.01$, ■ Fig. 6) and in control patients ($R^2 = 0.6176$; $p < 0.01$, ■ Fig. 6). When considering differences between patients with DSPL and those with normal spines, the relative contributions of posterior PT and hip extension necessary to achieve a standing position were also different postoperatively.

The changes of standing AA of patients with DSPL and those with normal spines before ($p = 0.354$) and after surgery ($p < 0.05$) were associated with a change in sagittal pelvic alignment following THA.

Table 2 Differences in lumbar-pelvic-femoral alignment parameters between patients with normal spines (control) and patients with degenerative lumbar spondylolisthesis (DSPL) before and 6 months after total hip arthroplasty

Parameters	Pre-standing Mean \pm SD	P-Value	Post-standing Mean \pm SD	P-Value	Pre-sitting Mean \pm SD	P-Value	Post-sitting Mean \pm SD	P-Value
DSPL	36 \pm 11	–	40 \pm 12	–	14 \pm 12	–	9 \pm 9	–
SS	–	0.167	–	0.218	–	0.226	–	0.204
Control	44 \pm 9	–	45 \pm 12	–	8 \pm 11	–	9 \pm 15	–
DSPL	29 \pm 11	–	31 \pm 7	–	50 \pm 15	–	60 \pm 8	–
AA	–	0.354	–	0.012 ^a	–	0.118	–	0.148
Control	25 \pm 10	–	23 \pm 6	–	46 \pm 13	–	54 \pm 14	–
DSPL	35 \pm 10	–	42 \pm 12	–	18 \pm 13	–	13 \pm 12	–
LL	–	0.017 ^a	–	0.259	–	0.383	–	0.416
Control	43 \pm 14	–	46 \pm 13	–	15 \pm 12	–	14 \pm 10	–
DSPL	194 \pm 16	–	187 \pm 15	–	138 \pm 24	–	147 \pm 14	–
PFA	–	0.019 ^a	–	0.029 ^a	–	0.091	–	0.147
Control	174 \pm 16	–	179 \pm 11	–	130 \pm 15	–	144 \pm 15	–
DSPL	58 \pm 15	–	61 \pm 17	–	59 \pm 15	–	62 \pm 16	–
PI	–	0.117	–	0.076	–	0.213	–	0.198
Control	52 \pm 10	–	50 \pm 9	–	51 \pm 10	–	52 \pm 11	–
DSPL	24 \pm 10	–	22 \pm 14	–	44 \pm 15	–	42 \pm 13	–
PT	–	0.006 ^b	–	0.008 ^b	–	0.181	–	0.201
Control	8 \pm 9	–	7 \pm 6	–	42 \pm 14	–	39 \pm 14	–

DSPL degenerative lumbar spondylolisthesis, LL lumbar lordosis, PI pelvic incidence, PT pelvic tilt, SS sacral slope, PFA pelvic-femoral angle, AA acetabular anteversion

^aSignificant difference

^bHighly significant difference

There was a positive correlation between preoperative standing PT and postoperative standing AA in patients with DSPL ($R^2 = 0.8416$; $p < 0.01$, **Fig. 7**) and in patients with normal spines ($R^2 = 0.6872$; $p < 0.01$, **Fig. 7**).

A significant positive correlation was found between preoperative standing PT and postoperative standing CSI in patients with DSPL ($R^2 = 0.9459$; $p < 0.01$, **Fig. 8**) and that in patients with normal spines ($R^2 = 0.7129$; $p < 0.01$, **Fig. 8**). As shown in **Fig. 9**, preoperative and postoperative CSI (PFA + AA) of a 74-year-old female with DSPL were significantly higher than that of the 48-year-old male without spinal arthrosis. Patients with DSPL exhibited more hip extension and required more posterior pelvic tilt in a standing position to prevent spinal flexion due to reduction of lumbar lordosis compared to control patients.

Discussion

To achieve sagittal balance, a normal posture keeps the pelvis tilt back at 20°, hip extension about 55–70°, and LL de-

creases when changing the stance from upright standing to sitting [21], which may explain the variation of position in spine-pelvic motion in our study (**Fig. 4**). We discovered that compared to control patients, patients with DSPL had significantly increased preoperative PT ($p < 0.01$) and decreased LL ($p < 0.05$) in the standing position. Although the pelvic incidence was not statistically significant, the patients with DSPL still showed an increasing trend. Barrey et al. [27] analyzed the spinopelvic alignment of the pelvic-spine complex in three degenerative lumbar diseases and concluded that patients with DSPL have variations of sagittal alignment such as greater PI, less global LL, and increased PT. Lumbar slippage in the DSPL populations increases tendency to lose lordosis, resulting in a significant anterior displacement of the center of gravity and pelvis back tilt, which accommodates an increased flexion moment applied to the spine (**Fig. 5**, patient 2).

Compared with lumbar fusion and other fixed spinopelvic alignment, DSPL populations demonstrated flexible mo-

bility of the pelvis with a much wider range through which adaptation can occur. In the sitting position, the sagittal imbalance, which is clearly compensated for by the pelvic back tilt, is due not only to increased lumbar kyphosis [28], but also to the stiff arthritic hip joint [21], so less change will occur in the seated movement arc, although there may still be significant impingement based on the original imbalance. The phenomena of more hip flexion and insufficient backward tilt of the pelvis in patients with fixed spinopelvic alignment [29] would not occur in patients with DSPL. Therefore, in this study, there was no significant difference in the measurement parameters between the control patients with pelvic retroversion due to hip arthritis and the patients with DSPL in the sitting position.

Spine deformity has consequence on sagittal balance of the coxofemoral joint in standing position and its extension capacity, especially for pelvic retroversion, which increases cup inclination and anteversion, leading to edge loading or impingement [30]. Despite the

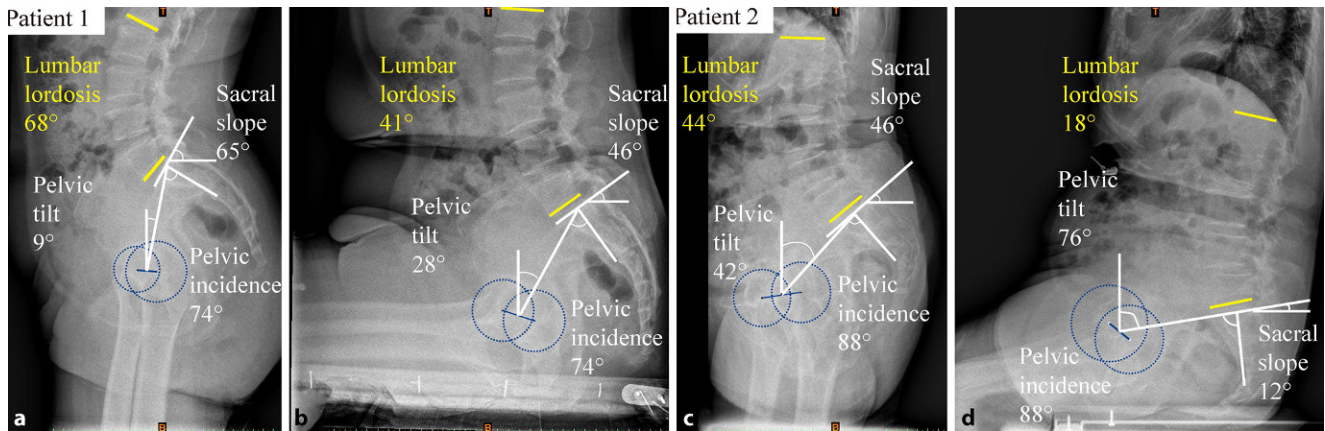


Fig. 5 ▲ Lateral radiographs of the pelvis of patient 1 without spine arthrosis before total hip arthroplasty: **a** standing, **b** seated; preoperative **c** standing and **d** seated lateral radiographs of patient 2 with degenerative spondylolisthesis of the fifth lumbar vertebra

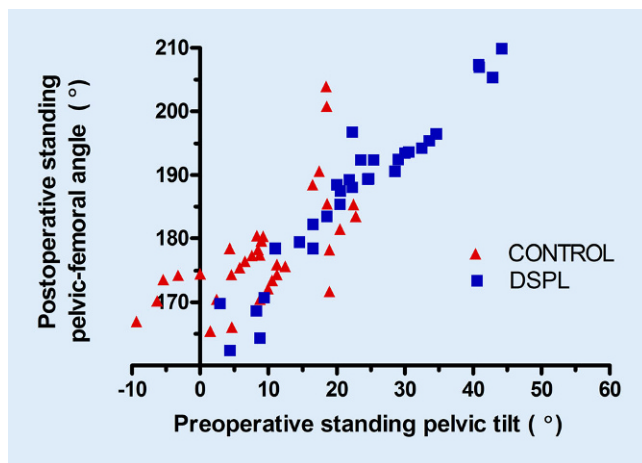


Fig. 6 ▲ The scatter plot shows a positive correlation between preoperative standing pelvic tilt and postoperative standing pelvic-femoral angle (THA) in control patients ($R^2 = 0.6176$) with normal spines and in patients with DSPL ($R^2 = 0.9180$). *DSPL* degenerative lumbar spondylolisthesis

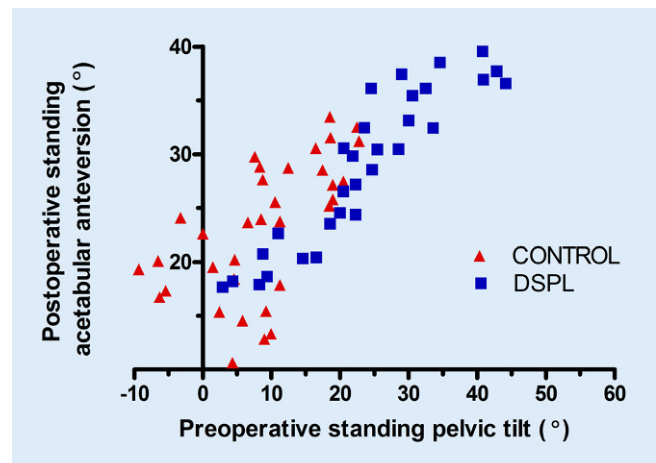


Fig. 7 ▲ The scatter plot shows a positive linear correlation between preoperative standing pelvic tilt and postoperative standing acetabular anteversion in (THA) control patients with normal spines ($R^2 = 0.6872$) and in patients with DSPL ($R^2 = 0.8416$). *DSPL* degenerative lumbar spondylolisthesis

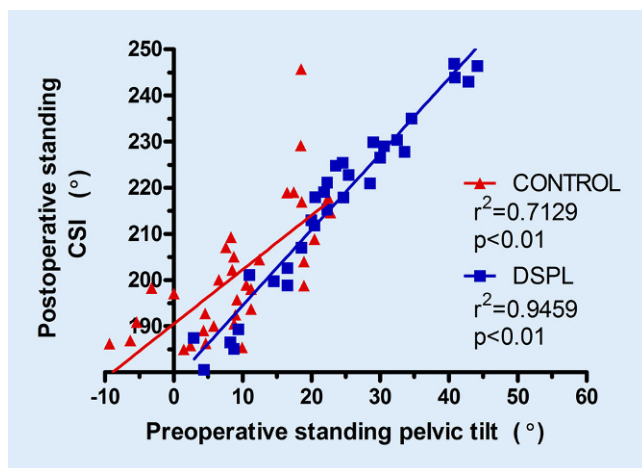


Fig. 8 ▲ The scatter plot shows a positive linear correlation between preoperative standing pelvic tilt and postoperative standing CSI (THA) in control patients ($R^2 = 0.7129$) with normal spines and in patients with DSPL ($R^2 = 0.9459$). *DSPL* degenerative lumbar spondylolisthesis, *CSI* combined sagittal index

improvement in hip stiffness after THA, patients with DSPL while standing still kept a higher PT ($p < 0.01$) than control patients (Fig. 9). THA helped restore the hip anatomy, resulting in a clearer trajectory of the acetabular component and lumbar-pelvic-femoral movement. With back tilt of the pelvis, our study found that postoperative standing AA and PFA of the patients with DSPL increased ($p < 0.05$), and there was increased likelihood of posterior hip impingement with maximum hip extension.

The validation of the correlation between the combined sagittal index (CSI), which defined the functional safe zone [6], and dislocation is given in the study by Heckmann et al. [1] in which 90% of

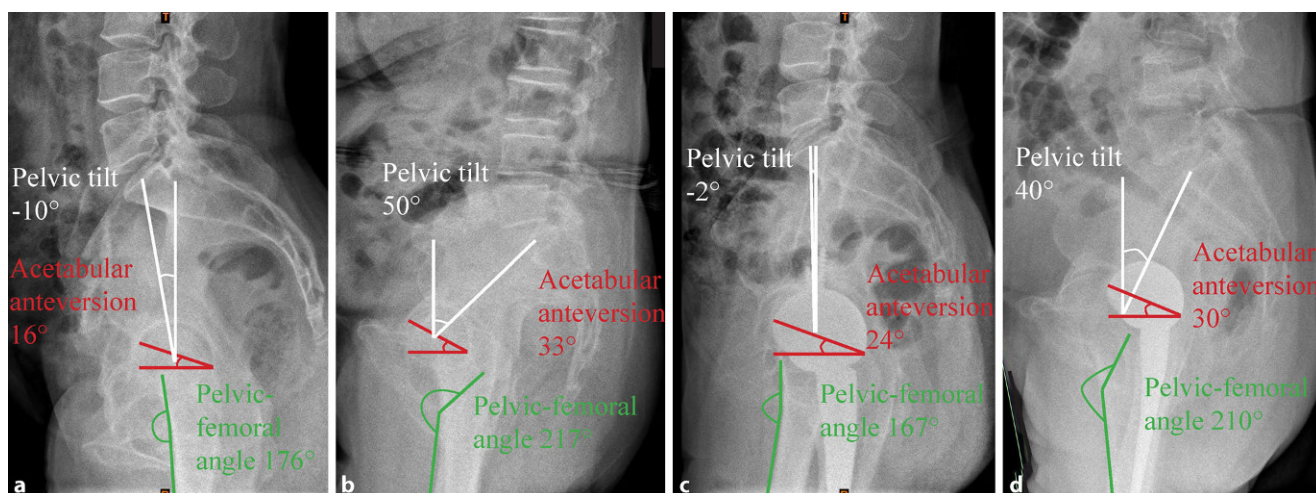


Fig. 9 ▲ Standing lateral radiographs of the pelvis of a 48-year-old male without spinal arthrosis: **a** preoperative, **c** postoperative; standing lateral radiographs of the pelvis of a 74-year-old female with degenerative spondylolisthesis of the first sacral vertebra: **b** preoperative, **d** postoperative

patients had the outliers of CSI associated with late dislocation. Our study found that the variation in the trend of postoperative standing CSI was more significant in patients with DSPL, among which 5 patients with CSI outliers (including only abnormal standing femoral position or abnormal acetabular position for standing CSI outliers) accounted for 16.13%, and 1 patient in the control patients accounted for 2.94%. In addition, we also found that there were positive correlations in both of the two study groups between preoperative standing PT and postoperative standing AA and PFA, of which the patients with DSPL, whose preoperative standing PT and PFA were higher, were more significant than those of the control patients. For patients with DSPL, preoperative posterior PT due to lumbar spondylolisthesis was associated with decreased coverage of the femoral head by the acetabular component and increased hip extension after surgery. Therefore, the patients with DSPL were more likely to develop the potential risk of anterior dislocation due to posterior impingement during hip extension.

The risk of impingement of the patients in standing position is relevant to the daily activities. A previous study [31] in a THA patient population has shown that anatomic AA increased 7.5° from the supine to standing positions, and the PFA had higher values in the standing position. When moving from

sitting to standing, an acetabulum with normal mobility is able to cover approximately 15° [6] of anteversion, while the DSPL patients is about 29° of anteversion in our study; however, the risk of posterior impingement in standing position does not decrease due to the pelvis back tilt and femoral hyperextension of DSPL patients. In addition, potential posterior impingement often occurs while the patients are walking or getting in or out of bed [15]. It is necessary to include standing and sitting lateral spine-pelvic-hip radiographs (from thoracolumbar junction to the distal femur) that may predict the risk and direction of impingement into a standardized preoperative diagnostic pathway. Based on these radiographs, the sagittal change influenced by positioning in the DSPL patient with excessive AA and PFA can be visualized. Therefore, orthopedic doctors need to carry out education of daily activities for patients to avoid greater physical activity and poor posture, strengthen the training of dorsal lumbar muscles and decrease loads on the lumbar spine.

Phan et al. [24] summarized the current research on the influence of sagittal spinal deformity on AA during THA, and divided patients into four patterns. In this study, the patients with DSPL, with a potential increase in extension of hip and an increased AA during standing, belong to a flexible and unbalanced type whose abnormal pelvic parameters

are $PT > 25^\circ$ and $PI-LL > 10^\circ$. Phan et al. concluded that there are two preoperative treatment options for the management of the flexible and unbalanced type. Patients who have abnormal lumbopelvic parameters should preferentially consider adjustment for spinal realignment. Patients with DSPL with lumbar instability should be converted to the rigid and balanced orientation by fusion surgery in a balanced position that puts the acetabulum in a more predictable position before THA. The other possible option is to proceed with THA, in which placement of the acetabular component of patients with DSPL should be more retroverted to help correct the relative AA, especially when standing. This decreased anteversion compensates for a greater extension arc of the hips to decrease the likelihood of impingement and dislocation. It is worth noting that there is a risk of revision THA to accommodate the acetabular cup reorientation if patients with DSPL undergo spinal surgery following THA.

Although a retrospective cohort study was conducted to regulate the accuracy of data collection and measurement as much as possible, limitations still exist in this study. First, the follow-up time was short, and none of the patients in this study experienced hip dislocation at the 6-month follow-up. Although we did not correlate measurements with clinical outcomes, we are following these patients for complications, including dislocation, to

Abbreviations	
AA	Acetabular anteversion
AI	Ante-inclination
BMI	Body mass index
CSI	Combined sagittal index
DSPL	Degenerative lumbar spondylolisthesis
ICC	Intraclass correlation coefficient
IRB	Institutional review board
LL	Lumbar lordosis
PFA	Pelvic-femoral angle
PI	Pelvic incidence
PT	Pelvic tilt
SS	Sacral slope
THA	Total hip arthroplasty

identify those at high risk of instability in combination with postoperative imaging parameters. Second, most patients in our study also had contralateral hip arthritis to different degrees, which affected the study results because osteoarthritis of the hip restricted pelvic mobility as it was defined earlier. Moreover, the sample size was small, and we need more patients to demonstrate the reliability of our conclusions. Finally, although static imaging in standing and sitting may not fully replicate the patient's pelvic orientation during activities of daily living, it was of referential significance as the most common position for hip dislocation [32], and previous studies used the same method [13, 14, 20]. Despite these limitations in the present study, we tried to conduct a retrospective observational cohort study and demonstrated that DSPL can affect hip stability, and more attention should be paid to the risk of dislocation caused by the increase of AA in the postoperative standing position. We are looking forward to maximum samples and multicenter prospective controlled trials, which may better characterize this relationship in outliers, as well as the possible effects on stability after THA.

Conclusion

The mechanism by which patients with DSPL achieve a standing posture is different from those with a normal spine, with more hip extension and posterior tilt of the pelvis. The imbalance of the seated sagittal plane in patients with DSPL is usually insignificant and compensable, but more attention should be paid to the risk of impingement caused by the increase of AA in the postoperative standing position.

Corresponding address

Eryou Feng, MD, PhD

Department of Arthroscopy Surgery, Fuzhou Second Hospital Affiliated to Xiamen University No. 47, Shangteng Road, Cangshan District, Fuzhou, China
fey9001@126.com

Author Contribution. All co-authors actively participated in this study and have read and approved the final manuscript.

Compliance with ethical guidelines

Conflict of interest. K. Shen, L. Lin, E. Feng, Y. Zhang, L. Xiao, F. Lin and Z. Li declare that they have no competing interests.

Ethical standards. All procedures performed in studies involving human participants or on human tissue were in accordance with the ethical standards of the institutional and/or national research committee and with the 1975 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Committee of Fuzhou Second Hospital affiliated to Xiamen University. Written informed consent was obtained from all patients enrolled in the investigation.

References

- Heckmann N, McKnight B, Stefl M, Trasolini NA, Ike H, Dorr LD (2018) Late dislocation following total hip arthroplasty: spinopelvic imbalance as a causative factor. *J Bone Joint Surg Am* 100(21):1845–1853
- Buckland AJ, Ayres EW, Shimmin AJ, Bare JV, McMahon SJ, Vigdorichik JM (2020) Prevalence of sagittal spinal deformity among patients undergoing total hip arthroplasty. *J Arthroplasty* 35(1):160–165
- Ellenrieder M, Bader R, Bergschmidt P, Frohlich S, Mittelmeier W (2015) Coexistent lumbar spine disorders have a crucial impact on the clinical outcome after total hip replacement. *J Orthop Sci* 20(6):1046–1052

- Lewinnek GE, Lewis JL, Tarr R, Compere CL, Zimmerman JR (1978) Dislocations after total hip-replacement arthroplasties. *J Bone Joint Surg Am* 60(2):217–220
- DeSole EM, Vigdorichik JM, Schwarzkopf R, Errico TJ, Buckland AJ (2017) Total hip arthroplasty in the spinal deformity population: does degree of sagittal deformity affect rates of safe zone placement, instability, or revision? *J Arthroplasty* 32(6):1910–1917
- Tezuka T, Heckmann ND, Bodner RJ, Dorr LD (2019) 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* 34(1):3–8
- He LC, Wang YX, Gong JS, Griffith JF, Zeng XJ, Kwok AW, Leung JC, Kwok T, Ahuja AT, Leung PC (2014) Prevalence and risk factors of lumbar spondylolisthesis in elderly Chinese men and women. *Eur Radiol* 24(2):441–448
- Warashina H, Kato M, Kitamura S, Kusano T, Hasegawa Y (2019) The progression of osteoarthritis of the hip increases degenerative lumbar spondylolisthesis and causes the change of spinopelvic alignment. *J Orthop* 16(4):275–279
- Sasagawa T, Nakamura T (2016) Associated factors for lumbar degenerative spondylolisthesis in Japanese patients with osteoarthritis of the hip: a radiographic study. *Asian Spine J* 10(5):935–939
- Blizzard DJ, Sheets CZ, Seyler TM, Penrose CT, Klement MR, Gallizzi MA, Brown CR (2017) The impact of lumbar spine disease and deformity on total hip arthroplasty outcomes. *Orthopedics* 40(3):e520–e525
- Malkani AL, Garber AT, Ong KL, Dimar JR, Baykal D, Glassman SD, Cochran AR, Berry DJ (2018) Total hip arthroplasty in patients with previous lumbar fusion surgery: are there more dislocations and revisions? *J Arthroplasty* 33(4):1189–1193
- Buckland AJ, Puvanesarajah V, Vigdorichik J, Schwarzkopf R, Jain A, Klineberg EO, Hart RA, Callaghan JJ, Hassanzadeh H (2017) Dislocation of a primary total hip arthroplasty is more common in patients with a lumbar spinal fusion. *Bone Joint J* 99-B(5):585–591
- Esposito CI, Miller TT, Kim HJ, Barlow BT, Wright TM, Padgett DE, Jerabek SA, Mayman DJ (2016) Does degenerative lumbar spine disease influence femoroacetabular flexion in patients undergoing total hip arthroplasty? *Clin Orthop Relat Res* 474(8):1788–1797
- Berliner JL, Esposito CI, Miller TT, Padgett DE, Mayman DJ, Jerabek SA (2018) What preoperative factors predict postoperative sitting pelvic position one year following total hip arthroplasty? *Bone Joint J* 100-B(10):1289–1296
- Luthringer TA, Vigdorichik JM (2019) A preoperative workup of a “hip-spine” total hip arthroplasty patient: a simplified approach to a complex problem. *J Arthroplasty* 34(7S):S57–S70
- Sultan AA, Khlopas A, Piuze NS, Chughtai M, Sodhi N, Mont MA (2018) The impact of Spinopelvic alignment on total hip arthroplasty outcomes: a critical analysis of current evidence. *J Arthroplasty* 33(5):1606–1616
- Queally JM, Abdulkarim A, Mulhall KJ (2009) Total hip replacement in patients with neurological conditions. *J Bone Joint Surg Br* 91(10):1267–1273
- Wagner ER, Kamath AF, Fruth KM, Harsen WS, Berry DJ (2016) Effect of body mass index on complications and reoperations after total hip arthroplasty. *J Bone Joint Surg Am* 98(3):169–179
- Koslosky E, Gendelberg D (2020) Classification in Brief: The Meyerding Classification System

- of Spondylolisthesis. Clin Orthop Relat Res 478(5):1125–1130
20. Lazennec JY, Brusson A, Rousseau MA (2013) Lumbar-pelvic-femoral balance on sitting and standing lateral radiographs. Orthop Traumatol Surg Res 99(1 Suppl):S87–103
 21. Lee SH, Lim CW, Choi KY, Jo S (2019) Effect of spine-pelvis relationship in total hip arthroplasty. Hip Pelvis 31(1):4–10
 22. Schwab FJ, Blondel B, Bess S, Hostin R, Shaffrey CI, Smith JS, Boachie-Adjei O, Burton DC, Akbarnia BA, Mundis GM, Ames CP, Kebaish K, Hart RA, Farcy JP, Lafage V, International Spine Study G (2013) Radiographical spinopelvic parameters and disability in the setting of adult spinal deformity: a prospective multicenter analysis. Spine 38(13):E803–E812
 23. Stefl M, Lundergan W, Heckmann N, McKnight B, Ike H, Murgai R, Dorr LD (2017) Spinopelvic mobility and acetabular component position for total hip arthroplasty. Bone Joint J 99-B(1 Suppl A):37–45
 24. Phan D, Bederman SS, Schwarzkopf R (2015) The influence of sagittal spinal deformity on anteversion of the acetabular component in total hip arthroplasty. Bone Joint J 97-B(8):1017–1023
 25. Kanawade V, Dorr LD, Wan Z (2014) Predictability of acetabular component angular change with postural shift from standing to sitting position. J Bone Joint Surg Am 96(12):978–986
 26. Koo TK, Li MY (2016) A guideline of selecting and reporting Intraclass correlation coefficients for reliability research. J Chiropr Med 15(2):155–163
 27. Barrey C, Jund J, Noseda O, Roussouly P (2007) Sagittal balance of the pelvis-spine complex and lumbar degenerative diseases. A comparative study about 85 cases. Eur Spine J 16(9):1459–1467
 28. Kobayashi H, Endo K, Sawaji Y, Matsuoka Y, Nishimura H, Murata K, Takamatsu T, Suzuki H, Aihara T, Yamamoto K (2019) Global sagittal spinal alignment in patients with degenerative low-grade lumbar spondylolisthesis. J Orthop Surg 27(3):2309499019885190
 29. Esposito CI, Carroll KM, Sculco PK, Padgett DE, Jerabek SA, Mayman DJ (2018) Total hip arthroplasty patients with fixed Spinopelvic alignment are at higher risk of hip dislocation. J Arthroplasty 33(5):1449–1454
 30. Lazennec JY, Brusson A, Folinais D, Zhang A, Pour AE, Rousseau MA (2015) Measuring extension of the lumbar-pelvic-femoral complex with the EOS(R) system. Eur J Orthop Surg Traumatol 25(6):1061–1068
 31. Eddine TA, Migaud H, Chantelot C, Cotten A, Fontaine C, Duquennoy A (2001) Variations of pelvic anteversion in the lying and standing positions: analysis of 24 control subjects and implications for CT measurement of position of a prosthetic cup. Surg Radiol Anat 23(2):105–110
 32. Sierra RJ, Raposo JM, Trousdale RT, Cabanela ME (2005) Dislocation of primary THA done through a posterolateral approach in the elderly. Clin Orthop Relat Res 441:262–267

Entscheidungsassistenz

Eine Brücke auf dem Weg zur Einwilligungsfähigkeit von Menschen mit Demenz in medizinische Maßnahmen

DGGG/DGPPN/DGN (Hrsg.)

Einwilligung von Menschen mit Demenz in medizinische Maßnahmen

Interdisziplinäre S2k-Leitlinie für die medizinische Praxis



Kohlhammer

Die 2020 veröffentlichte Interdisziplinäre Leitlinie „Einwilligung von Menschen mit Demenz in medizinische Maßnahmen“ [1] und die 2021 hierzu in der *Zeitschrift für Gerontologie+Geriatric* CME-validierte Fortbildung [2] zeigen einen strukturierten Handlungspfad mit dem Ziel, die Selbstbestimmung des Menschen mit Demenz möglichst lange zu erhalten.

Die Diagnose einer Demenz kann und darf nicht mit Unfähigkeit zur Einwilligung gleichgesetzt werden. Die Entscheidung des Patienten für eine medizinische Maßnahme muss auf einer informierten Einwilligung beruhen. Die Voraussetzungen hierfür sind:

1. Informationsvermittlung
2. Informationsverständnis
3. freie Entscheidung
4. Einwilligungsfähigkeit

Bestehen Zweifel an der Einwilligungsfähigkeit und somit an der Bestimmbarkeit des Willens eines Menschen mit Demenz, muss die Einwilligungsfähigkeit im Sinne eines klinischen Urteils valide geprüft werden:

1. Informationsverständnis
2. Einsicht in die Krankheit und die Notwendigkeit der Behandlung
3. Urteilsvermögen
4. Kommunizieren einer Entscheidung

Die Synthese dieser vier Felder ergibt die Bestimmbarkeit des Willens.

Erscheint die Einwilligungsfähigkeit des Gegenübers in einen medizinischen Eingriff nach valider Prüfung nicht oder nicht sicher gegeben, kann durch Herbeiführen einer so genannten Entscheidungsassistenz unter Umständen eine Einwilligungsfähigkeit erreicht werden.

Entscheidungsassistenz ließe sich als einen empathisch wertschätzenden individualisierten Prozess im Konzept des ärztlichen Aufklärungsgesprächs in räumlicher, sozialer und dinglicher Kontextgestaltung definieren: eine ruhige Atmosphäre ohne störende Einflüsse, eine den Besonderheiten der Demenz und etwaigen weiteren Beeinträchtigungen der betreffenden Person angepasste Form der Kommunikation, vor allem das Sehen und das Hören betreffend, gegebenenfalls unter Hinzunahme notwendiger Hilfen und Hilfsmittel, ein klare und einfache bis hin zur leichten Sprache, bei Bedarf eine zusätzliche schriftliche Information, gegebenenfalls auch Anwesenheit einer Begleitperson. Fazit: Auch wenn nicht in allen Fällen bei betroffenen Personen eine Einwilligungsfähigkeit erreicht werden kann, so kann doch mithilfe dieses Konzeptes zwischen einer eher zustimmenden und einer eher ablehnenden Haltung („assent“ versus „dissent“) differenziert werden.

Literatur

[1] DGGG/DGPPN/DGN (Hrsg.) (2020) Einwilligung von Menschen mit Demenz in medizinische Maßnahmen, Interdisziplinäre S2k-Leitlinie für die medizinische Praxis (AWMF-Leitlinie Registriernummer 108-001), 1. Auflage, W. Kohlhammer GmbH, Stuttgart; www.awmf.org/leitlinien/detail/II/108-001.html

[2] Haberstroh J, Tesky VA, Pantel J (2021) Einwilligungsfähigkeit von Menschen mit Demenz, Einblicke in die S2k-AWMF-Leitlinie 108-001. Z Gerontol Geriat 54:167-175; doi.org/10.1007/s00391-020-01820-4

Korrespondenzadresse:

Dr. Udo Hennighausen
Augenarzt, Anerkennung Geriatrie
Jürgen-Töpfer-Straße 10
22763 Hamburg
E-Mail: Udo.Hennighausen@web.de

Hier steht eine Anzeige.

