Pelvic Sagittal Rotation in Patients With Hip Joint Disease

haizhao wu (✉ wuhz@enzemed.com)

Taizhou Hospital of Zhejiang Province

zhongyi chen

Taizhou Hospital of Zhejiang Province

shouli wang

Taizhou Hospital of Zhejiang Province

zhong zhu

Taizhou Hospital of Zhejiang Province

jiajing ye

Taizhou Hospital of Zhejiang Province

Research Article

Keywords: spine-pelvic sagittal parameters, hip arthropathy surgery

Posted Date: June 7th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-557872/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Objective: The functional orientation of the acetabular cup depends on the pelvic orientation when standing. Therefore, predicting the standing orientation of the pelvis after total hip arthroplasty(THA)is important to the preoperative plan. This study aimed to explore the rule suitable for different categories of patients.

Methods: A total of 262 patients who had undergone hip arthroplasty in our hospital from 2011 to 2019 were retrospectively analyzed. Based on the spine and hip joint, they were divided into 5 categories: no flexion contracture of the hip joint - good lumbar range of motion (group A); no flexion contracture of the hip joint - limited lumbar motion (group B: B1, tanterior pelvic plane tilt (APPt) $>0^{\circ}$; B2, APPt $<0^{\circ}$); hip flexion contracture - good lumbar range of motion (group C); and hip flexion contracture - limited lumbar motion (group D). Changes of the pelvic sagittal parameter before and after THA were analyzed.

Results: In group A, there was no significant difference in pelvic incidence (PI) and sagittal vertical axia (SVA) between preoperation and postoperation ($P>0.05$), but the mean value of sacral slope (SS) (from 44.99° to 40.50°), lumbar lordosis(LL) (from 51.42 to 47.45), pelvic tilt (PT) (from 8.71° to 11.91°), and tanterior pelvic plane tilt (APPt) (from 4.5° to 1.27°) had statistic difference ($P<0.05$); In group B1 and B2, PI, SVA, SS, PT, LL, and APPt had no significant difference before and after operation ($P>0.05$); In group C, significant difference was not observed in PI ($P>0.05$), but found ($P<0.05$) in LL (from 52.17° to 43.43°), SS(44.90° to 38.34°), PT (from 5.70° to 13.36°), APPt (from 9.18° to 2.18°), and SVA (from 3.46cm to 1.16cm). In group D: the pelvis was in supination state before and after operation, and the spine sagittal position was imbalanced. Neither was there significant difference in SVA, PI, SVA, SS, ll and APPt between preoperation and postoperation ($P>0.05$). In addition, Harris scores of different groups changed accordingly.

Conclusion: The sagittal rotation of the pelvis caused by different conditions of the spine-hip has a certain change law after total hip arthroplasty.

Introduction

Spine disease and hip disease are common today, and tend to coexist, thus making a new challenge of clinical diagnosis and treatment.

On one hand, the doctor has difficulty in determining some symptoms related to the spine or the hip. On the other hand, the body needs each of the segments cooperating to maintain the balance, including the spine, hip, knee, ankle joint, etc. There, the matter in one part, as well as the muscles and ligaments in other parts should be adjusted to maintain the mechanical balance. As the extension of the spine, the pelvis plays a connecting role. Both spine disease and hip disease can cause pelvic rotation. For hip arthroplasty, pelvic rotation may significantly change the orientation of acetabular prosthesis.

Since Lewinnek^[1] proposed the concept of "safe triangle area" in 1978, safe triangle has become the gold standard for the placement of total hip arthroplasty (THA). However, clinical evidence shows that dislocation still occurs after THA, even if the acetabulum is placed in the safe triangle^[2]. Although many factors lead to dislocation after THA, more and more studies have shown that abnormal rotation of the pelvis in sagittal position is an important reason for the late dislocation after THA. Phan et al. found that it would increase the risk of anterior impact and posterior dislocation of the artificial hip if the pelvis does not rotate normally from standing to sitting position^[3]. However, considering that standing is a common position, it is essential to study the stability of hip prosthesis in that position. Currently, few studies are available in this area. Some scholars have proposed that the standing spine-pelvis X-ray is particularly critical at the preoperative stage. When installing acetabulum prosthesis, the preoperative coronal plane, i.e. functional pelvic plane (FPP), should be referred to, rather than the inherent anterior pelvic plane (APP). Nevertheless, after THA, the deformity of the hip joint has been corrected, the relatively normal hip joint reconstructed, and the pain of the hip relieved. Also, the functional posture would be changed, the new spinal pelvic sagittal balance re-established, and the position of pelvis in the sagittal plane changed. Therefore, we believe that the pelvic position after THA is the real bearing state of the prosthesis, and also that the angle of the acetabulum prosthesis is the functional angle when standing and walking. Because the standing position is the daily functional position of patients, it is more appropriate to refer to the postoperative sagittal position of the spine pelvis.

Pelvic sagittal rotation change rules before and after hip surgery can therefore be used to predict the postoperative sagittal state of the spine-pelvis in different patients, which helps make a better preoperative plan for surgeons^[4-6]. To date, there are few studies in this area, and some reports now available have different results. All this makes it necessary to classify and analyze these patients to explore some rules.

Patients And Methods

Inclusion criteria:

From 2011 to 2019, the patients were mainly diagnosed with osteonecrosis of the femoral head (stage IV), osteoarthritis of the hip (stage III and IV), developmental dysplasia of the hip (DDH) with osteoarthritis, ankylosing osteoarthritis involving the hip, and rheumatoid arthritis involving the hip. They had complete data (the lumbar dynamic position film, full-length film of the spine before and 3 months after operation, Harris score, a clear evaluation of the hip and lumbar function). These patients were all operated by the same group of doctors, with posterolateral approach and postoperative treatment method being the same.

Exclusion criteria:

Neurological or musculoskeletal diseases or diseases that may have adverse effects on pelvic positioning; femoral neck fracture; surgical complications, such as periprosthetic fracture or nerve palsy after operation; patients with bilateral hip joint disease receiving only one side surgery and having grade

III or IV DDH; patients less than three months after hip replacement (spine and pelvis parameters were not measured on the postoperative day).

A total of 262 patients were included in this study: 69 cases of hip osteoarthritis, 59 cases of femoral head necrosis with osteoarthritis, 91 cases of hip dysplasia with osteoarthritis, 15 cases of rheumatoid arthritis involving the hip, and 28 cases of ankylosing spondylitis, of whom 114 were males and 148 females. The shortest course of disease was 15 months, and the longest 120 months, with an average of 35.2 ± 12.6 months. Significant difference was not identified in age, sex ratio and body mass index (BMI) among the five groups, but observed not only in the course of disease among the five groups but also between group A and other groups. (Table 1)

Surgical technique and postoperative rehabilitation

Lateral position, the posterior approach, the biological acetabulum prosthesis, the biological femoral stem with anteversion angle of 10° to 15° were adopted. During the operation, the posterior joint capsule and external rotator muscles were repaired strictly.

Rivaroxaban and physical prevention of thrombosis were taken 12 hours after operation. To prevent infection, antibiotics were injected once before operation, once on the day after operation and once on the first day after operation. Nonsteroidal anti-inflammatory and analgesic drugs were used routinely. On the afternoon of the first day after operation, walking and functional exercise were carried out with the assistance of walkers.

Radiographic evaluation

Method: In addition to routine examination, all patients underwent standing anteroposterior and lateral position films of the whole spine before and after operation, and lumbar dynamic films were taken before operation. *Position requisition:* hip and knee joints were fully extended and elbow joint was fully flexed, with two fists in the same side of the clavicle position.

Measurement:

All parameters: lumbar lordosis(LL), pelvic incidence (PI), pelvic tilt(PT), sacral slope(SS), anterior pelvic plane tilt(APPt),sagittal vertical axia (SVA) (Figures 1, 2) were measured on PACS system by three groups of experienced orthopedic doctors (double blind method, mean values recorded, before and three months after operation).

Flexion contracture: inability of hip joint to extend completely. In this study, residual flexion contracture refers to the angle $>15^\circ$.

Limited range of motion of lumbar spine refers to Δ ss of lumbar spine $<20^\circ$ in the dynamic radiograph.

The patients were divided into 5 groups according to the range of motion (ROM) of hip joint and spinal deformity: no flexion contracture of hip joint with good ROM of lumbar (group A); no flexion contracture

of hip joint with limited ROM of lumbar (group B, B1:APPt $> 0^{\circ}$; B2: APPt $< 0^{\circ}$); flexion contracture of hip joint with good ROM of lumbar (group C); and flexion contracture of hip joint with limited ROM of lumbar (group D) .

Harris score before and after operation: the hip function was evaluated by 10 items including pain, function, deformity, and range of motion, etc.

Statistical analysis:

Statistical data were analyzed using SPSS version 22.0. The age, course of disease, weight and course of disease of the two groups were analyzed by ANOVA; the spine pelvic parameters and Harris score before and after operation were analyzed by t test; and the gender ratio of the five groups was tested by chi square test. $P < 0.05$ was statistically significant.

Results

The parameters of pelvic sagittal rotation in group A (Table 2): there was no significant difference in PI and SVA before and after operation, and the mean value of SS changed from 44.8° preoperatively to 40.5° postoperatively, PT from 8.7° to 11.8° , LL from 51.6° to 47.5° , and APPT from 4.3° to 1.3° , all being significantly different. No significant difference was identified in PI, SVA, SS, PT and APP before and after operation in groups B1 and B2 (Table 3.4). In group C (Table 5), significant difference was not found in PI before and after operation, while there were significant differences in LL from 50.8° before operation to 42.2° after operation, with the mean value of SS changing from 46.2° to 40.0° , PT from 9.1° to 12.3° , APPT from 10° to 2.1° , and SVA from 3.5° to 1.2° , all suggestive of significant difference. In group D (Table 6), the parameters of pelvic sagittal rotation: the pelvis was in a backward rotation state and the spine in imbalance state before and after operation, and the changes of SVA, PI, SVA, SS, LL and APPT before and after operation had no significant difference.

Harris score was used to evaluate the pain, function, deformity and ROM of the hip. In group A (Table 7), the Harris score increased significantly (with significant difference) from preoperation to postoperation, mainly in the relief of pain and improvement of function (with significant difference), but there was no significant difference in deformity and ROM. In group B1 (Table 8), the Harris score also increased significantly (with significant difference), mainly in the relief of pain and improvement of function (with significant difference), while there was no significant difference in deformity and ROM. The Harris score of group B2 (Table 9) was also improved (with significant difference), the main reason for which was the relief of pain and the improvement of function (with statistical difference), and there was no statistical difference in deformity and ROM. In group C (Table 10), the Harris score grew significantly (with significant difference), and also there were significant differences in pain, deformity, function and range of motion. Similarly, the Harris score of group D (Table 11) was improved (with significant difference), also mainly due to the reduction of pain (with significant difference) and the improved function, but no statistical difference was observed in deformity and ROM. Among the five groups (Table 12), there were significant differences in the total score and each sub-item of the five groups: the total score was the

smallest in group D but the largest in group C; the functional score was the smallest in group D but the largest in group C; the deformity and activity were the smallest in group D but the largest in group C; and the pain score was the smallest in groups C and D (there was no statistical difference between the two groups) but the largest in group B .

Discussion

Pelvis is called pelvic vertebra. The upper part of the pelvis forms the base of the spine via the sacrum, and the lower part connects the lower limbs through the hip joint. It is an important structure for the connection between the spine and the lower limbs. The dysfunction caused by spine and hip joint diseases often leads to the rotation of the pelvis. For patients with THA, the pelvis is the carrier of acetabular prosthesis, which also rotates along with the rotation of pelvis. Therefore, the situation of spine-pelvis-hip of patients with THA needs to be paid attention to, so as to avoid joint dislocation and reduce the edge loading ^[7-10].

1. Findings of previous studies regarding the sagittal rotation of pelvis before and after THA

According to Kamilevazov et al., there was no difference between the preoperative pelvic spinal sagittal parameters in 28 cases of hip arthropathy with spinal deformity and those of postoperation^[11]. However, the patients' posture was significantly improved, and the low back pain was also significantly relieved. Weng et al. divided the patients with hip joint disease into two groups with or without low back pain, and found significant difference in pelvic spinal sagittal parameter of the patients^[5]. Digioia et al. reported the preoperative and postoperative pelvic tilt of 84 patients with THA: the average preoperative pelvic tilt in standing position was $1.2 \pm 7.9^\circ$; the mean postoperative pelvic tilt was $1.1 \pm 8.2^\circ$. Although there was no statistical significance in the overall change of pelvic tilt, the authors pointed out that there were some individuals whose pelvic tilt was more than 10 degrees^[12]. Parrate et al. used gait analysis method to study the pelvic tilt of 21 patients before and after operation, and found that the change scope of pelvic tilt of higher than 37% patients before and 1 year after operation was more than 5 degrees, that of 11% patients was more than 10 degrees, and more than 20 degrees in some individuals^[13]. A 5-year follow-up study by Suzuki et al. of 77 patients with DDH who had undergone unilateral total hip arthroplasty after surgery showed that compared with preoperation, the pelvis tilted backward after THA; the average pelvic tilt was 8-20 degrees; and the maximum tilt angle was 25 degrees^[14]. The results of these studies were different, which may be related to the different samples. If patients are not divided into groups reasonably, it has little value for clinical guidance.

2. Grouping of patients

As Phan et al^[3] reported, patients may fall into four categories according to the relationship between spine-pelvis mobility and sagittal plane balance: first, good mobility (flexibility) and balance; second, poor mobility (stiffness) but balance; third, good mobility (flexibility) but imbalance; fourth, poor mobility (stiffness) and imbalance. They also applied the categorization to guide the angle of acetabular

prosthesis installation. This method focused on the rotation of the pelvis from standing position to sitting position. Hironori et al. ^[15] by dividing patients with hip arthropathy into three categories: preoperative sagittal balance-postoperative balance group, preoperative sagittal imbalance-postoperative balance group, and preoperative sagittal imbalance-postoperative imbalance group, pointed out that preoperative sagittal imbalance-postoperative imbalance group had poor outcome. This classification method focused on the effect of spinal pelvic sagittal balance on surgical outcomes.

Both literature reports and our own clinical findings, pelvic sagittal rotation is affected by spine and hip joint. Therefore, classification of patients based on spinal function and hip joint flexion contracture, and rules of pelvic sagittal rotation before and after operation would provide better reference for preoperative plan. Severe hip osteoarthritis reportedly increases lumbar lordosis, pelvic anteversion, and low back pain. The reason may lie behind the protective anteversion of the pelvis, which is caused by hip pain. Some authors assume that the flexion contracture of hip joint could contribute to compensatory flexion of lumbar vertebrae, and then cause the pelvis to tilt forward. Because of the reduced hip joint pain and improved hip joint function, the pelvis can return to a neutral position or slightly anteroposterior position after operation. Therefore, in our study, in addition to spinal deformity and stiffness, we also considered the influencing factor of the hip joint, thus dividing the patients into five groups. Given that the flexion contracture of the hip less than 15° is often easily compensated by the lumbar spine, in this study, the patients with flexion contracture greater than 15° were included in the flexion contracture group. For the range of motion of lumbar, Dorr team ^[16] regarded the change of sacral tilt angle above 35° as high range of motion, below 20° as stiffness, and 20° to 35° as normal. We divided the patients into five groups: group A: no flexion contracture of hip joint - good motive lumbar; group B: no flexion contracture of hip joint - limited motive lumbar (B1, APt > 0°; B2, APt < 0°); group C: flexion contracture of hip joint - good motive lumbar; and group D: flexion contracture of hip joint - poor motive lumbar.

3. Changes of sagittal parameters of spine pelvis in different follow-up times after THA.

The sagittal parameter of spine pelvis varies with follow-up time after THA. The follow-up of Taki et al. ^[17] revealed that the pelvic sagittal plane tilt of patients after THA changed year by year, the change range of pelvic tilt was the largest one year after THA, and the plateau stage appeared one year later. However, some authors considered it was 3 months after operation ^[18, 19]. Similar results were found in our clinical observation. Additionally, this time was good for patients to comply with.

4. Changes of pelvic sagittal rotation before and after operation in five groups

Group A: no flexion contracture of hip joint - good motive lumbar

Most of the patients developed osteonecrosis of the femoral head, DDH with osteoarthritis and hip osteoarthritis. The course of disease was relatively short and the patients were relatively young. The patients complained of hip pain, but the dynamic films showed, spine balance and no stiffness. Three months after operation, LL? and SS decreased, PT increased, and APPT gradually approached to 0°. For

such patients, the changes of spine-pelvis sagittal parameters before operation resulted from hip pain, making the patients have protective pelvic anteversion, which is consistent with the literature report^[20].

Group B: no flexion contracture of hip joint – limit motive lumbar (B1, APPT> 0 °; B2, APPT<0 °)

Most of the patients in this group were diagnosed with femoral head necrosis, DDH with osteoarthritis, primary hip osteoarthritis as well, often accompanied by low back pain, or lumbar surgery history. They were subdivided according to the direction of pelvic tilt. For patients with pelvic anteversion (B1), preoperative mild pelvic anteversion may be related to hip pain, that is, preoperative hip pain caused pelvic protective anteversion. However, due to the limited range of motion of the lumbar spine, the compensatory anteversion of the pelvis was also limited, and thus the pelvic anteversion of these patients was relatively small. With the gradual relief of hip pain after surgery, the anteversion of pelvis could gradually decrease. However, in our study, there was no significant difference between preoperative and postoperative parameters. We also found that about 15% of the patients had more than 10° after operation. The reason may be related to the degree of lumbar motion limitation. For this reason, we will further collect samples to explore the relationship between lumbar ROM and pelvic tilt. In patients with pelvic retroversion (B2), the kyphosis deformities, or the limitation of lumbar flexion and thoracic vertebra extension (flat back deformity) cannot compensate for the sagittal imbalance of the spine, causing the pelvis to be retroverted. Because only a small change was made to the pelvic retroversion even after surgery, sagittal imbalance of the spine was difficult to be corrected.

Group C: flexion contracture of hip joint - good motive lumbar

Hip flexion contracture can bring about abnormal sagittal parameters of spine- pelvis, which has been extensively recognized. However, it is also generally accepted that hip flexion contracture can lead to pelvic pronation^[21], and some authors contend that patients with hip flexion contracture have pelvic supination changes^[22]. Our observation showed that patients with pelvic retroversion were usually accompanied by stiff spine, and the patients without stiff spine often had anteversion pelvis. The patients with larger flexion contracture (> 30 °) often contracted sagittal imbalance of spine, for the lumbar flexion cannot fully compensate for the hip flexion contracture. For such patients, together with the recovery of hip motion, the anteversion of the pelvis was significantly improved, PT was reduced, APPT was close to 0°, and SVA was close to normal. This is called pseudo- imbalance by some scholars^[15].

Group D: flexion contracture of hip joint -pool motive lumbar

Hip arthroplasty can restore the hip rom, but cannot change the original deformity and stiffness of the spine, causing relatively poor outcome in patients, especially when ankylosing spondylitis involves the spine and hip. Such patients of ours had small SS, large PT, small LL, APP retroversion and SVA imbalance before operation. There was less improvement of pelvic retroversion after operation, and the spine was still in imbalance. The reason may be that the spine and pelvis were completely rigid.

5. Functional outcomes in different groups

We also used the Harris score to investigate the functions of these patients before and after surgery.

For group A patients, the outcome after THA was good, and clinical results showed that Harris score was significantly improved. It might be because the matter of the patients is due to the hip, and the course of disease was short. After THA, the pain gradually disappeared and the function improved.

For group B1, in addition to the pathological changes of hip joint, there was limited lumbar ROM, and some patients underwent lumbar fusion, but the sagittal position of the spine was in a balanced state, so the patients' satisfaction was also higher. However, the Harris score was lower than that of group A, and the patients could not put on socks and shoelaces themselves, which may be related to the limited ROM of the lumbar and pelvis.

For group B2, the patients often had flat back deformity, and some patients were in an imbalance state in sagittal position of spine. They failed to restore their balance after THA, and needed to bend the knee to compensate. Therefore, the gait and function of the patients were poor.

Speaking of Group C patients with hip flexion contracture, although there was sagittal imbalance of the spine, no obvious deformity and stiffness of the spine were observed. The imbalance was due to the excessive flexion contracture of the hip, leading the lumbar flexion not to fully compensate, and the barycentre of the body to be still in front of the foot support area. This imbalance is usually called "false imbalance". After THA, the flexion contracture of the hip joint was relieved, and the spine was restored to balance. Harris score improved greatly and patients' satisfaction was higher, which is consistent with the literature reports^[15].

Most of group D patients had ankylosing spondylitis involving the hip and spine. To maintain the balance of the body, the pelvis will be backward, and the knee joint will be flexed. Patients' hip and spine are mostly stiff. Hip arthroplasty can improve the function of hip joint, but it cannot change the imbalance of spine. The improvement of Harris score was relatively small in our study.

Conclusions

According to the function of the spine hip joint and spine in patients with hip arthropathy, this study shows that the sagittal rotation of the pelvis before and after THA surgery has some rules, which may help guide the installation of artificial hip prosthesis. It can also be used to predict the satisfaction of patients after operation.

The limitations of this study: 1.The sample size Small. 2. long-term follow-up study is warranted. 3. There is a possibility that the changes of pelvic sagittal rotation before and after operation may be affected by other factors. 4. Some cases cannot be included in the five categories of this study.

Abbreviations

THA	total hip arthroplasty
DDH	developmental dysplasia of the hip
BMI	body mass index
ROM	range of motion
LL	lumbar lordosis
PI	pelvic incidence
PT	pelvic tilt
SS	sacral slope
APP	anterior pelvic plane
APPt	anterior pelvic plane tilt
FPP	functional pelvic plane
SVA	sagittal vertical axis

Declarations

Availability of data and materials

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgements

Thanks to Professor Wang Xuming for his contribution to the statistical analysis of this study.

Funding

None

Authors' information

Department of Orthopaedics, Taizhou Hospital of Zhejiang Province, Taizhou, Zhejiang, 317000, China

Hai-zhao WU, Zhong-yi CHEN, Shou-li WANG, Zhong ZHU, Jia-jing YE

Contributions

Project administration Hai-zhao WU Zhong-yi CHEN, Investigation and measurement Shou-li WANG Zhong ZHU Jia-jing YE Hai-zhao WU Writing original draft preparation Hai-zhao WU .The authors read and approved the final manuscript

Corresponding author

Correspondence to Hai-zhao WU;Email:wuhz@enzemed.com

Ethics approval and consent to participate

Each author certifies that the institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

Competing interests

The authors declare no competing interests.

References

1. Lewinnek GE, Lewis JL, Tarr R, Compere CL, Zimmerman JR: **Dislocations after total hip-replacement arthroplasties.** *The Journal of bone and joint surgery American volume* 1978, **60**(2):217-220.
2. 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.
3. Phan D, Bederman SS, Schwarzkopf R: **The influence of sagittal spinal deformity on anteversion of the acetabular component in total hip arthroplasty.** *Bone Joint J* 2015, **97-B**(8):1017-1023.
4. 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.
5. Weng W, Wu H, Wu M, Zhu Y, Qiu Y, Wang W: **The effect of total hip arthroplasty on sagittal spinal-pelvic-leg alignment and low back pain in patients with severe hip osteoarthritis.** *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2016, **25**(11):3608-3614.
6. Radcliff KE, Orozco F, Molby N, Delasotta L, Chen E, Post Z, Ong A: **Change in spinal alignment after total hip arthroplasty.** *Orthop Surg* 2013, **5**(4):261-265.
7. Rutherford M, O'Connor JD, Gill HS, Hill J, Beverland D, Lennon AB, Dunne NJ: **Operative and radiographic acetabular component orientation in total hip replacement: Influence of pelvic orientation and surgical positioning technique.** *Med Eng Phys* 2019, **64**:7-14.

8. Blizzard DJ, Nickel BT, Seyler TM, Bolognesi MP: **The Impact of Lumbar Spine Disease and Deformity on Total Hip Arthroplasty Outcomes.** *The Orthopedic clinics of North America* 2016, **47**(1):19-28.
9. Luthringer TA, Vigdorchik JM: **A Preoperative Workup of a "Hip-Spine" Total Hip Arthroplasty Patient: A Simplified Approach to a Complex Problem.** *J Arthroplasty* 2019, **34**(7S):S57-S70.
10. Diebo BG, Beyer GA, Grieco PW, Liu S, Day LM, Abraham R, Naziri Q, Passias PG, Maheshwari AV, Paulino CB: **Complications in Patients Undergoing Spinal Fusion After THA.** *Clin Orthop Relat Res* 2018, **476**(2):412-417.
11. Eyvazov K, Eyvazov B, Basar S, Nasto LA, Kanatli U: **Effects of total hip arthroplasty on spinal sagittal alignment and static balance: a prospective study on 28 patients.** *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2016, **25**(11):3615-3621.
12. Digioia AM, 3rd, Jaramaz B, Plakseychuk AY, Moody JE, Jr., Nikou C, Labarca RS, Levison TJ, Picard F: **Comparison of a mechanical acetabular alignment guide with computer placement of the socket.** *J Arthroplasty* 2002, **17**(3):359-364.
13. Parratte S, Pagnano MW, Coleman-Wood K, Kaufman KR, Berry DJ: **The 2008 Frank Stinchfield award: variation in postoperative pelvic tilt may confound the accuracy of hip navigation systems.** *Clin Orthop Relat Res* 2009, **467**(1):43-49.
14. Suzuki H, Inaba Y, Kobayashi N, Ishida T, Ike H, Saito T: **Postural and Chronological Change in Pelvic Tilt Five Years After Total Hip Arthroplasty in Patients With Developmental Dysplasia of the Hip: A Three-Dimensional Analysis.** *J Arthroplasty* 2016, **31**(1):317-322.
15. Ochi H, Homma Y, Baba T, Nojiri H, Matsumoto M, Kaneko K: **Sagittal spinopelvic alignment predicts hip function after total hip arthroplasty.** *Gait Posture* 2017, **52**:293-300.
16. Kanawade V, Dorr LD, Wan Z: **Predictability of Acetabular Component Angular Change with Postural Shift from Standing to Sitting Position.** *The Journal of bone and joint surgery American volume* 2014, **96**(12):978-986.
17. Taki N, Mitsugi N, Mochida Y, Akamatsu Y, Saito T: **Change in pelvic tilt angle 2 to 4 years after total hip arthroplasty.** *J Arthroplasty* 2012, **27**(6):940-944.
18. Tiberi JV, 3rd, Antoci V, Malchau H, Rubash HE, Freiberg AA, Kwon YM: **What is the Fate of Total Hip Arthroplasty (THA) Acetabular Component Orientation When Evaluated in the Standing Position?** *J Arthroplasty* 2015, **30**(9):1555-1560.
19. Barry JJ, Sing DC, Vail TP, Hansen EN: **Early Outcomes of Primary Total Hip Arthroplasty After Prior Lumbar Spinal Fusion.** *J Arthroplasty* 2017, **32**(2):470-474.
20. Weng WJ, Wang WJ, Wu MD, Xu ZH, Xu LL, Qiu Y: **Characteristics of sagittal spine-pelvis-leg alignment in patients with severe hip osteoarthritis.** *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2015, **24**(6):1228-1236.

21. Riviere C, Lazic S, Dagneaux L, Van Der Straeten C, Cobb J, Muirhead-Allwood S: **Spine-hip relations in patients with hip osteoarthritis.** *EFORT Open Rev* 2018, **3**(2):39-44.
22. Sariali E, Lazennec JY, Khiami F, Gorin M, Catonne Y: **Modification of pelvic orientation after total hip replacement in primary osteoarthritis.** *Hip Int* 2009, **19**(3):257-263.

Tables

Table 1. Comparison of age, sex ratio, BMI index and course of disease among 5 groups of patients

group	Age(y)	Gender(M/F)	BMI	course of disease
A(96)	58.0±6.2	43:53	25.7±6.3	28.1±9.0
B1(68)	59.3±8.1	30:38	26.3±8.6	33.6±11.8
B2(37)	57.6±9.5	16:21	25.8±6.9	34.8±12.0
C(33)	58.6±9.2	14:19	26.0±7.6	35.2±10.2
D(28)	62.3±7.5	11:17	26.7±8.0	38.4±12.3
F/c2	1.34	0.30	1.13	8.46
P	>0.05	>0.05	>0.05	<0.05

Table 2. Comparison of spinal pelvic parameters before and after operation in group A

group	PI	SS	PT	SVA(mm)	APPt	LL
preoperation	54.3±11.4	44.8±6.7	8.7±6.3	0.5±1.3	4.3±3.1	51.6±9.4
postoperation	54.6±11.2	40.5±6.3	11.8±6.0	0.4±1.2	1.3±1.2	47.5±8.2
t	0.38	1.87	1.84	0.51	3.01	2.01
P	>0.05	<0.05	<0.05	>0.05	<0.05	<0.05

Table 3. Comparison of spinal pelvic parameters before and after operation in group B1

group	PI	SS	PT	SVA(mm)	APPt	LL
preoperation	55.1±10.3	40.9±7.6	12.8±5.3	0.7±1.0	3.6±2.1	42.3±6.8
postoperation	54.3±10.7	39.9±6.9	13.1±4.7	0.6±1.2	3.0±1.3	41.3±5.2
t	0.45	0.48	0.44	0.44	0.50	0.53
P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Table 4. Comparison of spinal pelvic parameters before and after operation in group B2

group	PI	SS	PT	SVA(cm)	APPt	LL
preoperation	54.8±13.2	35.4±8.4	18.7±6.3	3.0±2.0	-10.1±5.2	37.8±6.8
postoperation	54.3±13.0	34.6±8.2	18.2±6.0	2.8±1.8	-8.1±5.0	36.9±6.6
t	0.35	0.32	0.40	0.48	0.56	0.43
P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Table 5. Comparison of spinal pelvic parameters before and after operation in group C

group	PI	SS	PT	SVA(cm)	APPt	LL
preoperation	55.6±12.1	46.2±6.1	9.1±6.4	3.5±1.0	10.0±3.3	50.8±10.2
postoperation	55.2±11.6	40.0±6.8	12.3±5.8	1.2±1.5	2.1±2.6	42.2±8.1
t	0.55	2.02	1.98	2.21	4.95	2.68
P	>0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Table 6. Comparison of spinal pelvic parameters before and after operation in group D

group	PI	SS	PT	SVA(mm)	APP	LL
preoperation	52.3±13.0	34.3±8.2	21.2±8.8	5.4±2.0	-18.8±6.5	30.2±7.3
postoperation	51.8±13.2	36.5±5.2	19.2±9.6	4.8±2.8	-16.3±8.1	28.6±8.1
t	0.49	0.52	0.55	0.38	0.46	0.58
P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Table 7. Comparison of Harris score before and after operation in group A

group	pain	deformity	ROM	function	Total score
preoperation	18.51±3.84	4.0±0.67	4.49±0.64	32.28±3.25	55.69±5.49
postoperation	38.01±6.80	4.0±0.46	4.79±0.72	40.08±4.28	86.32±8.56
t	3.29	0.18	0.29	2.01	2.84
P	<0.05	>0.05	>0.05	<0.05	<0.05

Table 8. Comparison of Harris score before and after operation in group B1

group	pain	deformity	ROM	function	Total score
preoperation	18.37±3.42	3.82±0.47	4.33±0.60	30.95±4.10	57.26±6.71
postoperation	38.69±7.91	3.97±0.68	4.64±0.66	37.26±4.57	82.64±9.47
t	3.37	0.26	0.30	1.92	2.31
P	<0.05	>0.05	>0.05	<0.05	<0.05

Table 9. Comparison of Harris score before and after operation in group B2

group	pain	deformity	ROM	function	Total score
poperation	17.57re±6.86	3.90±0.47	4.23±0.46	28.16±5.15	52.28±6.42
postoperation	38.45±8.63	3.93±0.62	4.64±0.68	33.56±6.38	76.64±8.32
t	3.29	0.38	0.31	1.96	2.09
P	<0.05	>0.05	>0.05	<0.05	<0.05

Table 10. Comparison of Harris score before and after operation in group C

group	pain	deformity	ROM	function	Total score
preoperation	23.30±5.76	1.82±0.32	2.63±0.28	18.92±4.17	44.28±6.04
postoperation	39.60±7.90	3.58±0.60	4.14±0.52	40.06±8.50	87.34±11.40
t	2.79	2.28	2.88	4.86	4.06
P	<0.05	<0.05	<0.05	<0.05	<0.05

Table 11. Comparison of Harris score before and after operation in group D

group	pain	deformity	ROM	function	Total score
preoperation	21.35±5.40	1.02±0.35	0.68±0.28	13.95±5.18	37.84±5.38
postoperation	36.88±9.91	3.28±0.68	2.84±0.57	18.86±3.74	60.64±10.40
t	2.80	2.43	2.98	1.97	2.36
P	<0.05	<0.05	<0.05	<0.05	<0.05

Figures

Figure 1

Schematic drawing of APt

Figure 3

group A, no flexion contracture of hip joint - good mobile lumbar, evident preoperative pelvic anteversion, and little postoperative pelvic anteversion, with APPT being close to 0°.

Figure 4

group B1, no flexion contracture of hip joint – limited mobile lumbar ($APPT > 0^{\circ}$), little pelvic rotation from preoperation to postoperation.

Figure 5

group B2, no flexion contracture of hip joint – limited mobile lumbar (B2, APPT < 0 °), pelvic retroversion, kyphosis deformities, and pelvis retroversion. Because only a small change was made to the pelvic retroversion even after surgery, sagittal imbalance of the spine was difficult to be corrected.

Figure 6

group C, flexion contracture of hip joint - good mobile lumbar; preoperative pelvis anteversion, sagittal spine imbalance, postoperation pelvis neutral position, and sagittal spine balance.

Figure 7

group D, flexion contracture of hip joint -poor mobile lumbar, preoperative sagittal imbalance of the spine and less improvement of pelvic retroversion after operation.