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Roles of Sagittal Anatomical Parameters of the Pelvis in Primary Total Hip Replacement for Patients with Ankylosing Spondylitis

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ABSTRACT

We examined the correlation between acetabular prostheses and sagittal anatomical parameters of the pelvis for the preoperative evaluation of total hip arthroplasty in 29 patients with ankylosing spondylitis between April 2004 and November 2011. No implant dislocation or subsidence was observed at 4.18 years. The relationship between sagittal parameters conformed to the equation Pelvic incidence (PI)=Pelvic tilt (PT)+Sacral slope (SS). Better outcomes were achieved in the SS>PT group, postoperative function was positively correlated with SS/PI. Functional abduction and anteversion were positively correlated with PT but negatively correlated with SS. Due to the compensatory changes in the pelvis and spine of patients with AS, the preoperative assessment of sagittal parameters plays pivotal roles in placing acetabular prostheses in optimal positions and preventing postoperative impingement and dislocation.

Ankylosing spondylitis (AS) is a common chronic and progressive inflammatory disease that primarily affects the thoracic spine, lumbosacral joints, and large joints near the trunk. The incidence of hip involvement is 25–50%, among which bilateral involvement accounts for 90% [1]. Hip joint lesions eventually lead to joint flexion contracture and stiffness, affecting patient joint function and quality of life. Total hip arthroplasty (THA) remains an optimal therapeutic strategy in the management of patients with AS and advanced hip joint lesions [2]. However, the balance among the vertebral column, pelvis, hips, and knees must be considered when performing THA in patients with AS. Although sagittal balancing of the trunk is used as a parameter for the spine, pelvis, hip, and knees and has attracted much attention and been studied in spinal surgery [3], its role in the field of joint surgery has not drawn adequate attention.

A preoperative analysis based on the sagittal plane is also needed by joint surgeons prior to performing THA in patients with AS. Due to the compensatory forward bending of the spine in these patients, pelvic retroversion will occur and thereby cause the hip to extend backward, resulting in hip impingement (including femoroacetabular impingement and/or impingement from osteophytes), which causes postoperative pain, accelerates implant wear, and possibly leads to compensatory knee flexion. Therefore, sagittal balance plays important roles in guiding and analyzing surgical strategies for hip surgery in patients with AS.

Between April 2004 and November 2011, 29 patients with AS (40 hip lesions) underwent THA in our institution. Of these patients, 24 (33 hip lesions) were followed up and achieved favorable outcomes. In the present study, a retrospective analysis was performed to analyze the correlation between sagittal parameters of the pelvis and the position of the acetabular prosthesis in THA and investigate the role of these parameters in THA for patients with AS.

Materials and Methods

General Information

A total of 29 patients (40 hip lesions) were eligible for treatment. Follow-up was conducted on 24 patients (33 hip lesions) with a follow-up rate of 82.76% for an average period of 4.18 ± 2.42 years (range, 1–8 years). Patients were all men with a mean age of 37.73 ± 9.24 years (range, 20–57 years) at surgery. Of these lesions, 17 hip lesions were on the left side and 16 were on the right side, and there were 15 cases of unilateral hip involvement and nine cases of bilateral involvement. Patients presented mainly with pain in the lumbar region and hip, significant limitations in standing and walking, kyphosis, and muscle atrophy. Physical examinations revealed flexion contracture and stiffness of the hip in all patients with a mean preoperative Harris Hip Score (HHS) of 43.83 ± 8.69 points. According to the American College of Rheumatology classification criteria, radiographic findings of the hips showed grade IV, among which 18 hips of 16 patients had developed ankylosis. All patients had a confirmed diagnosis of AS according

Abbreviations: AS, ankylosing spondylitis; THA, total hip arthroplasty; PI, pelvic incidence; PT, pelvic tilt; SS, sacral slope.

Conflict of Interest: None of the authors have any conflicts of interest or disclosures in relation to this work.

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Table 1
Patient Characteristics.

Parameters	Results
Patients (THAs)	29(40)
Patients (THAs) at final follow-up	24(33)
Male(%)	100
Follow-up periods (years) mean ± SD	4.18±2.42
Age when operation (years) mean ± SD	37.73±9.24
Average duration from onset (years) mean ± SD	12.65±5.47
Pre-operative HHS (points) mean ± SD	43.83±8.69
HHS at the last follow-up (points) mean ± SD	87.12 ± 9.54

THA=Total hip arthroplasty; HHS=Harris hip score.

to the 1984 modified New York criteria [4]. The average duration of the disease was 12.65 ± 5.47 years (range, 0.5–20 years) (Table 1). All patients had previously received non-steroidal anti-inflammatory medicine with poor outcomes. All had also undergone primary replacement with a metal-on-polyethylene interface and the implantation of biological acetabular prostheses, including uncemented prostheses (Smith & Nephew in 14 cases, Depuy in 16, and Zimmer in 2) used in 32 hips of 23 patients and cemented hip prosthesis (Link) in one hip of one patient.

Surgical Procedures

Under continuous epidural anesthesia combined with a subarachnoid block, the surgery was performed with each patient in the lateral decubitus position on the healthy side. A posterolateral approach was used to access the hip joint by resection of the femoral neck obliquely at 1 cm of the tip of the lesser trochanter of the femur, retrieval of the femoral head, and exposure of the acetabulum. The acetabular labrum and part of the joint capsule were resected followed by removal of the osteophytes. After acetabular reaming, the appropriate acetabular cup was selected and positioned at 45° abduction and 15° anteversion. The femoral bone marrow cavity was enlarged progressively for placement and stabilization of the femoral stem in 10° anteversion and implantation of the femoral head prosthesis at the appropriate length. After joint repositioning, the soft tissue tension, hip range of motion, and artificial joint stability were examined. The external rotators were repaired followed by sutured closure of the incision.

Postoperative Management

Patients received routine postoperative antibiotics and prophylatic treatment for deep vein thrombosis of the lower extremities, analgesics, and other symptomatic treatment. Patients were trained to perform rehabilitation exercises at 24–48 h postoperatively.

Analysis of Sagittal Parameters

Both pre- and postoperative hip functions were evaluated using HHS. Radiography of the full length of the lateral spine (covering full-length spine + pelvis + upper pelvis) or anterolateral view covering areas from L1 to the knee joint (including the spine from L1 to the lumbar spine + pelvis + hip + knee) were performed at follow-up. (1) Sagittal anatomical parameters (Fig. 1): Pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS) were measured. PI was defined as the angle between the line perpendicular to the sacral plate at its midpoint and the line connecting this point to the midpoint between the femoral heads. PT refers to the angle between the vertical plane and the line through the midpoint between the upper sacral endplate and the femoral head axis. SS was defined as the angle between the horizontal plane and the upper sacral endplate [5]. (2) Functional abduction and functional anteversion were obtained by examining standing anteroposterior pelvic radiographs. The functional anteversion was calculated using the formula arcsin = a/b proposed by McLaren [6]. (3) Loosening of the acetabular prosthesis and femoral prosthesis were assessed [7].

Statistical Analysis

All data were analyzed using SPSS statistical software version 17.0 (SPSS, Chicago, IL, USA). Data are presented as mean ± standard deviation. A paired t-test was performed to compare pre- and postoperative HHS. Differences between the SS>PT and SS<PT groups were compared using independent t-tests with values of $\alpha = 0.05$. The correlation between postoperative HHS and SS/PP was analyzed using Pearson correlation analysis. The correlations between various parameters, including the correlation of PT with the functional abduction and anteversion of the acetabulum as well as the correlation of SS with functional abduction and anteversion, were analyzed using Pearson correlation analysis. Values of $P < 0.05$ were considered statistically significant.

Results

Phase I incision healing was achieved in all patients without prosthetic dislocation, and no complications involving blood vessels, nerves, or deep vein thrombosis were observed. The follow-up study was conducted on 24 patients (33 hip lesions) with a follow-up rate of 82.76% for an average period of 4.18 ± 2.42 years (range, 1–8 years). Hip functions of all patients were significantly improved: Only one patient showed a moderate postoperative limp according to the gait analysis criteria of the American Association of Orthopedic Surgeons (AAOS), while the other patients had a normal gait. No implant dislocation or subsidence was observed at the last postoperative follow-up. The mean HHS at the last follow-up was 87.12 ± 9.54 points, significantly higher than the mean preoperative HHS of 43.83 ± 8.69 points ($t = 16.699$, $P = 0.000$) (Table 1).

The acetabular prostheses were positioned at 15.23–31.23° and 34–60° at anteversion and abduction, respectively. PI was at the range of 53.5–82°, SS at 28–61°, and PT at 17–48°. The relationship between the sagittal parameters of all patients conformed to the equation of PI = SS + PT. No significant differences were observed in preoperative HHS between the SS>PT and SS<PT groups (43.06 ± 9.43 vs. 45.89 ± 6.33) ($t = 0.828$, $P = 0.414$). However, the mean postoperative HHS of the SS>PT group (92.27 ± 4.41) was significantly different from that of the SS<PT group (73.39 ± 4.03) ($t = -11.196$, $P = 0.000$), indicating that better clinical efficacy was achieved in the SS>PT group (Table 2). Postoperative HHS was positively correlated with SS/PI with a Pearson correlation coefficient of 0.861 ($P = 0.000$). The functional abduction and anteversion of the acetabulum were positively correlated with PT with a Pearson correlation coefficient of 0.840 ($P = 0.000$) and 0.796 ($P = 0.000$), respectively, and negatively correlated with SS with a Pearson correlation coefficient of −0.354 ($P = 0.043$) and −0.664 ($P = 0.000$), respectively (Table 3). A power analysis has been performed with the equation of $Z_\beta = -Z_{a/2} + 1/2|\ln(\frac{1+\rho}{1-\rho})|\sqrt{n-3}$. The results are presented in Table 3.

Discussion

The balance of the body in the coronal and axial planes has drawn much attention from joint surgeons and considered key indicators for evaluating surgical success. However, using sagittal balance as parameters for evaluating the positions of the spine, pelvis, hip, and knees has not obtained sufficient attention in the field of joint surgery. The pelvic anatomical parameters in sagittal balance primarily consist of PI, PT, and SS, all of which play important roles in the evaluation of spinal morphology, the pelvis, hip, and knees as well as the force of gravity on the body. A close relationship among PI, PT, and SS had been reported by previous studies and was demonstrated in the present study to be PI = PT + SS, and this functional relationship has been reported to be similar in both men and women [8]. Previous studies have demonstrated that PI was within the range of 32–74°, PT in the range of 0–27°, and SS in the range of 24–55° [9], which is consistent with the results of the present study. The study of Mac-Thiong et al also showed that the non-