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Effects of types and degrees of ankylosing spondylitis hip structural damages on post-total hip arthroplasty outcome measurements

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Abstract

To determine the effects of ankylosing spondylitis (AS)-associated hip damages on the outcome measurements after total hip arthroplasty (THA).

The medical records of 122 patients with AS (181 hips) who underwent THA were retrospectively reviewed. The mean follow-up was 43.9 (32–129) months. The types and degrees of hip damages were evaluated by preoperative hip X-rays. The patients were grouped according to the satisfaction degree after the operation. Univariable and multivariable statistical analyses were conducted.

The intraclass correlation coefficients for the assessment between the 2 reviewers in the study were 0.86 to 0.97. Cox regression showed that femoral head erosion severity had an effect on the recovery time of independent walking without crutches postoperatively (odds ratio = 1.467, 95% confidence interval: 1.050–2.409, $P = .025$). The mean time to recover independent walking in the severe femoral head erosion group was 7.3 ± 0.9 weeks, which was 4.6 ± 0.4 weeks longer than in the non-severe femoral head erosion group, as confirmed by the log-rank (Mantel–Cox) test (Chi-squared = 11.684, $P = .001$). The multivariable analysis showed that higher acetabular sclerosis scores correlated with lower postoperative dissatisfaction risk (odds ratio = 0.322, 95% confidence interval: 0.136–0.764). The multiple linear regression analysis showed that postoperative range of motion (ROM) improvement was affected by preoperative ROM of the hip, space narrowing degree, and ceramic-ceramic material for the weight-bearing surface ($F = 179.81$, $P < .001$), with preoperative ROM of the hip having the greatest impact.

Severe femoral head erosion prolongs the recovery time of independent walking after THA. Acetabular sclerosis is not associated with poor outcomes in patients with AS-associated hip damage undergoing THA.

Abbreviations: AS = ankylosing spondylitis, BASRI-hip = Bath Ankylosing Spondylitis Radiology Hip Index, CI = confidence interval, CRP = C-reactive protein, OR = odds ratio, ROM = range of motion, THA = total hip arthroplasty.

Keywords: ankylosing spondylitis, hip, joint radiographic score, structural damage, total hip arthroplasty

1. Introduction

Ankylosing spondylitis (AS) is a chronic inflammatory rheumatic disorder mainly affecting the sacroiliac joint and spine. As the disease progresses, structural damage and activity limitations may occur in the affected areas. The hip is the most common extra-spinal joint involved in AS, and it is also the main cause of disability in patients with AS.[1–3] The proportion of hip involvement in patients with AS is as high as 20% to 40%, and that of patients undergoing hip replacement surgery due to severe hip disease is 5% to 8%, of which nearly half of patients undergo bilateral hip replacement surgery.[4] Hip involvement not only accounts for a high proportion of AS cases, but patients are also prone to disability, and this is worthy of attention by rheumatologists and orthopedic surgeons.

In the 2016 edition of the recommendations for the Assessment of Spondyloarthritis International Society and the European League Against Rheumatism for spinal arthritis treatment, patients with AS and severe hip involvement may be considered for total hip arthroplasty (THA).[5] It has been reported that THA for AS has shown good outcomes. Nevertheless, it may affect postoperative function improvement and patient satisfaction because of hip structural damages and biomechanical changes caused by AS.[6,7]

There are currently no clear definitions and criteria for AS hip damage,[4] which can be defined only by describing certain

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

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characteristics of hip involvement and can be determined by anamnesis, physical examination, and imaging.[4] The current radiographic definition based on the Bath Ankylosing Spondylitis Radiology Hip Index (BASRI-hip) is among the most common assessment methods for hip joints and is also the most widely used evaluation criterion for AS hip damages and structural changes.[4,8–10] Based on the radiographic changes of AS hip involvement and BASRI-hip criteria, we attempted to explore a new refined scoring criterion for hip damages to assess the radiographic severity of the AS hip involvement and to verify its reliability, convenience, and sensitivity to hip radiographic changes.[11] Our research draw lessons from the refined scoring and BASRI-hip criteria.

We aimed to assess AS hip damage using the graded refinement of acetabular erosion, femoral head erosion, bone sclerosis of the acetabulum, bone sclerosis of the femoral head, joint space narrowing, and acetabular protrusion. Based on this refinement evaluation method, we intended to determine which of those AS hip damages affect patient satisfaction and hip function improvement after THA and to predict which of the AS hip structural damages may be a poor prognostic factor after THA.

2. Methods

2.1. Study subjects

The medical records of 267 patients with AS who underwent THA in the orthopedic department of our hospital between January 2001 and December 2010 were collected. One hundred eighty-one cases (122 patients, 181 hips) met the following inclusion criteria:

(1) definitive diagnosis of AS according to the revised New York Standard (1984)[9];
(2) severe hip pain, limited mobility, and posture disorder;
(3) stable disease activity assessed preoperatively by rheumatologists and Bath Ankylosing Spondylitis Disease Activity Index ≤4;
(4) underwent unilateral THA; and
(5) at least 2-year follow-up records post-surgery. Among the 122 patients, 63 patients underwent THA in 1 stage, and 59 patients underwent THA in 2 stages.

The exclusion criteria were:

(1) tumor or hematological diseases;
(2) hip or systemic infections;
(3) severe medical complications;
(4) history of severe hip trauma or hip surgery;
(5) revision history of the contralateral hip for any cause; or
(6) incomplete follow-up data. This study protocol was approved by the institution's Ethics Committee (Approval No. 201904–07). Obtaining informed consent was not required.

General information, preoperative acute inflammatory markers (erythrocyte sedimentation rate, C-reactive protein [CRP]), preoperative joint function score (preoperative Harris score), preoperative hip passive range of motion (preoperative total ROM), preoperative hip X-ray, postoperative satisfaction, postoperative joint function score (postoperative Harris score), postoperative hip passive ROM (postoperative total ROM), and the recovery time of independent walking without crutches were recorded. Clinical and self-care ability assessments were performed at 1, 3, and 6 months and 1 year postoperatively, and then yearly. Patient satisfaction was assessed using a 4-point Likert scale for self-management (very satisfied, somewhat satisfied, somewhat dissatisfied, and very dissatisfied).[12,13] Then, the patients were divided into the following groups according to their postoperative satisfaction: satisfied (those who rated satisfaction as very satisfied) and dissatisfied (those who rated satisfaction as somewhat satisfied, somewhat dissatisfied, and very dissatisfied).

2.2. Study methods

The THA indications were unbearable severe pain, restricted movement and posture, and deformity. To control the effects of surgical factors on the outcomes, a conventional posterolateral approach was performed by the same joint surgeon team. All acetabular and femoral materials used in operation were cementless components. For the weight-bearing surface, ceramic-ceramic, ceramic-polyethylene, and metal-polyethylene materials were used in 96 (53.0%), 50 (27.6%), and 35 hips (19.3%), respectively.

The Harris hip score[14] and imaging score were given independently by 2 specialists who did not participate in the surgery. The Harris hip score was based on pain, function, deformity, and ROM assessments. On a 100-point scale, ≥90, 80 to 89, 70 to 79, and ≤70 were defined as very good, good, moderate, and poor, respectively. The preoperative hip X-ray films were simultaneously evaluated with the BASRI-hip[10] (0–4 points) and refinement scores.[11] In the BASRI-hip scoring system, AS hip involvement was classified into grades 0 to 4, mainly based on hip joint space. The AS hip damages in the hip X-ray were assessed separately according to the graded refinement of acetabular erosion, femoral head erosion, bone sclerosis of the acetabulum, bone sclerosis of the femoral head, joint space narrowing, and acetabular protrusion.

The acetabular protrusion was evaluated based on Sotelo Garza and Charnley's criteria[15] that considered the pelvic brim as the projection of the upper margin of the superior pubic ramus. The specific assessment methods are shown in Table 1 and Figures 1 and 2. Statistical analysis was performed on the mean of the scores given by the 2 specialists. The patients were also grouped according to the preoperative scores on the severity of femoral head erosion: severe group (those with severe femoral head erosion) and non-severe group (those with no, mild, and moderate femoral head erosion). Two authors (MSL and JXJ) independently reviewed the radiographs before THA and at last follow-up, with a third author (HZY) adjudicating any discrepancies between the reads of the other 2 authors. The reviewers were blinded to the surgery of THA.

Total passive ROM of the diseased hip, which was the sum of degrees of hip flexion, extension, abduction, adduction, internal rotation, and external rotation, was recorded before surgery and during follow-up. Pre- and postoperative total ROM changes were calculated as the difference between the 2 measured values on both sides. Hip ankylosis was defined as complete loss of hip movement on physical examination.[16]

2.3. Statistical analysis

Continuous variables with a normal distribution were presented as means with standard deviations and analyzed with the

Table 1

The refinement scores of the preoperative hip X-ray films (unilateral).

Bone erosion (on the acetabular surface and femoral head were evaluated separately)
Absence of bone erosion, defined as "no";
Rough articular surface, blurred cortical bone, and no cortical bone discontinuity, defined as "mild";
Significant articular surface erosion, articular surface discontinuity, and cortical bone defect, defined as "moderate";
Morphological changes on the articular surface in addition to obvious cortical bone erosion, defined as "severe."
Bone sclerosis and new osteon formation (the femoral head and the acetabulum were evaluated separately)
1. on the acetabular side:
Normal cortical bone on the articular surface without obvious increase in density, defined as "no,"
The thickened cortical bone on the articular surface with an increase in density or a sharpened edge of the acetabulum, defined as "yes";
2. on the femoral head side:
Normal cortical bone on the lateral or medial margin of the femoral head without obvious increase in density, defined as "no,"
The thickened cortical bone on the lateral or medial margin of the femoral head with an increased density, defined as "mild,"
Bone sclerosis of the lateral and medial sides of the femoral head, and a "collar" formation or apparently isolated osteophytes at the femoral head-neck junction, defined as "severe."
Joint space narrowing
No abnormal changes in the superior and axial joint space, defined as "none";
The superior or axial joint space narrowing $\geq$2 mm and <4 mm, defined as "mild";
The superior or axial joint space narrowing<2 mm, defined as "severe."
Acetabular protrusion
The medial margin of the femoral head that did not go beyond the ilioischial line, defined as "none";
The medial margin of the femoral head that went beyond the ilioischial line but not the iliopubic line, defined as "mild";
The medial margin of the femoral head that went beyond the iliopubic line, defined as "severe."

2-independent-sample *t* test. Continuous variables with a non-normal distribution were presented as medians with quartiles (25%–75%) and analyzed with the Wilcoxon signed-rank test. Categorical variables were presented as percentages and frequencies and analyzed with the Chi-squared test. Intraclass correlation coefficientsICCs were calculated to assess the inter-rater reliability and to measure agreement between reviewers.

Univariable analyses were performed on dichotomous variables using the independent sample *t* test or the Mann–Whitney *U* and Chi-squared tests to evaluate whether each variable of interest was related to subjective and objective evaluation indexes after THA.

The post-THA subjective evaluation was based on patient satisfaction, and a logistic regression model was used to evaluate the risk factors that were selected in the evaluation. The possible preoperative baseline influencing factors were screened according to univariable analysis, then selected through clinical analysis. Post-THA objective evaluation was based on postoperative total passive ROM change of hip to verify whether the dependent variable, namely ROM change of hip, had a normal distribution, and in the case of a normal distribution, a multivariable linear regression model was used to evaluate the possible risk factors identified in the analysis. Abandoning crutches postoperatively was defined as the outcome event. Interaction items (such as degree of space narrowing × acetabular erosion, degree of space narrowing × femoral head erosion, acetabular sclerosis × acetabular erosion, and femoral head sclerosis × femoral head erosion) were tried in the model, using the stepwise method. Cox regression analysis was performed based on the time to abandoning crutches to analyze its influencing factors, and the Kaplan–Meier curve was generated. Baseline indicators were screened using univariable analysis, and possible factors with $P < .01$ and basic demographic information were included as independent variables for multivariable analysis (stepwise method). The odds ratio (OR) within a 95% confidence interval (CI) and associated *P*-value were determined. All reported *P*-values were 2-tailed with an alpha value of .05. Data analysis was performed using SPSS 23.0 (SPSS Inc., Chicago, IL), with $P < .05$ indicating a significant difference.

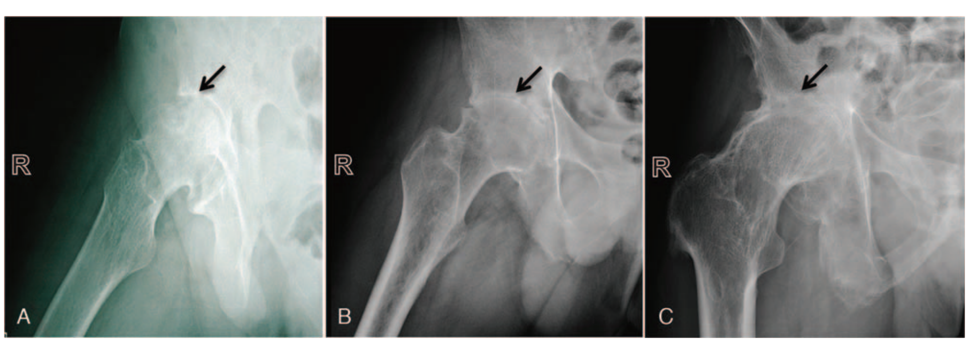

Figure 1. Acetabular erosion (X-ray). (A) X-ray revealing rough articular surface, blurred cortical bone, and no cortical bone discontinuity on the acetabular surface, defined as "mild." (B) X-ray revealing significant articular surface erosion, articular surface discontinuity, and cortical bone defect on the acetabular surface, defined as "moderate." (C) X-ray revealing morphological changes on the articular surface in addition to obvious cortical bone erosion on the acetabular surface, defined as "severe."

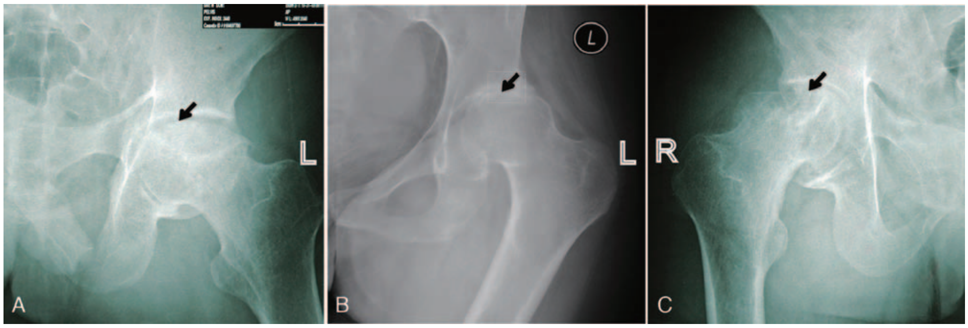

Figure 2. Femoral head erosion (X-ray). (A) X-ray revealing rough articular surface, blurred cortical bone, and no cortical bone discontinuity on the femoral head, defined as "mild." (b) X-ray revealing significant articular surface erosion, articular surface discontinuity, and cortical bone defect on the femoral head, defined as "moderate." (C) X-ray revealing morphological changes on the articular surface in addition to obvious cortical bone erosion on the femoral head, defined as "severe."

3. Results

3.1. General information

Regarding postoperative satisfaction, 94 patients were very satisfied, 77 patients were somewhat satisfied, 10 patients were somewhat dissatisfied, and 0 patient was very dissatisfied. Therefore, and 87 patients were not very satisfied. The main reasons for not being very satisfied were postoperative pain, limited mobility, and unequal leg length. The mean follow-up period was 43.9 months (32–129 months).

There were no significant differences in sex, age at onset, age at fusion, age at surgery, the interval of treatment, the interval of fusion, body mass index, preoperative total passive ROM of the hip, preoperative inflammatory markers (erythrocyte sedimentation rate and CRP), and preoperative Harris and BASRI-hip scores between the satisfied and dissatisfied groups. There were no differences in demographic information, disease course, and preoperative indicators between the 2 groups, with stable and comparable baseline data. In acetabular sclerosis, the satisfied group had a significantly higher score than the dissatisfied group ($P=.005$). In joint space narrowing, the dissatisfied group had a significantly higher score ($P=.003$). The Intraclass correlation coefficients for the assessment between the 2 reviewers in the study were 0.86 to 0.97. The material selection for the weight-bearing surface also differed between the 2 groups ($P=.029$) (Table 2).

3.2. Complications

Postoperative complications included 2 cases of dislocation, 1 periprosthetic femur fracture, 2 cases of iatrogenic sciatic nerve injuries, and 42 cases of heterotopic ossification.

3.3. Multivariable analysis of the subjective assessment of postoperative satisfaction

The results of the logistic regression analysis showed that acetabular sclerosis and joint space narrowing were associated with poor satisfaction after THA ($P=.01$) (Table 3). Patients with acetabular sclerosis had low postoperative dissatisfaction risk (OR, 0.322; 95% CI: 0.136–0.764). The more severe the degree of narrowing, the more likely the postoperative dissatisfaction (OR: 4.509; 95% CI: 1.438–14.137). Sex, age, acetabular erosion, femoral head erosion, femoral head sclerosis, preoperative fusion status, preoperative total ROM, preoperative CRP, material selection for weight-bearing surface, and femoral head prosthesis diameter had no effects on postoperative satisfaction.

3.4. Multivariable analysis of the objective assessment of postoperative hip ROM improvement

Postoperative hip ROM improvement is among the important indicators for evaluating surgery. An objective index of hip ROM improvement was obtained by calculating the post- and preoperative total passive ROM of the hip. Postoperative ROM improved to $165.69° \pm 4.24°$. The results of the multiple linear regression analysis, with postoperative ROM as the dependent variable, showed that the postoperative hip ROM improvement was affected by the preoperative total passive ROM, degree of space narrowing, and C-C material for the weight-bearing surface ($F=179.81$, $P<.001$), whereas the other variables had no effects on it (Table 4). The preoperative total passive ROM of the hip had the greatest impact on postoperative ROM improvement. The R^2 value ($R^2=0.768$) indicated that the 3 independent variables accounted for 76.8% of the dependent variable variation, indicating that the model was well fitted. Supplementary Table S1, http://links.lww.com/MD/F180 shows that none of the interaction terms (such as degree of space narrowing × acetabular erosion, degree of space narrowing × femoral head erosion, acetabular sclerosis × acetabular erosion, and femoral head sclerosis × femoral head erosion) were associated with postoperative ROM.

3.5. Survival analysis of the time to recover independent walking without crutches

The cumulative percentage of patients who could walk independently without crutches at 6 months postoperatively was 96%, with the mean and medians time of 5.66 ± 0.44 and 3.98 ± 0.11 weeks, respectively.

3.6. Multi-Factor analysis of the recovery time of independent walking without crutches

The multivariable Cox proportional hazard regression analysis showed that the severity of femoral head erosion had an effect on the recovery time of independent walking without crutches (relative risk, RR=1.467, 95% CI 1.050–2.409, $P=.025$),

Table 2

Baseline characteristics of the patients.

Clinical features	All patients N = 181	Postoperative satisfaction grouping: Satisfactory (n = 94)	Dissatisfactory (n = 87)	P value
Male, n,%	146 (80.7)	80 (84.2)	66 (76.7)	.218
Age at surgery, $\bar{x} \pm s$	36.08±11.67	35.85±11.28	36.48±12.13	.799
Disease course, x±s	14.49±9.82	14.00±8.06	15.15±11.46	.855
Age at onset, x±s	21.51±8.42	21.71±8.90	21.23±7.97	.905
Age at fusion, $\bar{x} \pm s$	28.20±8.05	28.33±7.91	28.22±8.26	.925
Interval of fusion, x±s	6.49±6.94	4.92±4.19	7.94±8.52	.384
BMI, x±s	22.45±4.57	22.52±5.04	22.38±4.04	.699
Preoperative total ROM, $\bar{x} \pm s$	35.17±53.78	39.52±51.90	30.81±53.83	.089
Preoperative CRP, $\bar{x} \pm s$	23.68±24.17	23.57±21.34	23.98±27.13	.149
Preoperative ESR,$\bar{x} \pm s$	29.56±23.92	31.09±24.51	28.14±23.33	.429
Acetabular erosion, x±s	2.61±0.54	2.53±0.60	2.68±0.47	.148
Femoral head erosion, x±s	2.23±0.79	2.23±0.74	2.29±0.75	.540
Acetabular sclerosis, x±s	0.81±0.37	0.88±0.32	0.75±0.39	.005*
Femoral head sclerosis, x±s	0.86±0.79	0.84±0.81	0.89±0.78	.591
Hip joint space narrowing, x±s	1.88±0.33	1.80±0.40	1.95±0.21	.003*
Acetabular protrusion, x±s	0.37±0.88	0.30±0.57	0.27±0.49	.988
Preoperative BASRI-hip score, x±s	3.47±0.53	3.41±0.54	3.52±0.53	.172
Preoperative hip fusion, n, %				.036a,*
No	75 (41.4)	46 (48.9)	29 (33.3)	
Yes	106 (58.6)	48 (51.1)	58 (66.7)	
Preoperative Harris score, x±s	18.16±13.46	18.10±11.19	18.22±15.63	.232
Materials for the weight-bearing surface, n, %				.029a,*
CC	96 (53.1)	55 (58.5)	41 (47.1)	
CPE	50 (27.6)	18 (19.1)	32 (36.8)	
MPE	35 (19.3)	21 (22.3)	14 (16.1)	
Diameter of the femoral head prosthesis, n, %				.071a
28 mm	108 (59.7)	50 (53.2)	58 (66.7)	
32 mm	73 (40.3)	44 (46.8)	29 (33.3)	

a Crosstabs (Kappa) Chi-squared test.

* $P<.05$.

BASRI-hip = Bath Ankylosing Spondylitis Radiology Hip Index score, BMI = body mass index, CC = ceramic-ceramic, CPE = ceramic-polyethylene, CRP = C-reactive protein, ESR = erythrocyte sedimentation rate, MPE = metal-polyethylene, ROM = range of motion.

whereas the other variables had no effects (Table 5). The recovery time of independent walking without crutches was 1.467 times longer when the degree of femoral head erosion was increased by 1 grade preoperatively.

3.7. Comparison of the recovery time of independent walking without crutches

The mean time to recover independent walking without crutches in the severe femoral head erosion group was 7.25±0.85 weeks, which was 4.57±0.43 weeks higher than that in the non-severe femoral head erosion group. The difference in the survival curves between the 2 groups was statistically significant. The time to abandoning crutches in the non-severe femoral head erosion group was shorter, confirmed by the Log Rank (Mantel–Cox) test (Chi-squared = 11.684, $P=.001$) (Fig. 3).

4. Discussion

Postoperative satisfaction was considered the core outcome measure of the postoperative therapeutic effect in this study for the following reasons. First, THA has an effect on pain and joint function recovery in patients with end-stage AS,[17–19] and patients with AS and without AS have similar postoperative THA complications and safety.[20] Second, many physicians pay attention to the patients' subjective feelings of satisfaction,[21,22] and patient satisfaction improvement is helpful to increase

Table 3

Logistic regression analysis of postoperative satisfaction.

	B	SE	Wald	P	Exp (B)	Exp (B) 95% CI Lower	Upper
Acetabular sclerosis	−1.134	0.441	6.605	.010*	0.322	0.136	0.764
Space narrowing	1.506	0.583	6.672	.010*	4.509	1.438	14.137

* $P<.05$.

CI = confidence interval, SE = standard error.

Table 4

Multiple linear regression analysis of postoperative hip range of motion improvement.

	B	SE	Beta	t	P
Constant	229.043	13.082		17.508	<.001*
Preoperative total ROM	−0.928	0.041	−0.878	−22.827	<.001*
Space narrowing	−20.194	6.629	−0.117	−3.046	.003*
Material CC	15.003	4.131	0.137	3.632	<.001*

* $P<.05$.

CC = ceramic-ceramic, ROM = range of motion, SE = standard error.

Table 5

Cox regression analysis of the time to abandoning crutches.

						Exp (B) 95% CI	
	B	SE	Wald	Sig.	Exp (B)	Lower	Upper
Femoral head erosion	0.383	0.171	5.037	0.025*	1.467	1.050	2.409

* $P < .05$.
CI = confidence interval, SE = standard error.

postoperative patient compliance.[23] Finally, our data showed that all patients had a long-term disease course (mean duration: 14.49±9.82 years). There were no differences in the age of onset, age of fusion, and age of surgery between the satisfactory and dissatisfactory groups, who had similar psychological factors.

X-ray evaluation of hip damages in patients with AS has been widely used with good stability and accuracy.[10,24,25] According to the refinement evaluation of AS hip structural damages, these were classified into erosion, sclerosis, space narrowing, and acetabular protrusion (axial displacement). Of these, both erosion and sclerosis were evaluated on the acetabular and femoral head surfaces, respectively. Many factors play a role in improving post-THA outcome measures, including patient, prosthetic design, surgical technique, and rehabilitation factors. To maximally control the impact of the surgery itself on the postoperative outcome measures, the same surgeon team, surgical procedure, and postoperative rehabilitation guidance were selected. With respect to the surgical prosthesis materials, both acetabular and femoral materials consisted of cementless components, and different interface materials and prosthetic femoral head diameters were included in the multivariable analysis. Multivariable analysis of satisfaction showed that patients with acetabular sclerosis had lower postoperative dissatisfaction risk, whereas those with more severe space narrowing had greater postoperative dissatisfaction risk, which differed from the results of a previous small-sample study.[26] Indeed, Ding et al showed that the hip fusion group had higher post-THA satisfaction scores than the unfused group.[26] The space narrowing degree also affected the improvement of postoperative hip ROM; these results suggest that hip space narrowing might be an unfavorable risk factor for postoperative outcome measures.

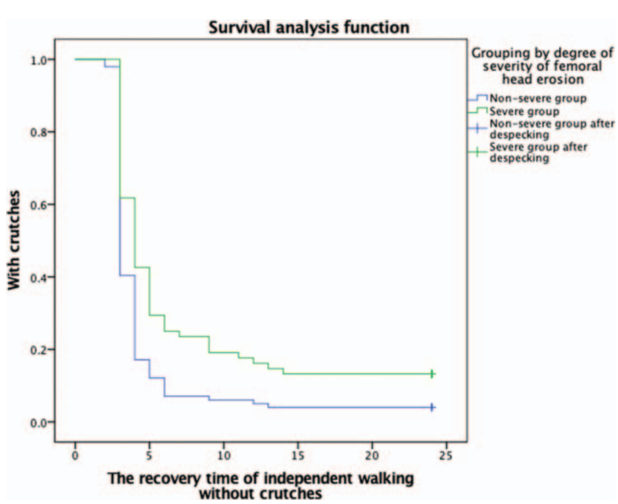

Figure 3. Kaplan–Meier curve of the recovery time of independent walking without crutches for 2 groups.

AS hip sclerosis, especially acetabular sclerosis, needed to be re-recognized in this study. AS hip damage, including bone sclerosis and osteophyte formation, were previously considered to be poor outcomes, and in the imaging evaluation, osteophyte formation may increase the BASRI-hip score on hip damages.[10] By contrast, we found that patients with acetabular sclerosis accounted for a higher proportion of the satisfied group, and, in the multivariable analysis, the risk of postoperative dissatisfaction in patients with acetabular sclerosis was 0.32 times higher than that of patients without acetabular sclerosis. Therefore, we speculate that, in patients with severe AS hip damage who underwent THA, bone sclerosis of the acetabulum may be a protective factor, possibly having a positive effect on postoperative satisfaction.

Among the postoperative outcome measures, mobility is increasingly considered an important parameter in treatment and outcome assessments. A previous review of patients' expectations of functional improvement within 1 year after THA reported that the most desired expectation in nearly 50% of patients was independent walking.[27] Therefore, independent walking time was considered as an outcome measurement of postoperative functional recovery evaluation. In this study, the more severe the femoral head erosion, the longer the recovery time of independent walking without crutches. The mean time to recover independent walking without crutches in patients with severe femoral head erosion was 2.7 weeks longer than that of patients with non-severe erosion. These data suggest that femoral head erosion severity may affect post-THA functional recovery time in AS patients.

This study had limitations. First, the results were based on the final follow-up data. A dynamic assessment of postoperative hip mobility was not performed; therefore, the dynamic changes could not be confirmed. Second, comprehensive rehabilitation training contributes to postoperative functional improvement. Rehabilitation training guidance was provided to all postoperative patients, but rehabilitation monitoring was not performed. Therefore, this factor was not considered in the regression analysis. We are continuously monitoring these patients and conducting dynamic assessments annually. The development of a suitable method for remote monitoring, including using an internet-based platform or a WeChat patient group management model in future studies is warranted. Third, the condition of the joint on the non-operative side was not evaluated at the final follow-up, and this may have had an influence on the clinical evaluations and imaging progress evaluations on the result.

In summary, those results are meaningful for surgeons and patients for the prediction of surgical outcomes and functional recovery time and for improvement of postoperative satisfaction.

Author contributions

S. Man made a major contribution to the manuscript, including the collection and analysis of data as well as preparation of the manuscript (total 40%). X. Ji, L. Zhang, and Z. Hu assisted in data analysis and critically reviewed the manuscript (total 15%). Y. Lv and Y. Zhou participated in the study design (total 15%). H. Song and F. Huang contributed to the project and participated in the study design and critically reviewed the manuscript (30%).

References

[1] Brophy S, Mackay K, Al-Saidi A, et al. The natural history of ankylosing spondylitis as defined by radiological progression. J Rheumatol 2002;29:1236–43.
[2] Robertson LP, Davis MJ. A longitudinal study of disease activity and functional status in a hospital cohort of patients with ankylosing spondylitis. Rheumatology 2004;43:1565–8.
[3] Brophy S, Calin A. Ankylosing spondylitis: interaction between genes, joints, age at onset, and disease expression. J Rheumatol 2001;28: 2283–8.
[4] Vander Cruyssen B, Munoz-Gomariz E, Font P, et al. Hip involvement in ankylosing spondylitis: epidemiology and risk factors associated with hip replacement surgery. Rheumatology 2010;49:73–81.
[5] van der Heijde D, Ramiro S, Landewe R, et al. 2016 update of the ASAS-EULAR management recommendations for axial spondyloarthritis. Ann Rheum Dis 2017;76:978–91.
[6] Thilak J, Panakkal JJ, Kim TY, et al. Risk factors of heterotopic ossification following total hip arthroplasty in patients with ankylosing spondylitis. J Arthroplasty 2015;30:2304–7.
[7] Wang W, Huang G, Huang T, et al. Bilaterally primary cementless total hip arthroplasty in patients with ankylosing spondylitis. BMC Musculoskelet Disord 2014;15:344.
[8] Vander Cruyssen B, Vastesaeger N, Collantes-Estevez E. Hip disease in ankylosing spondylitis. Curr Opin Rheumatol 2013;25:448–54.
[9] van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York criteria. Arthritis Rheum 1984;27:361–8.
[10] MacKay K, Brophy S, Mack C, et al. The development and validation of a radiographic grading system for the hip in ankylosing spondylitis: the bath ankylosing spondylitis radiology hip index. J Rheumatol 2000; 27:2866–72.
[11] Hu Z, Man S, Ji X, et al. Exploratory study of a new evaluation method for the severity of hip joint involvement in ankylosing spondylitis. Chin J Rheumatol 2019;23:19–24.
[12] Mahomed N, Gandhi R, Daltroy L, et al. The self-administered patient satisfaction scale for primary hip and knee arthroplasty. Arthritis 2011;10:591253.
[13] Kahlenberg CA, Nwachukwu BU, Schairer WW, et al. Patient satisfaction reporting after total hip arthroplasty: a systematic review. Orthopedics 2017;40:e400–4.
[14] Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am 1969;132:737–55.
[15] Sotelo-Garza A, Charnley J. The results of Charnley arthroplasty of hip performed for protrusio acetabuli. Clin Orthop Relat Res 1978;12–8.
[16] Bangjian H, Peijian T, Ju L. Bilateral synchronous total hip arthroplasty for ankylosed hips. Int Orthop 2012;36:697–701.
[17] Braun J, van den Berg R, Baraliakos X, et al. 2010 update of the ASAS/EULAR recommendations for the management of ankylosing spondylitis. Ann Rheum Dis 2011;70:896–904.
[18] Pivec R, Johnson AJ, Mears SC, et al. Hip arthroplasty. Lancet 2012;380:1768–77.
[19] Carr AJ, Robertsson O, Graves S, et al. Knee replacement. Lancet 2012;379:1331–40.
[20] Ward MM. Complications of total hip arthroplasty in patients with ankylosing spondylitis. Arthritis Care Res 2019;71:1101–8.
[21] Stratford PW, Kennedy DM. Performance measures were necessary to obtain a complete picture of osteoarthritic patients. J Clin Epidemiol 2006;59:160–7.
[22] Mizner RL, Petterson SC, Clements KE, et al. Measuring functional improvement after total knee arthroplasty requires both performance-based and patient-report assessments: a longitudinal analysis of outcomes. J Arthroplasty 2011;26:728–37.
[23] Dyck BA, Zywiel MG, Mahomed A, et al. Associations between patient expectations of joint arthroplasty surgery and pre- and post-operative clinical status. Expert Rev Med Devices 2014;11:403–15.
[24] Wanders AJ, Landewe RB, Spoorenberg A, et al. What is the most appropriate radiologic scoring method for ankylosing spondylitis? A comparison of the available methods based on the outcome measures in rheumatology clinical trials filter. Arthritis Rheum 2004;50: 2622–32.
[25] Kim H, Lee J, Ahn JK, et al. Predictive factors of radiographic progression in ankylosing spondylitis. Korean J Intern Med 2015; 30:391–7.
[26] Ding L, Gao YH, Li YR, et al. Determinants of satisfaction following total hip arthroplasty in patients with ankylosing spondylitis. Int Orthop 2018;42:507–11.
[27] Heiberg KE, Ekeland A, Mengshoel AM. Functional improvements desired by patients before and in the first year after total hip arthroplasty. BMC Musculoskelet Disord 2013;14:243.