



# Primary Sjögren's syndrome is not associated with poor outcomes after total hip arthroplasty: a retrospective case–control study with a matched cohort of osteoarthritis patients

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Received: 12 May 2022 / Revised: 7 June 2022 / Accepted: 15 June 2022 / Published online: 28 June 2022  
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## Abstract

**Introduction** The number of patients with primary Sjögren's syndrome (PSS) requiring total hip arthroplasty (THA) is expected to increase, but few studies have detailed their outcomes. The purpose of this study was to evaluate a THA cohort of patients with avascular necrosis of the femoral head (ANFH) who had PSS and to compare their outcomes with those of matched patients with osteoarthritis.

**Method** A case–control study using data from a single-institution arthroplasty registry was performed. Forty-two THAs in 32 patients undergoing THA with a diagnosis of PSS were identified and were matched with 84 THAs in 64 patients with osteoarthritis (1:2 ratio). Functional and health-related quality of life (QoL) evaluations were performed, and complications were recorded at the last follow-up. Logistic regression was used to determine factors associated with reaching the transfusion trigger of hemoglobin < 8 g/dL (TT8) in PSS patients.

**Results** After a mean 5-year follow-up, both cohorts had similar hip function and health-related QoL outcomes. The incision complications and reaching TT8 were greater in the PSS group. No differences were observed in the rate of 90-day readmission, reoperation, or overall revision. By multivariate analysis, the influencing factors for reaching TT8 in PSS patients were lower preoperative hemoglobin ( $OR=0.842$ , 95%  $CI$  [0.741–0.958],  $P<0.05$ ).

**Conclusion** Our study demonstrated PSS patients who received THA due to ANFH could achieve clinical outcomes similar to those of non-PSS patients. Improving preoperative Hb level can reduce the risk of transfusion.

## Key Points

- THA significantly improved hip function and health-related quality of life in PSS patients with osteonecrosis of the femoral head.
- Patients with PSS were more likely to reach the transfusion trigger and higher rates of incision complications after THA.
- Improving preoperative Hb level can reduce the risk of transfusion for PSS patients who underwent THA.

**Keywords** Outcomes · Postoperative transfusion · Primary Sjögren's syndrome · Total hip arthroplasty

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## Introduction

Primary Sjögren's syndrome (PSS) is a chronic autoimmune disease characterized by lymphocyte infiltration and decreased exocrine gland secretion, often with multiple-organ involvement [1, 2]. The prevalence rate of PSS is approximately 0.3/1000–1/1000 and commonly occurs in middle-aged women [3]. PSS is a chronic, slowly developing, and non-life-threatening disease for most patients, with a 10-year survival rate exceeding 90%. Glucocorticoids and

immunosuppressants are the most common treatments for PSS [1]. A longer disease course and the use of glucocorticoids increase the risk of avascular necrosis of the femoral head (ANFH) in these patients.

Total hip arthroplasty (THA) is the standard treatment for end-stage ANFH and significantly improves hip function and quality of life (QoL) in rheumatic diseases such as systemic lupus erythematosus (SLE) and rheumatoid arthritis (RA), although its complications and long-term survival are controversial [4–7]. There is a lack of studies on the clinical outcomes of THA in patients with PSS. A previous study showed that Sjögren's syndrome (SS) was not associated with implant infection, revision surgery, or mortality post-THA; however, SS patients had a high rate of blood transfusion after THA [8]. Understanding the THA outcomes of PSS will help provide effective evidence for treating osteonecrosis in this young and mostly immunosuppressed patient group. In addition, previous studies have not distinguished between PSS and secondary SS and have lacked control subjects.

In this study, we examined a large single-center database to evaluate whether PSS patients who received THA due to ANFH could achieve clinical outcomes similar to those of non-PSS patients and to determine the risk factors for blood transfusion by case-matching patients with hip osteoarthritis who had no history of inflammatory disease at the time of surgery. Specifically, we evaluated the following: (1) hip function, (2) quality of life, (3) complications, and (4) influencing factors of the transfusion trigger.

## Materials and methods

### Participants

In this retrospective study, patients diagnosed with PSS and ANFH were screened from the hip replacement database. Patients who had other rheumatic immune system diseases or received revision surgery or emergency surgery for fracture were excluded. From January 2002 to December 2020, 36 patients with PSS underwent THA due to ANFH. Four of them were lost to follow-up and could not be contacted by telephone. The final study cohort included 42 THAs in 32 patients. All patients met the 2002 or 2016 diagnostic criteria for PSS [9, 10], and their medical records all contained the record of the diagnosis made by the rheumatologists in our hospital. All 32 patients (30 females and 2 males) were followed up for more than 1 year, and the average follow-up duration was  $5.05 \pm 3.99$  years (range: 1.2–19.6 years). Three patients underwent simultaneous bilateral THAs, and seven patients underwent staged bilateral THAs; the total number of operations was 39.

To reduce the effects of selection bias and potential confounders, a matched comparison cohort was subsequently created as a control group. The control group was matched to the PSS group at a ratio of 1:2 from the database of 10,378 THAs. The cohorts were matched for age (within 1 year), sex, bilateral or staged surgery, American Society of Anesthesiologists (ASA) score (within 1 point), and surgical data (within 1 year). This process yielded 84 THAs in 64 patients who underwent primary THA for hip osteoarthritis, of which six patients underwent simultaneous bilateral arthroplasty and fourteen patients underwent staged bilateral THAs. The outcome of the patients was not known at the time of matching. Informed consent was obtained from all patients prior to inclusion in the study. The study protocol was approved by the local ethics committee.

A group of surgeons with high surgical volume who underwent the same surgical training completed the procedure. All patients had a posterolateral approach and cementless fixation. The acetabular components included the Pinnacle (DePuy Orthopaedics, Warsaw, IN, USA), R3 (Smith & Nephew, Memphis, TN, USA), Tritanium (Stryker, Mahwah, NJ, USA), and trabecular metal (Zimmer, Warsaw, IN, USA) components. The femoral prostheses included the Corail Stem (DePuy Orthopaedics, Warsaw, IN, USA), Synergy (Smith & Nephew, Memphis, TN, USA), and Accolade II (Stryker, Mahwah, NJ, USA) prostheses.

They were also similar in terms of perioperative analgesia, infection prevention, thromboprophylaxis protocol, and rehabilitation. Routine follow-up was at 4 weeks, 3 months, 6 months, and 12 months and then annually thereafter. Patients who did not return for regularly scheduled visits were contacted by telephone.

### Data collection

The demographic data included age, sex, BMI, ASA score, operation time, and length of hospital stay. All data were obtained from the electronic medical record system. For patients in the PSS group, the age at diagnosis of PSS and the time from PSS diagnosis to surgery were also recorded.

The Hip Disability and Osteoarthritis Outcome Score (HOOS), a patient-reported outcome measure (PROM), was used to evaluate the hip function [11]. Pain was evaluated using the visual analog scale (VAS) pain score [12]. QoL was assessed using the EuroQol 5-Dimensions (EQ-5D) and the EQ-VAS [13, 14]. The patients were explained these scales in detail before they performed the PROM.

Postoperative complications were also recorded through the electronic medical record system and each follow-up record. Surgical complications included wound complications (delayed wound healing, exudation, hematoma,

superficial surgical site infection, deep surgical site infection), vascular and nerve injury, high fever (temperature > 39 °C except from infection), hypokalemia, hypocalcemia, vomiting, dislocation, periprosthetic infection (PJI), and pulmonary and urinary tract infections within 30 days after surgery. Deep-vein thrombosis and pulmonary embolism were diagnosed by color Doppler ultrasound of the lower-extremity vessels and computed tomography angiography of the pulmonary arteries in patients with related symptoms within 90 days after surgery. Revision surgery was defined as the replacement of any prosthetic component for any reason. Reoperation and 90-day readmission related to the hip joint or complications were also recorded.

The hematological indicators were collected and the total estimated blood loss was calculated by a formula described in previous studies [15, 16]. The decision on blood transfusion greatly depended on the clinician and more stringent thresholds for transfusion of 7–8 g/dL of Hb have been recommended [17, 18]. For the purposes of this study, we used the conservative Hb level of 8 g/dL as the transfusion trigger (TT8). The EULAR Sjögren's Syndrome Patient Reported Index (ESSPRI) was used to evaluate the preoperative PSS activity [19]. The kidney involvement (renal tubular acidosis, renal tubular injury, renal interstitial lesions, etc.), liver involvement (primary biliary cholangitis, autoimmune hepatitis, abnormal liver function, etc.), and lung involvement (interstitial lung disease, multiple pulmonary bullae, pulmonary nodular amyloidosis, etc.) in PSS patients were also recorded. The preoperative hematological markers useful for diagnosis, activity evaluation indicators, and the preoperative use of glucocorticoids and disease-modifying antirheumatic drugs (DMARDs) were recorded.

### Statistical analysis

Statistical analyses were performed with SPSS version 23 (SPSS, Chicago, IL). All data are reported using standard descriptive statistics, including mean  $\pm$  SD for continuous variables and count for categorical variables. Categorical variables were compared using the chi-squared test or Fisher's exact test. Continuous variables were compared by the two-sample *t*-test or the Wilcoxon rank-sum test. Predictors that were found statistically significant in the univariate analysis were included in the multivariate analysis to estimate odds ratios and 95% confidence intervals of reaching the transfusion trigger. The final models for multivariate analysis were chosen using enter selection method. BMI and preop Hb were forced into the final model during the model selection. A *P* value < 0.05 was considered to be statistically significant.

## Results

### Demographic characteristics

There was no difference in age, gender, BMI, or ASA score between the two groups (*P* > 0.05). The average follow-up durations were 5.05  $\pm$  3.99 years for the PSS group and 5.02  $\pm$  4.16 years for the control group (*P* > 0.05). The operation time was 143.60  $\pm$  27.19 min in the PSS group and 148.13  $\pm$  32.12 min in the control group (*P* > 0.05). The two groups had no difference in the average length of hospital stay (*P* > 0.05). See Table 1 for details.

### Hip function and health-related quality of life outcomes

Patients in both groups had similar hip function scores before surgery, and there were no differences in the individual components of the HOOS or the total HOOS at the final follow-up. VAS scores improved in both groups, with VAS scores of 1.51  $\pm$  0.94 versus 1.45  $\pm$  1.17 in the PSS and control groups, respectively, at the final follow-up (*P* > 0.05). In terms of QoL outcomes, patients with PSS had a worse preoperative EQ-VAS than controls (*P* < 0.05). Postoperatively, there were no differences in any component or in the total EQ-VAS score between the two groups. The satisfaction scores of patients in both groups were 94.72  $\pm$  3.96 versus 95.14  $\pm$  4.22, respectively (*P* > 0.05). Four patients with PSS still required walking aids at the last follow-up; however, none of these was related to pain or functional decline of the hip joint. See Tables 2 and 3 for details.

### Complications and reoperation

Incision complications occurred in four patients in the PSS group, including two cases of delayed wound healing,

**Table 1** Demographic characteristics

	PSS group	Control group	<i>P</i> value
Age (years)	49.87 $\pm$ 13.38	49.94 $\pm$ 13.19	0.980
Gender (female/male)	30/2	60/4	1.000
BMI (kg/m <sup>2</sup> )	23.67 $\pm$ 3.12	23.75 $\pm$ 3.33	0.895
ASA score	2.10 $\pm$ 0.38	2.11 $\pm$ 0.42	0.960
Operation time (min)	143.60 $\pm$ 27.19	148.13 $\pm$ 32.12	0.468
Length of hospital stay (days)	11.74 $\pm$ 6.51	11.55 $\pm$ 7.31	0.887
Follow-up time (years)	5.05 $\pm$ 3.99	5.02 $\pm$ 4.16	0.970

Abbreviations: *BMI*, body mass index; *ASA*, American Society of Anesthesiologists

**Table 2** Hip function

	PSS group	Control group	P value
Preoperative			
HOOS-symptom	39.51 ± 21.33	40.17 ± 17.60	0.860
HOOS-pain	40.23 ± 19.07	35.58 ± 11.26	0.100
HOOS-ADL	29.46 ± 14.84	33.36 ± 15.42	0.194
HOOS-SR	16.49 ± 11.89	18.53 ± 11.71	0.379
HOOS-QOL	25.95 ± 14.96	29.86 ± 15.57	0.197
HOOS	30.33 ± 11.14	31.50 ± 5.08	0.536
VAS pain score	6.38 ± 1.43	6.85 ± 1.83	0.171
Postoperative			
HOOS-symptom	84.67 ± 17.76	87.32 ± 11.69	0.401
HOOS-pain	95.26 ± 6.09	93.97 ± 6.76	0.320
HOOS-ADL	83.41 ± 12.62	85.95 ± 10.99	0.265
HOOS-SR	75.08 ± 15.34	77.06 ± 14.83	0.501
HOOS-QOL	80.44 ± 20.01	82.56 ± 11.26	0.540
HOOS	83.77 ± 6.81	85.37 ± 4.77	0.192
VAS pain score	1.51 ± 0.94	1.45 ± 1.17	0.767

Abbreviations: *HOOS*, hip disability and osteoarthritis outcome score; *ADL*: activity of daily living; *SR*, sports/recreation; *QOL*, quality of life; *VAS*, visual analog scale

**Table 3** Health-related quality of life assessment outcomes

	PSS group	Control group	P value
Preoperative			
EQ-mobility	3.23 ± 1.20	2.88 ± 1.07	0.116
EQ-self care	3.21 ± 1.45	2.88 ± 1.35	0.240
EQ-usual activity	3.74 ± 0.88	3.76 ± 0.90	0.942
EQ-pain	3.87 ± 0.77	3.77 ± 1.14	0.613
EQ-anxiety	2.79 ± 1.36	3.00 ± 1.31	0.432
EQ-scores	0.18 ± 0.21	0.22 ± 0.20	0.250
EQ-VAS	55.82 ± 12.62	61.87 ± 15.48	0.037
Postoperative			
EQ- mobility	1.85 ± 0.63	1.60 ± 0.69	0.067
EQ-self care	1.28 ± 0.46	1.22 ± 0.42	0.448
EQ-usual activity	1.33 ± 0.53	1.45 ± 0.53	0.267
EQ-pain	1.33 ± 0.58	1.29 ± 0.49	0.706
EQ-anxiety	1.54 ± 0.64	1.71 ± 0.81	0.264
EQ-scores	0.86 ± 0.085	0.87 ± 0.084	0.719
EQ-VAS	76.18 ± 13.07	80.14 ± 14.36	0.150
Walking aid (Y/N)	4/28	4/60	0.434
Patient satisfaction	94.72 ± 3.96	95.14 ± 4.22	0.603

Abbreviations: *EQ*, European Quality of Life Scale; *VAS*, visual analog scale

one case of incision exudation, and one case of redness and swelling around the incision. Delayed wound healing occurred in one patient in the control group. All patients with incision complications improved after repeated dressing

changes. Pulmonary infection occurred in four patients in the PSS group including two with preoperative pulmonary interstitial fibrosis and in two patients in the control group. Among the patients with postoperative pulmonary infection, two PSS patients with preoperative pulmonary interstitial fibrosis were cured after antibiotic treatment. In the PSS group, sixteen patients reached the transfusion trigger ( $P < 0.05$ ). Postoperative dislocation occurred in two patients in the PSS group during hospitalization. One of these patients had anterior dislocation caused by excessive posterior extension, and the other patient had posterior dislocation. The two patients did not have dislocation after reduction and brace fixation. The two groups had no significant differences in other complications, and none of the patients in either group had 90-day readmission, revision, or reoperation. See Table 4 for details.

### Hematological outcomes and risk of reaching the transfusion trigger

The two groups had no difference in preoperative Hb or HCT. The patients in the PSS group had lower Hb on the first postoperative day and lower HCT on the third postoperative day ( $P < 0.05$ ). The two groups had no difference in the total blood loss. However, more patients in the PSS group than in the control group reached the transfusion trigger ( $P < 0.05$ ). Among the univariate factors, the predictors associated with reaching TT8 in PSS patients included low

**Table 4** Perioperative complications. Values are Y/N unless otherwise specified

	PSS group	Control group	P value
Wound complications ( <i>n</i> )	4/38	1/83	0.042
Pulmonary infection ( <i>n</i> )	4/35	2/76	0.177
Urinary tract infection ( <i>n</i> )	3/36	1/77	0.300
DVT ( <i>n</i> )	0/39	0/78	1.000
PE ( <i>n</i> )	0/39	0/78	1.000
Hb < 80 g/L ( <i>n</i> )	16/23	14/64	0.013
Hypokalemia ( <i>n</i> )	15/24	20/58	0.199
Hypocalcemia ( <i>n</i> )	5/34	6/72	0.503
High fever ( <i>n</i> )	5/34	6/72	0.503
Vomiting ( <i>n</i> )	4/35	7/71	0.999
Neurovascular events ( <i>n</i> )	0/42	0/84	1.000
Periprosthetic infection ( <i>n</i> )	0/42	0/84	1.000
Periprosthetic fracture ( <i>n</i> )	0/42	0/84	1.000
Dislocation ( <i>n</i> )	2/40	0/84	0.109
90-day readmission ( <i>n</i> )	0/42	0/84	1.000
Reoperation ( <i>n</i> )	0/42	0/84	1.000
Revision ( <i>n</i> )	0/42	0/84	1.000

Abbreviations: *DVT* deep vein thrombosis, *PE* pulmonary embolism, *Hb* hemoglobin

**Table 5** Perioperative hematological index

	PSS group	Control group	P value
Preop Hb (g/L)	120.51 ± 11.25	124.72 ± 12.48	0.079
Hb POD1 (g/L)	96.36 ± 12.75	101.86 ± 12.81	0.032
Hb POD3 (g/L)	88.30 ± 13.52	91.86 ± 22.85	0.384
Preop Hct (%)	36.08 ± 4.302	36.97 ± 3.79	0.256
HCT POD1 (%)	29.35 ± 4.08	30.47 ± 3.55	0.133
HCT POD3 (%)	27.21 ± 4.52	28.90 ± 3.82	0.043
Total blood loss (mL)	1109.23 ± 412.34	995.47 ± 492.81	0.220
Preop Albumin (g/L)	37.85 ± 3.94	40.23 ± 3.56	0.001
Postoperative albumin (g/L)	29.23 ± 3.30	30.69 ± 3.21	0.025

Abbreviations: *Preop*, preoperative; *Hb*, hemoglobin; *POD*, postoperative day; *Hct*, hematocrit

BMI ( $P=0.043$ ) and low preoperative Hb ( $P<0.001$ ). By multivariate analysis, preoperative Hb was statistically significant predictors of reaching TT8. A 1-g/dL increase in hemoglobin was associated with decreased risk of reaching transfusion trigger ( $OR=0.842$ , 95%  $CI$  [0.741–0.958],  $P<0.05$ ). See Tables 5 and 6 and Supplementary Table 1 for details.

## Discussion

With the gradual increase in the number of PSS survivors receiving corticosteroids and immunosuppressants [1, 2], the number of patients requiring THA will increase steadily. It is important to assess whether these patients can achieve good post-THA outcomes without suffering a higher risk of complications. To the best of our knowledge, this is the first study to assess clinical outcomes in patients with PSS compared to a matched group of control patients. It was found that PSS patients achieved post-THA clinical outcomes similar to those of osteoarthritis patients despite their differences in postoperative incision complications and reaching transfusion trigger. In addition, multivariate analysis showed that low preoperative Hb was risk factors for blood transfusion in PSS patients who underwent THA.

The results showed that hip arthroplasty improved hip function and QoL in patients with PSS to the same extent as it did in patients with osteoarthritis. Similar improvements in functional outcomes have also been found in RA and SLE. In a study of SLE patients who underwent THA, the Harris hip score of the 13 SLE patients (19 THAs) increased from an average of 65.3 points to 94.9 points at the latest follow-up, which was not different from that in the matched non-SLE control group [20]. Wakabayashi et al. [21] performed THA in 28 RA patients and found that the average postoperative 5-year hip score improved satisfactorily. However,

**Table 6** Univariate analysis for Hb < 80 g/L (transfusion trigger) in PSS patients

	Hb ≥ 80 g/L	Hb < 80 g/L	P value
Age (years)	53.09 ± 14.02	45.25 ± 11.24	0.071
Gender (female/male)	21/2	16/0	0.503
BMI (kg/m <sup>2</sup> )	24.50 ± 2.88	22.47 ± 3.14	0.043
Age at diagnosis (years)	42.57 ± 15.37	37.69 ± 9.17	0.264
PSS duration (years)	10.48 ± 9.71	7.44 ± 7.19	0.294
ASA score	2.13 ± 0.34	2.06 ± 0.44	0.593
Unilateral/simultaneous (n)	22/1	14/2	0.557
Operation time (min)	136.66 ± 29.85	149.13 ± 21.85	0.178
Renal involvement (Y/N)	10/13	5/11	0.517
Liver involvement (Y/N)	5/18	4/12	0.999
Lung involvement (Y/N)	7/16	6/10	0.736
Glucocorticoid (Y/N)	23/0	16/0	1.000
DMARDs (Y/N)	17/6	10/6	0.498
Smoking, n (%)	22/1	16/0	0.999
Preop Hb (g/dL)	125.65 ± 7.32	113.13 ± 11.97	0.001
WBC counts (× 10 <sup>9</sup> /L)	5.84 ± 2.87	5.74 ± 2.10	0.906
Platelet counts (× 10 <sup>9</sup> /L)	177.52 ± 64.08	205.44 ± 81.26	0.238
Albumin (g/L)	37.09 ± 3.94	38.94 ± 3.79	0.151
Anti-Ro/SSA (+) (Y/N)	14/6	6/5	0.452
Anti-La/SSB (+) (Y/N)	7/13	3/8	0.999
ANA (+) (Y/N)	16/4	9/2	0.999
RF (+) (Y/N)	3/15	4/8	0.392
Low C3 cells (Y/N)	9/11	3/9	0.452
Low C4 cells (Y/N)	7/13	3/9	0.703
High IgG levels (Y/N)	14/4	5/5	0.210
Pre VAS pain score	6.61 ± 1.34	6.06 ± 1.53	0.244
Pre HOOS	31.15 ± 13.41	29.15 ± 6.94	0.548
EQ-scores	0.18 ± 0.21	0.17 ± 0.21	0.831
EQ-VAS	58.94 ± 10.36	53.65 ± 13.78	0.202
ESSPRI	6.04 ± 1.07	5.56 ± 1.15	0.188

Abbreviations: *Hb*, hemoglobin; *BMI*, body mass index; *PSS*, primary Sjogren’s syndrome; *ASA*, American Society of Anesthesiologists; *DMARDs*, disease modifying antirheumatic drugs; *Preop Hb*, preoperative hemoglobin; *ANA*, antinuclear antibodies; *RF*, rheumatoid factor; *VAS*, visual analog scale; *HOOS*, hip disability and osteoarthritis outcome score; *ESSPRI*, EULAR Sjogren’s Syndrome Patient Reported Index. Low C3 cells = C3 < 0.73 g/L; low C4 cells = C4 < 0.1 g/L; high IgG levels = IgG ≥ 17.00 g/L

Momohara et al. [22] found, in the post-THA follow-up of 77 RA patients, that although THA improved clinical outcomes in damaged hips and had a positive secondary systemic effect on RA disease activity, it did not have a continuously good effect on the measures of health-related QoL. In our case, although PSS patients had poor preoperative EQ-VAS scores, they achieved a postoperative QoL similar to that of osteoarthritis patients.

Patients with inflammatory arthritis have a higher incidence of post-THA complications [23, 24]. In our study, the



PSS patients had a higher incidence of incision complications after THA, but none of them had thrombosis, infection, or revision surgery. Singh et al. [8] found although SS was associated with significantly higher odds of discharge to a rehabilitation/inpatient facility after THA, SS was not associated with implant infection or revision or mortality. Chen et al. [25] found that the risk of prosthetic joint infection (PJI) in SLE patients was 2.74 times than in non-SLE patients who underwent THA. Immune diseases are typically treated with corticosteroids or other immunosuppressants, both of which are thought to increase the incidence of PJI [26]. In addition, patients with SLE are more susceptible to major infections, and those patients with prosthetic hip joints may have a risk of hematogenous spread [27, 28]. PSS patients are susceptible to infection. According to Lin et al. [29], the mortality rate of SS patients was 3.1%, most of which was from pulmonary infection or other infection. In our study, although the number of patients with pulmonary infection was not significantly different from the number of patients with urinary tract infection in the PSS group, these two rates were both greater than those in the control group.

Blood transfusion is not a benign treatment but may increase the risk of viral transmission and cause acute hemolytic transfusion reactions, circulatory overload, and PJI [30]. However, blood transfusion is done based on many factors and, to a large extent, depends on the judgment of the clinician [17, 18]. Therefore, we applied a transfusion trigger to eliminate this bias, and we found that more PSS patients reached the transfusion trigger. Low preoperative Hb was the independent risk factor for blood transfusion in PSS patients. The low preoperative Hb in PSS patients might have been caused by various factors. The circulatory system is one of the systems commonly affected by PSS, mainly because the presence of a variety of autoantibodies in the serum of PSS patients can cause a decrease in Hb [31, 32]. Normocytic normochromic anemia occurs in approximately 20% of PSS patients. Long-term use of immunosuppressants can cause bone marrow suppression, resulting in reduced blood cell populations [33]. Bini et al. [18] also found that lower preoperative Hb was associated with a higher risk of blood transfusion in RA patients after total joint arthroplasty. The systematic review conducted by Wilson et al. [34] showed that erythropoietin and iron treatment of RA patients who were about to undergo arthroplasty significantly reduced their need for transfusion. These results suggest that the optimization of preoperative Hb can reduce the risk of blood transfusion.

The present study had several limitations, and our findings should be interpreted with them in mind. First, although we used cohort matching, potential bias still existed due to the inherent limitations of this retrospective study. Second, due to the limited sample size, differences in rare complications could not be identified, and additional variables (e.g.,

the use of tranexamic acid, the types of disease-modifying antirheumatic drugs, and more details on autoantibodies and the dose of glucocorticoids) could not be included in the multivariate analysis. However, the incidence of PSS is lower compared to other rheumatic diseases such as SLE and RA; hence, the lower incidence means that the potential number of patients performing THA is even lower. Third, the different surgeons used different implants from different manufacturers, though we believe that this diverse setting can more truthfully reflect the real-world results in the community and make the results more generalizable. Fourth, although the hip function of all patients was similar at the last follow-up and no reoperation was performed, a comparison of imaging data, such as loosening and heterotopic ossification, was lacking. The reason is that some patients could not come to the hospital for X-rays due to the restrictions for the COVID-19 epidemic.

Despite these shortcomings, given the limited amount of matched comparative data on this particular patient population, we believe this study is a valuable addition to the literature. It was found that THA significantly improved hip function and QoL in this young, immunosuppressed patient population compared with the general population. Patients with PSS were more likely to reach the transfusion trigger and higher rates of incision complications, but there were no differences in other complications, readmissions, or reoperations. According to our results, rheumatologists and orthopedist should not feel reluctant to suggest THA for PSS patients with femoral head necrosis because of concerns about outcomes or potential medical complications. This information can also be used to help counsel patients with PSS who are considering hip arthroplasty. Improving preoperative Hb level can reduce the risk of transfusion. Future prospective multicenter studies with large samples are needed to evaluate the long-term effects of THA in patients with PSS.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s10067-022-06256-2>.

**Acknowledgements** We appreciate Li Wang from Department of Epidemiology and Biostatistics, School of Basic Medicine Peking Union Medical College for her generous help with statistics.

**Funding** This work was supported by Non-profit Central Research Institute Fund of Chinese Academy of Medical Science (Grant number A2020418300) and National Natural Science Foundation of China (Grant numbers 81972046,2019).

## Declarations

**Ethics approval and consent to participate** All procedures involving human participants carried out in the studies were in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and its later amendments or

comparable ethical standards. This study was approved by the Peking Union Medical College Hospital Institutional Review Board, and the informed consent was obtained from each participant before the enrollment of this study.

**Disclosures** None.

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