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ORIGINAL ARTICLE

When and how do prosthetic hips fail after total hip arthroplasties?—A retrospective study

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Background/Purpose: Understanding failure modes, time to revision, and vulnerable components in revision hips could help reduce the risk of revision surgeries. Our aim was to investigate the association between the index diagnosis and the failure mode in patients undergoing revision surgeries.
Methods: A total of 402 patients who underwent a first revision surgery in a single hospital between 2000 and 2012 were recruited in a retrospective study. Multiple logistic regression analysis was used to evaluate the association of the index diagnosis of the primary total hip arthroplasty and short-term failure, as well as specific failure mode that occurred early, while controlling for sex, age, and the type of prosthesis.
Results: The mean time to revision due to all failure modes was 9.48 (standard deviation = 6.08) years. Defining short-term failure as a time to revision <5 years after total hip arthroplasty, the primary failure mode was infection (32.4%), followed by loosening (25.7%) and instability (17.1%). In multivariate analysis, as compared to osteonecrosis, patients with index diagnosis as infection was significantly associated with revision due to infection (odds ratio = 9.69, $p = 0.013$). In addition, osteoarthritis increased the odds of loosening (odds ratio = 4.18, $p = 0.012$). In contrast to studies in the United States and Europe, acetabular component revisions were the most common type found in our study.

Conflicts of interest: The authors have no conflicts of interest relevant to this article.

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Conclusion: This study demonstrates that, compared with patients with osteonecrosis, patients with infection and osteoarthritis had higher odds of revision due to infection and loosening, respectively. Further studies are needed to examine the cause–effect relationship between index diagnosis and mode of failure.

Introduction

Total hip arthroplasty (THA) is one of the most successful orthopedic surgical procedures in recent years. The success rate of THA at 10 years is ~80–93%.[1,2] Despite its high success rate, the proportion of revision THAs continues to grow steadily over the years.[3] The increasing life expectancy in an aging population is associated with an increasing incidence of THAs, leading—as would be expected—to a rising trend in revision surgeries. Identifying the factors that influence the need for revision surgery is challenging and difficult, because revision THA usually occurs years or a decade after the primary THA. The common causes of revision THA are wear, loosening, dislocation or instability, and infection. The patient-related factors that have been shown to be associated with the causes of revision THA include sex, age, activity, high body mass index, the index diagnosis of the primary THA, poor bone quality, and other reasons related to infection or dislocation.[4–6]

From previous studies, we have observed that the index diagnosis of THA differs between the Caucasian and Asian populations.[7–10] Whereas osteoarthritis (OA) is the main diagnosis for patients in the West, osteonecrosis (ON) has been a major cause for Asian patients (e.g., Taiwanese) undergoing primary THA. Compared with Caucasian countries, the main differences in Taiwan are that the most common index diagnosis is ON (43–47%), the majority of patients are male (~60%), and the patients are relatively young (mean age 55 years).[7,8,10] Thus, it is of interest to know how differences in patient characteristics contribute to different distributions of failure modes requiring revision surgery. The purpose of this study was to explore the relationship between the failure modes of the prosthesis and patient-related factors, the time of revision after primary THA, and the type of revision, including the components exchanged. In addition, a better understanding of the short-term failure of prosthetic hips would benefit attempts to reduce the risk of revision THA.

Methods

Patients and measurements

A retrospective chart review was conducted for all patients who underwent revision surgery of a primary THA performed between 2000 and 2012 at the Department of Orthopedics, Hualien Tzu Chi Medical Center, Eastern Taiwan. The study protocol was approved by the hospital's Institutional Review Board. Revision surgeries included revision THA, partial revision, Girdlestone procedure, synovectomy or debridement of the hip, and fracture fixation. Patients who had undergone hemiarthroplasty revision and rerevision were excluded. We ultimately recruited a total of 402 patients for whom information about their primary THA was available. Two experienced surgeons (T.C.Y. and I.H.C.) performed the majority of the revision surgeries (>90%). Most patients (>90%) were operated with a posterolateral incision and a posterior arthrotomy with cementless implant fixation. Detailed demographic and clinical data were collected, including age at primary and revision surgeries, sex, index diagnosis of primary THA, brand and type of prosthesis, failure modes for revision surgeries, time to revision surgeries, and components exchanged. Data were derived from a retrospective review of clinic notes, operative notes, and radiographs recorded by the surgeons. The index diagnoses were classified into the following categories: primary OA, ON, developmental dysplasia of hip, inflammatory arthritis (including ankylosing spondylitis arthritis and rheumatoid arthritis), posttraumatic arthritis, and others, including acetabular fracture. During the study period, a total of 23 different brands of prosthesis were used. The top five brands were Secur-Fit Osteonics (37.5%) (Howedica Osteonics Corp, Mahwah, New Jersey, USA), PCA E-series Howmedica (13.4%) (Howmedica, Rutherford, New Jersey, USA), Omnifit Osteonics (9.4%) (Osteonics, Allendale, New Jersey, USA), Harris-Galante Zimmer (7.3%) (Zimmer Inc, Warsaw, Indiana, USA), and ABG Howmedica (7.1%) (Benoist Girardh, Boulevard de la Grande Delle, Hérouville-Saint-Clair, France), which accounted for 75% of all prostheses. For the purpose of analysis, we further grouped these prosthesis brands into two types, cemented and cementless, based on the method of fixation of the components.[11,12]

To determine the cause of the revision surgeries, three surgeons identified and grouped those diagnoses that were mainly related to the implant failure, based on the radiographic evaluation and intraoperative findings recorded on operative notes. Radiological evaluation was performed using standing anteroposterior and lateral views. Definitive loosening was defined as gross mechanical instability or a progressive radiolucent line wider than 2 mm on an image study. Polyethylene (PE) wear was considered when there was gross asymmetry in the radiographic views or a change in thickness noted in the intraoperative findings. Loosening was further divided into two subgroups: (1) loosening associated with PE liner wear (wear + loosening) and (2) loosening not associated with PE liner wear (loosening). All other failure modes were included, such as periprosthetic fracture, instability, and infection.

The time to revision was defined as the time interval (in years) from the index date of the primary THA to the revision date. We further divided patients into three groups, short-term (within 5 years after primary THA, as in previous studies[13,14]), mid-term (5–10 years after primary THA, as in a previous study[15,16]), and long-term failure (>10 years). Records of exchanged components were also collected, including insert, head, cup, and stem. As in the Australian national joint registry, we determined revision types as: (1) minor revision, in which bearing surfaces, including insert and head, were exchanged; and (2) major revision, in which major components, including the cup and stem, were removed or replaced.[9]

Statistical analyses

Descriptive statistics were calculated for all variables of interest. Categorical measures were summarized as counts and percentages, and continuous measures were summarized as means, standard deviations, and medians. The p values for comparing means of continuous variables such as age, were computed using a two-sample t test (for female vs. male) or analysis of variance (for comparison of short-, mid-, and long-term revision). For nonnormal variables such as time to revision, nonparametric Mann–Whitney U test was used to compute the p values. For examining the association of two categorical variables, Chi-square test was applied or Fisher's exact test was considered if rare count data existed. Multiple logistic regression analysis was performed to obtain the adjusted odds ratio (OR) and 95% confidence interval (CI) for index diagnosis (ON as the reference group) with adjustment for potential confounding factors such as sex (female as the reference group), age at primary THA, and type of prosthesis (cemented type as the reference group). Because short-term results would provide meaningful information for surgeons, we examined the relevant factors in relation to short-term failure. In addition to considering short-term failure based on time to revision, specific failure mode occurred early was evaluated as compared to wear + loosening, which occurred longer than other modes. Separate logistic regression analyses were performed on short-term failure consisting of (1) short-term revision (short-term vs. "mid-term or long-term" as a category), (2) infection versus wear + loosening, (3) loosening versus wear + loosening, and (4) instability versus wear + loosening. A p value < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS software (version 17.0; SPSS Inc., Chicago, IL, USA).

Results

Patient characteristics

Of the 402 patients older than 25 years undergoing revision surgeries between 2000 and 2012, 248 (61.7%) were males. The mean ages of all patients at primary THA and revision surgeries were 47.1 ± 13.6 years and 56.6 ± 13.4 years, respectively. The most common index diagnosis was ON (53.7%; mean age 45.5 years), followed by primary OA (13.7%; mean age 62.4 years), developmental dysplasia of hip (14.9%; mean age 45.3 years), posttraumatic arthritis (10.4%; mean age 43.8 years), and inflammatory arthritis (4.0%; mean age 35.1 years). The index diagnosis ($p < 0.001$; Table 1) and failure modes ($p = 0.018$) were associated with sex. This first finding would originate from the different etiology of index diagnosis between men and women. Infection and periprosthetic fracture were more common in men than in women, whereas loosening and instability occurred more frequently in women. Overall, the mean time to revision surgeries was 9.48 ± 6.08 years (range, from 8 days to 30 years). The most common failure mode was wear + loosening (47.5%), followed by wear (20.9%), infection (10.2%), and loosening (10%). There was no significant difference in the time to revision between men and women for a given failure mode.

Relationship of index diagnosis and failure modes

The association between index diagnoses and failure modes is presented in Table 2 ($p < 0.001$). The majority of failure modes were bearing surface failure (>56%), including wear and wear + loosening, for all index diagnoses with the exception of infection. The results indicated that the most frequent cause for failure in patients whose index diagnosis due to infection was also infection (50%), followed by posttraumatic arthritis (16.7%) and ON (11.1%). Interestingly, there was a higher proportion of loosening (20%) and instability (14.5%) in the primary OA group compared to the other index diagnoses (Table 2). Figure 1 shows the distribution of time to revision with respect to failure mode. Overall, 25.8% of all revisions occurred <5 years after the primary THA (i.e., short-term revision), 29.6% from 5 years to 10 years (i.e., mid-term revision), and 44.6% after > 10 years (i.e., long-term revision). Most short-term revisions were attributable to infection (31.4%), followed by loosening (26.5%) and instability (16.7%), whereas for mid- or long-term revisions, wear + loosening (60.7–61.4%) and wear (23.1–29%) were the most common causes of failure. In terms of time to revision, differences were also noted between the index diagnoses for the short-, mid-, and long-term groups ($p = 0.001$; Table 3). The proportions of patients with OA (23.5%), posttraumatic arthritis (14.7%), and infection (3.8%) as index diagnosis were higher for the short-term group than for the mid- or long-term group. The mean age at primary THA of patients for either the mid- or long-term group was significantly younger than that in the short-term group. The type of prosthesis was not associated with time to revision ($p = 0.186$). Apart from the time to revision, components exchanged at revision surgery were also examined. Major revisions accounted for 71.6% of all revision procedures. The revision type did not depend on failure time ($p = 0.784$), but on the failure mode (data not shown). The main reason for major revisions was wear + loosening (66.3%), followed by loosening (13.9%) and infection (11.8%). For minor revisions, the principal cause was PE wear (77.1%).

Factors associated with short-term failure of THA

We further used multiple logistic regression analysis to examine the association of short-term revision between patient characteristics, index diagnosis, and type of prosthesis (Table 4). In comparison with those who had mid- or long-term revisions, older age at primary THA was

Table 1 Distribution of baseline characteristics among revision patients ($n = 402$).

Characteristic	Total (n = 402)	Female (n = 154)	Male (n = 248)	p
Age at primary THA (y)	47.1 ± 13.6	50.93 ± 13.38	44.72 ± 13.21	<0.001
Index diagnosis				<0.001
Osteonecrosis	216 (53.7)	45 (29.2)	171 (69)	
Primary osteoarthritis	55 (13.7)	37 (24)	18 (7.3)	
Dysplasia	60 (14.9)	53 (34.4)	7 (2.8)	
Posttraumatic arthritis	42 (10.4)	12 (7.8)	30 (12.1)	
Inflammatory arthritis	16 (4.0)	3 (1.9)	13 (5.2)	
Infection	8 (2.0)	3 (1.9)	5 (2)	
Others	3 (0.7)	1 (0.6)	2 (0.8)	
Fracture	2 (0.5)	0	2 (0.8)	
Age at revision (y)	56.58 ± 13.41	60.29 ± 12.48	54.27 ± 13.47	<0.001
Type of prosthesis				0.002
Cemented	35 (8.9)	22 (14.5)	13 (5.3)	
Cementless	360 (91.1)	130 (85.5)	230 (94.7)	
Failure modes				0.018
Wear + loosening	191 (47.5)	75 (48.7)	116 (46.8)	
Wear	84 (20.9)	34 (22.1)	50 (20.2)	
Infection	41 (10.2)	8 (5.2)	33 (13.3)	
Loosening	40 (10.0)	19 (12.3)	21 (8.5)	
Instability	25 (6.2)	14 (9.1)	11 (4.4)	
Periprosthetic fracture	19 (4.7)	3 (1.9)	16 (6.5)	
Others	2 (0.5)	1 (0.6)	1 (0.4)	
Time to revision (y)[a]				
Overall	9.48 ± 6.08/9.75[b]	9.36 ± 6.05	9.55 ± 6.11	0.765
Infection	3.01 ± 4.41/1.08[b]	2.37 ± 3.7	3.17 ± 4.6	0.649
Periprosthetic fracture	5.51 ± 6.13/2.59[b]	1.09 ± 1.31	6.34 ± 6.34	0.219[c]
Loosening	5.42 ± 5.41/3.00[b]	5.23 ± 5.07	5.6 ± 5.82	0.835
Instability	3.95 ± 4.05/3.45[b]	3.68 ± 3.77	4.3 ± 4.55	0.713
Wear	11.37 ± 4.69/11.00[b]	11.31 ± 5.3	11.41 ± 4.28	0.922
Wear + loosening	12.08 ± 5.07/11.64[b]	11.78 ± 5.09	12.27 ± 5.06	0.514

Values are given as n (%) or mean ± standard deviation.
THA = total hip arthroplasty.
[a] Revisions due to Other were excluded as they were rare events.
[b] Represents median values.
[c] Based on Mann–Whitney U test.

significantly associated with short-term revision (OR = 1.03, 95% CI = 1.01–1.06, $p = 0.001$). After controlling for sex, age, and type of prosthesis, the association of short-term revision and index diagnosis was of marginal significance ($0.05 < p < 0.1$).[17] With ON as reference, marginal significance was found for dysplasia (OR = 0.4, 95% CI = 0.16–1.03, $p = 0.058$), posttraumatic arthritis (OR = 1.9, 95% CI = 0.91–3.94, $p = 0.086$), and infection

Table 2 Relation between index diagnosis and failure modes of revision surgeries.

	n	Failure modes of revision surgeries						p
		Wear + loosening	Wear	Loosening	Infection	Instability	Periprosthetic fracture	
Index diagnosis[a]								<0.001
Osteonecrosis	215[a]	102 (47.4)	47 (21.9)	16 (7.5)	24 (11.2)	10 (4.6)	16 (7.4)	
Primary osteoarthritis	54[a]	20 (37.0)	11 (20.4)	11 (20.4)	4 (7.4)	8 (14.8)	0 (0.0)	
Dysplasia	60	35 (58.3)	14 (23.3)	7 (11.7)	0(0.0)	4 (6.7)	0 (0.0)	
Posttraumatic arthritis	42	20 (47.6)	6 (14.3)	4 (9.5)	7 (16.7)	2 (4.8)	3 (7.1)	
Inflammatory arthritis	16	11 (68.8)	4 (25.0)	1 (6.3)	0(0.0)	0 (0.0)	0 (0.0)	
Infection	8	2 (25.0)	1 (12.5)	1 (12.5)	4 (50.0)	0 (0.0)	0 (0.0)	

Values are given as n (%).
[a] Index diagnoses of Other or Fracture, and revisions due to Other were excluded because they were rare events.

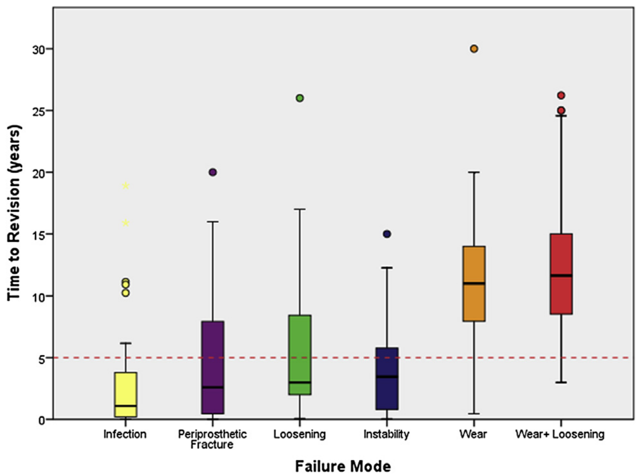

Figure 1 Time to revision for different failure modes.

(OR = 3.72, 95% CI = 0.86–16.16, $p = 0.08$). In addition, we provided the adjusted OR for specific failure modes, including infection, loosening, and instability, separately. These were the first three common modes in short-term revision. With infection as the outcome variable and with ON as reference, infection was significantly associated with revision due to infection when compared to wear + loosening (OR = 9.69, 95% CI = 1.63–57.62, $p = 0.013$). When patients with loosening failure mode compared to those revised due to wear + loosening, OA was the only significant associated factor for loosening (OR = 4.18, 95% CI = 1.38–12.7, $p = 0.012$), as compared to ON. With revision due to instability, results indicated that the only significant associated factor was age at primary THA (OR = 1.05, 95% CI = 1.01–1.1, $p = 0.017$). In multivariate analysis, sex and type of prosthesis were not significantly associated with short-term revision and each one of the first three short-term failure modes.

Discussion

The majority of studies of the causes of revision THA have been conducted in Caucasian populations, and reports related to Asian patients are lacking. Different patient characteristics would be expected to contribute to the various failure modes of revision THA among nations.[18] In this study, the distribution of the index diagnoses of primary THA was similar to that reported in previous reports from Taiwan.[7,8] The main differences from Caucasian countries were that ON was the primary index diagnosis (ON vs. OA) and that primary THA was performed at a young age

Table 3 Patient characteristics, index of diagnosis and failure modes by time to revision.

Characteristic	Time to revision			*p*
	<5 y	5–10 y	>10 y	
n	102 (25.8)	117 (29.6)	176 (44.6)	
Sex				0.782
Female	42 (41.2)	45 (38.5)	65 (36.9)	
Male	60 (58.8)	72 (61.5)	111 (63.1)	
Age at primary THA (y)	52.34 ± 14.47	47.47 ± 13.44	43.8 ± 11.88	<0.001
Index diagnosis[a]				0.001
Osteonecrosis	51 (50)	64 (54.7)	100 (56.8)	
Primary osteoarthritis	24 (23.5)	15 (12.8)	15 (8.5)	
Dysplasia	7 (6.9)	20 (17.1)	33 (18.8)	
Posttraumatic arthritis	15 (14.7)	12 (10.2)	15 (8.5)	
Inflammatory arthritis	1 (1)	3 (2.6)	12 (6.8)	
Infection	4 (3.8)	3 (2.6)	1 (0.6)	
Age at revision (y)	54.38 ± 14.36	55.49 ± 13.49	58.78 ± 12.28	0.015
Failure mode				<0.001
Wear + loosening	11 (10.8)	71 (60.7)	108 (61.4)	
Wear	5 (4.9)	27 (23.1)	51 (29)	
Infection	32 (31.4)	2 (1.7)	5 (2.8)	
Loosening	27 (26.5)	6 (5.1)	7 (4)	
Instability	17 (16.7)	5 (4.3)	2 (1.1)	
Periprosthetic fracture	10 (9.8)	6 (5.1)	3 (1.7)	
Type of prosthesis				0.186
Cemented	5 (4.9)	10 (8.5)	20 (11.4)	
Cementless	97 (95.1)	107 (91.5)	156 (88.6)	
Revision type				0.784
Minor revision	26 (25.7)	32 (27.4)	52 (29.5)	
Major revision	75 (74.3)	85 (72.6)	124 (70.5)	

Values are given as *n* (%) or mean ± standard deviation.
THA = total hip arthroplasty.
[a] Index diagnoses of Other or Fracture and revision due to Other were excluded because they were rare events.

Table 4 Adjusted OR (with ON as reference group) and 95% confidence interval (CI) estimated with short-term revision, with infection, with loosening and with instability as outcome variable in the analyses.

Factors	Outcome variable in the analyses											
	Short-term revision[a]			Infection[b]			Loosening[b]			Instability[b]		
	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*
Sex (ref: Female)												
Male	0.88	(0.50, 1.55)	0.650	2.01	(0.77, 5.27)	0.154	0.91	(0.38, 2.20)	0.832	0.60	(0.21, 1.68)	0.330
Age at primary THA (y)	1.03	(1.01, 1.06)	0.001	1.02	(0.99, 1.05)	0.324	0.99	(0.96, 1.02)	0.529	1.05	(1.01, 1.10)	0.017
Type of prosthesis (ref: cemented)												
Cementless	2.07	(0.72, 6.00)	0.179	—	—	—	2.52	(0.54, 11.83)	0.241	2.92	(0.34, 24.91)	0.327
Index diagnosis (ref: ON)												
OA	1.46	(0.70, 3.04)	0.308	0.87	(0.24, 3.20)	0.838	4.18	(1.38, 12.70)	0.012	1.57	(0.44, 5.65)	0.489
Dysplasia	0.40	(0.16, 1.03)	0.058	—	—	—	1.30	(0.41, 4.11)	0.656	0.90	(0.22, 3.68)	0.884
Posttraumatic arthritis	1.90	(0.91, 3.94)	0.086	1.81	(0.66, 4.95)	0.250	1.29	(0.39, 4.34)	0.677	0.98	(0.18, 5.28)	0.980
Inflammatory arthritis	0.33	(0.04, 2.61)	0.293	—	—	—	—	—	—	—	—	—
Infection	3.72	(0.86, 16.16)	0.080	9.69	(1.63, 57.62)	0.013	—	—	—	—	—	—

— = not applicable, because there are few patients ($n \leq 2$) with this type of index diagnosis or with cemented type of prosthesis. ON = osteonecrosis; OR = odds ratio.

[a] The reference group is "mid-term or long-term revision."

[b] The reference group is wear + loosening.

(56.58 years vs. 65.7 years).[4] The age at primary THA depends on the index diagnosis; thus, OA, the primary underlying diagnosis in Caucasian countries, is associated with relatively old patients. Prior to adjustment of other factors, the failure mode of revision was associated with sex. Regardless of wear-related complications, men had a higher proportion of infection (13.3% vs. 5.2%) or periprosthetic fracture (6.5% vs. 1.9%). By contrast, a higher proportion of women than men had loosening (12.3% vs. 8.5%) or instability (9.1% vs. 4.4%). Sex had no significant association with short-term revision when controlling other factors. However, the previous evidence is still not consistent with the effect of sex on the causes of revision THA. It is worth noting that the difference in index diagnoses among nations might be associated with the failure modes. Further study of Asian patients is necessary to investigate more deeply the interrelationships among sex and index diagnosis that could contribute to this finding.

A recent study reported that, in an institution in the United States from 2001 to 2011, 24.1% of revisions occurred within 5 years after the primary THA.[13] This is similar to our finding that short-term failure accounted for 25.8% of all revisions. Similarly, aseptic loosening, infection, and instability were the common causes of short-term failure. However, we found a difference in the short-term failure modes compared to previous reports in Caucasian countries. In the current study, infection was the most common cause of short-term failure, whereas revision due to aseptic loosening or instability is the most common cause in Caucasian countries.[4,13] However, the discrepancy between studies could be related to differences in the underlying diagnoses of primary THA, in which OA is the most common diagnosis for THA in Caucasian patients (70—90%), whereas ON was the most common index diagnosis in the present study. A possible explanation for this finding may be attributed to a higher risk of revision due to infection in patients who underwent THA due to ON, compared to those with OA.[18—22] ON has been related to risk factors and/or diseases that may affect the survival of a prosthetic hip. In Taiwan, the major etiology of ON is linked with heavy alcohol consumption and chronic corticosteroid therapy. All of these conditions and combined comorbidities would lead to immunocompromise, thus increasing the susceptibility to infections.

Multivariate analysis results indicated that only age at primary THA is positively associated with short-term revision. Several factors might contribute to this finding. Some studies have shown that older patients had a higher risk of short-term failure,[21] such as loosening,[23] instability,[24] and infection, compared to younger patients. A previous report also indicated that patient comorbidities were associated with an increased risk of early revision within 1 year after primary THA in elderly patients.[25] Through a chart review of patient comorbidities, we found that patients with diabetes mellitus or liver cirrhosis tend to have higher OR for revision due to infection (data not shown). Unfortunately, we did not have accurate information related to comorbid conditions in our sample. For example, patients with diabetes mellitus would be likely to visit other clinics or hospitals, not our hospital. Thus, it may result in misclassification error of comorbidity status. Given the concern over the validity of comorbidity information, further studies are needed to identify patient comorbidities of short-term failure in elderly patients. Another possible explanation is that this finding might result from sampling bias. Limited to chart review in a single hospital, for example, older patients who require long-term revision surgery might not present in our hospital. Thus, this finding should be interpreted with caution.

Our findings indicated marginal significance ($0.05 < p < 0.1$) for the index diagnosis with short-term failure. Index diagnosis of posttraumatic arthritis and infection had higher odds of short-term revision. Cordero-Ampuero and de Dios[26] had demonstrated that patients with posttraumatic arthritis had a relatively high risk of revision due to infection. Previous trauma surgeries probably lead to poorer microcirculation or insidious infection, thus increasing the risk of infection. In other words, this mechanism may lead to index diagnosis as infection. Therefore, the impact of underlying diagnosis of primary THA on short-term failure needs to be further studied. Regarding specific failure mode due to infection, the only significant associated factor was infection as index diagnosis. Of eight patients with infection who underwent primary THA, three (37.5%) experienced a subsequent prosthetic hip infection during the 3-month postoperative period. Several factors that may influence the survivorship of the infected hip included infected patients who are susceptible to infection,[27,28] characteristics of the pathogens, such as *Staphylococcus aureus*,[28] and occult infections caused by previous infection.[29] As for revision due to loosening, we found that OA patients had higher odds than ON patients. Previous reports also indicated that patients with OA were more likely to need revision for aseptic loosening.[5,19] Regarding instability, older age was associated with higher odds than younger patients in our series. This is comparable to former studies, and might be explained by abductor weakness after surgery and poor response to position change.[24,30] Similarly, as mentioned earlier, a sampling bias inherited in a retrospective study might also lead to the finding. Hence, the effect of age might be interpreted with caution.

For the long-term survival of prosthetic hips, we found that PE wear accounted for 88% of long-term revisions. This is in accordance with a previous study in the United States.[13] One possible explanation may be the introduction of wear-resistant bearing surface materials, including highly cross-linked PE, ceramic-on-ceramic, and/or metal-on-metal.[31–34] The improved materials can diminish microabrasion in the bearing surface and further foreign body reaction around the bones. We also found that the revision type depends on the failure modes of revision surgeries. Exchange of acetabular components accounted for the majority of major revisions, especially for revision surgeries due to wear + loosening and/or loosening. This finding differs from previous reports,[13,35] in which femoral component exchanges were the main procedure for revisions due to loosening. In a large study in Norway, aseptic loosening of the femur was slightly more common than aseptic loosening of the acetabulum.[36] A possible reason might be that the uncemented approach, as in our study, would have a higher risk of cup loosening and a lower risk of stem loosening compared to the cemented approach used in the Norwegian study.[36,37] The components exchanged for revision THA depend on several factors, such as bone loss status and the brands of components required to create a stable hip. It is still not clear whether the patient-related factors, implant-related factors, and surgical approach are directly linked to the difference in revision types. Furthermore, we found that the mean time to revision was not statistically significant for long-term failures due either to wear or to wear + loosening; however, the revision scales were totally different. It is well known that osteolysis, the biological response to wear particles, is the underlying mechanism of aseptic loosening. A possible solution might be to use a hybrid technique with cemented fixation proximal and cementless distally in hydroxyapatite-coated stem. This might impede the penetration of the wearing debris into the bone—component interface. Thus, it would be beneficial to prevent loosening related to wear particles. However, empirical studies are lacking, and this topic remains controversial.

This study had several limitations. First, we only recruited patients who had already undergone revision surgeries in a single hospital. This makes it difficult to conclude that the index diagnosis was the direct cause of failure. For evaluating the risk of revision surgeries, further studies are needed. For example, a control group composed of patients who underwent primary THAs only is required for comparison. Furthermore, this is a retrospective study of a chart review, which means that it is inevitably susceptible to the biases inherent in all retrospective studies. Our findings may not be generalizable to the whole population in Taiwan for the revision surgeries. Third, other potentially associated factors, such as other patient-related factors (e.g., obesity or patient comorbidities) and implant-related and surgical factors, might influence the survival of prosthetic hips. Previous studies had reported that obese patients were more likely to experience adverse events or short-term revision due to infection.[38,39] These issues should be considered in future studies. Our study highlights the impact of the underlying diagnosis of THA on revision surgery, especially for Asian patients. The factors associated with failure modes include sex, index diagnosis, time to revision, and revision type. Differences in the failure modes were noted compared to Caucasian reports. Regarding short-term failure, the most common cause of revision surgeries was infection, followed by early loosening and instability. With the predominant ON etiology, more attention should be given to preventing short-term revision due to infection. Therefore, the minimization of infection, loosening, and/or instability is essential for improving the results of THA.

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