CLINICAL ARTICLE

Exploring the Risk Factors for the Misdiagnosis of Osteonecrosis of Femoral Head: A Case-Control Study

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Objective: The purpose of the present study was to evaluate the present situation and risk factors for the misdiagnosis of osteonecrosis of femoral head (ONFH), providing the basis for accurate diagnosis of ONFH.

Methods: For this retrospective study, 1471 patients with ONFH were selected from the China Osteonecrosis of Femoral Head Database (CONFHD). These patients had been recruited between July 2016 and December 2018. According to whether or not they were misdiagnosed, the patients were divided into two groups, with 1168 cases (22–84 years old) included in the diagnosis group and 303 cases (21–80 years old) in the misdiagnosis group. Misdiagnosis was measured using the following criteria: (i) the patient had the same symptoms and signs, and the second diagnosis was not consistent with the initial diagnosis within 6 months; and (ii) the patient was admitted to a hospital participating in CONFHD and the previous diagnosis was inconsistent with the diagnosis given by the expert group. Comparisons of age, visual analogue scale for pain, and body mass index between the two groups were performed using a t-test. Gender, causes of ONFH, primary diseases requiring corticosteroids, methods of corticosteroid use, corticosteroid species, type of trauma, onset side of the disease, pain side, whether symptoms are hidden, and type of imaging examination at the initial visit were compared using the χ^2-test. Years of alcohol consumption, weekly alcohol consumption, and physician title at the initial visit were compared using a Mann–Whitney U-test. Furthermore, the statistically significant factors were evaluated using multiple regression analysis to investigate the risk factors of misdiagnosis.

Results: A total of 303 patients (20.6%) were misdiagnosed: 118 cases were misdiagnosed as lumbar disc herniation, 86 cases as hip synovitis, 48 cases as hip osteoarthritis, 32 cases as rheumatoid arthritis, 11 cases as piriformis syndrome, 5 cases as sciatica, and 3 cases as soft-tissue injury. Whether symptoms are hidden ($P = 0.038$, odds ratio [OR] = 1.546, 95% confidence interval [CI] = 1.025–2.332), physician title at the initial visit ($P < 0.001$, OR = 3.324, 95% CI = 1.850–5.972), X-ray examination ($P < 0.001$, OR = 4.742, 95% CI = 3.159–7.118), corticosteroids ($P < 0.001$, OR = 0.295, 95% CI = 0.163–0.534), alcohol ($P < 0.001$, OR = 0.305, 95% CI = 0.171–0.546), and magnetic resonance imaging (MRI) examination ($P = 0.042$, OR = 0.649, 95% CI = 0.427–0.985) were each found to be associated with misdiagnosis.

Conclusion: Osteonecrosis of the femoral head is easily misdiagnosed as lumbar disc herniation, hip synovitis, hip osteoarthritis, and rheumatoid arthritis. Patient history of corticosteroid use or alcohol abuse and MRI examination at the initial diagnosis may be protective factors for misdiagnosis. Hidden symptoms, physician title at the initial visit (as attending doctor or resident doctor), and only X-ray examination at the initial diagnosis may be risk factors for misdiagnosis.

Key words: Diagnostic errors; Logistic regression analysis; Osteonecrosis of femoral head; Risk factor

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Introduction

Osteonecrosis of femoral head (ONFH) causes loss of integrity of subchondral bone structure. It is the final common pathway of a complex interplay of genetic anomalies and stimulus factors that results in the loss of blood supply to the femoral head of the femur[1]. The underlying pathogenesis is unclear[2]. As a daunting orthopaedic intractable disease, ONFH can even gradually lead to lifelong disability in patients; it primarily affects young to middle-aged adults[3]. In the UK, the mean age of presentation is 58.3 years, with a prevalence of 2 per 100,000 patients[4]. The annual prevalence in the USA is between 15,000 and 20,000[5], and it is estimated that there are approximately 8.12 million people with ONFH in China over the age of 15[6]. On average, ONFH occurs earlier in life than typical osteoarthritis. It is more common in men and the highest prevalence is in men aged 25 to 44 and women aged 55 to 75[6]. The extremely high disability rate and prevalence of ONFH lead to loss of employment and economic burden to patients' families and society. ONFH remains a challenging clinical problem.

High levels of blood triglycerides, high total cholesterol, low density lipoprotein cholesterol, non-high density lipoprotein cholesterol, urban residence, heavy smoking, alcohol abuse, being overweight, coagulopathies, vasculopathies, high exposure to steroids, chemotherapy, and immunosuppressant medication are associated with an increased risk of ONFH[6, 7]. Zhao et al. reported that the odds of ONFH were 35.46 times greater in patients taking corticosteroids and 2.98 times greater in patients with alcoholism[6].

Early detection of ONFH is key to achieving good curative results[8, 9]. It is important to make an early diagnosis of ONFH to allow prompt selection of an effective joint-preserving treatment, including potential nonoperative pharmaco-therapy[10, 11] and joint-preserving surgery[12, 13]. However, there are challenges on clinical accurate diagnosis of ONFH. For instance, patients with ONFH can have coexisting chronic rheumatic and hematological problems, which may lead to diagnostic uncertainty[2]. A physical examination can help identify the anatomical structures that might be causing the pain, because hip pain can originate from multiple hip and non-hip areas. Presentations may be missed because accurate reproduction of groin pain on isolated hip movements can be challenging to elicit in a primary care setting due to time and space constraints. Normal plain radiographs in the early stages of ONFH can be falsely reassuring and delay appropriate referral. If the plain radiograph is negative and the patient continues to complain of hip pain, the doctor may give a diagnosis of non-specific hip pain and send the patient for physiotherapy. Another problem is that the available imaging modalities, including X-ray, nuclear scans, and magnetic resonance imaging (MRI), have differing sensitivities and specificities and their interpretation may be subject to inter-observer and intra-observer differences[14, 15]. Interestingly, in a study on radiological practice, Lee et al. (2014) concluded that current radiological practice in diagnosing ONFH was non-uniform and unsatisfactory[16]. A third problem is that there is a delay between corticosteroid use and ONFH development[17, 18], and even after ONFH has emerged, it may not be detectable on MRI[19, 20]. Therefore, it is easy to misdiagnose ONFH.

Exploring the causes of misdiagnosis of ONFH is of great significance for improving the diagnosis of the disease by clinicians. This study was based on the China Osteonecrosis of Femoral Head Database (CONFHD, http://onfh.keyanyun.com/). The CONFHD was established in 2016, with the purpose of improving the medical management of ONFH patients in mainland China. It is based on the National Key Technology Research and Development Program of the Ministry of Science and Technology of China. The database defines the rights and obligations of clinical cooperation units on the principle of "mutual benefit, equality, voluntary and open sharing." Between 2016 and 2018, the CONFHD recruited more than 2200 ONFH patients through joint efforts of 25 public hospitals from 11 administrative areas (provinces or municipalities) across mainland China. The sampling areas included Beijing Municipality, Shanghai Municipality, Shandong Province, Henan Province, Guangxi Province, Shaanxi Province, Guangdong Province, Jiangsu Province, Fujian Province, Hubei Province, and Jilin province. Data available in the CONFHD includes patients' age, sex, body mass index (BMI), side of the disease, cause of the disease, traditional Chinese medicine (TCM) syndrome type, TCM treatment method, stage, classification, treatment method, and evaluation index of curative effect. This data can be used for standardized diagnosis and treatment of ONFH.

For this retrospective study, we collect patients' general data, causes of ONFH, clinical manifestations, and type of imaging examination at the visit to: (i) evaluate the present situation for the misdiagnosis of ONFH; (ii) analyze risk factors for the misdiagnosis of ONFH; and (iii) through multivariate regression analysis, identify the most significant risk factors among these independent factors. This study may provide a basis for accurate diagnosis of ONFH.

Materials and Methods

A total of 1471 patients with ONFH (collected from the CONFHD and recruited from July 2016 to December 2018) were included in this retrospective analysis. According to whether or not they were misdiagnosed, pateints were divided into a diagnosis group and a misdiagnosis group. There were 303 cases in the misdiagnosis group and 1168 cases in the diagnosis group.

Inclusion Criteria

The inclusion criteria for all patients were as follows: (i) patients with ONFH; (ii) hip pain as the main complaint; (iii) age greater than 18 years old; and (iv) general information, medical history, and medical records were complete.

Exclusion Criteria

Exclusion criteria: (i) data were repeated; (ii) data with common sense errors; and (iii) data with logical errors.

Misdiagnosis Criteria

Misdiagnosis criteria[21]: (i) the patient had the same symptoms and signs, and the second diagnosis was not consistent with the initial diagnosis within 6 months; and (ii) the patient was admitted to a hospital participating in the CON-FHD, and the previous diagnosis was inconsistent with the diagnosis given by the expert group.

Study Methods

The following indicators were measured for each patient enrolled in this study.

Body Mass Index

The BMI was used to measure body fatness and health in an adult population. It is a neutral and reliable indicator, obtained by dividing a person's weight in kilograms by their height in meters squared[22].

Causes of Osteonecrosis of Femoral Head

The causes of ONFH were used to determine the specific factors that cause the disease. Four main aspects were considered: corticosteroids, alcohol, trauma, and others. Corticosteroid use[6, 23], alcohol intake[24], and trauma[25] have been identified as the major risk factors for ONFH. In our study, we subdivided the pathogenic factors. Corticosteroids include three aspects: primary diseases requiring corticosteroids (immune system diseases, skin diseases, urinary diseases, blood diseases, respiratory diseases, and other diseases), methods of corticosteroid use (oral, intravenous, and others), and corticosteroid species (medium, long-lasting, and others). Alcohol intake includes years of alcohol consumption (divided into four levels: (i) ≤10 years; (ii) >10 years, ≤20 years; (iii) >20 years, ≤30 years; and (iv) >30 years) and weekly alcohol consumption (divided into three levels: (i) ≤1500 mL; (ii) >1500 mL, ≤3500 mL; and (iii) ≥3500 mL). According to the type of trauma, trauma includes three aspects: fracture of the femoral neck, dislocation of the hip, and others.

Clinical Manifestations at the Initial Visit

Clinical manifestations at the initial visit were used to record the symptoms of patients and the title of the physician. For the patients who were misdiagnosed, one crucial factor was the symptoms at onset of the disease; another was the doctor's ability to make a correct diagnosis. Therefore, we investigate the symptoms and the physician factor. Clinical manifestations at the initial visit include five aspects: onset side of the disease, pain side, visual analogue scale (VAS) for pain, whether symptoms are hidden, and physician title. The onset side of the disease and pain side are either bilateral or unilateral. Whether symptoms are hidden are identified as hidden or obvious. The VAS score was used to assess the degree of hip joint pain. The score standard has a maximum of 10 points. The higher the score, the more severe the pain. The title of the physician at the initial visit is either a director physician or assistant director physician or an attending doctor or resident doctor.

Type of Imaging Examination at the Initial Visit

For the patients who were misdiagnosed, the third crucial factor is imaging examination. Some of the patients did not have the typical disease manifestation in the early stage, so we investigate the imaging factor. Type of imaging examinations at the initial visit were identified as X-ray, computed tomography (CT), or MRI only, or two or more of the three being performed at the initial diagnosis.

Statistical Analysis

Data analysis was performed using SPSS 20.0 software (SPSS, Chicago, IL). The quantitative data were expressed as the mean plus or minus the standard deviation (mean ± SD). The categorical data were expressed as a percentage. The age, the VAS for pain, and the BMI were compared between the diagnosis and misdiagnosis groups using the t-test. The gender, causes of ONFH, primary diseases requiring corticosteroids, methods of corticosteroid use, corticosteroid species, type of trauma, onset side of the disease, pain side, whether symptoms are hidden, and type of imaging examination at the initial visit were compared using the χ^2-test. Years of alcohol consumption, weekly alcohol consumption, and physician title at the initial visit were compared using the Mann–Whitney U-test. SPSS 20.0 was also used to conduct a logistic regression analysis and to calculate odds ratios (OR). Statistical association was considered significant if the P-value was less than 0.05.

Results

Participants Characteristics in the Misdiagnosis Group

Among 1471 patients with ONFH, 303 patients (20.6%) were misdiagnosed. Among these, 118 cases (38.9%) were misdiagnosed as lumbar disc herniation due to lumbar and leg pain and were treated with dehydration, analgesia, physical therapy, and lumbar minimally invasive surgery, but the symptoms were not significantly relieved. A total of 86 cases (28.4%) were misdiagnosed as hip synovitis due to hip pain after strenuous activities, with symptoms still existing after oral or external application of anti-inflammatory analgesics or external application of Chinese herbal medicine. A total of 48 cases (15.8%) were misdiagnosed as hip osteoarthritis due to hip pain after prolonged labor. They were given oral anti-inflammatory and analgesic drugs and limited lower limb activities. The pain recurred after stopping the drug. A total of 32 cases (10.6%) were misdiagnosed as rheumatoid arthritis due to hip pain and restricted mobility. After oral administration of anti-rheumatic drugs and Chinese herbal medicine, symptoms were not significantly relieved. A total of 11 cases (3.6%) were misdiagnosed as piriformis syndrome,

2 (1.7%) as sciatica, and 3 (1.0%) as soft-tissue injury. The symptoms were not significantly relieved after corresponding treatment.

After the misdiagnosed patients were correctly diagnosed, the treatment methods were chosen according to the "Chinese experts' consensus on the diagnosis and treatment of osteonecrosis of the femoral head in adults"[26]. A total of 56 cases received total hip arthroplasty (THA), 175 cases bone grafting, and 72 cases core decompression combined with Chinese herbal medicine. Symptoms were effectively relieved.

Factors Influencing Misdiagnosis

Sixteen targeted factors were analyzed and compared between the misdiagnosis and diagnosis groups. The composition ratio of causes of ONFH and type of imaging examination at the initial visit in the misdiagnosis group were different from those in the diagnosis group, and the differences were statistically significant (all $P < 0.001$). The proportion of bilateral onset was higher in the misdiagnosis group (49.8%) relative to the diagnosis group (42.8%) ($P = 0.028$). Significantly more participants in the misdiagnosis group (80.9%) had bilateral pain compared with the diagnosis group (73.9%) ($P = 0.012$). Furthermore, significantly more participants in the misdiagnosis group (60.4%) had symptoms hidden as compared with the diagnosis group (35.7%) ($P < 0.001$). The proportion of physician title at the initial visit as attending doctor or resident doctor was also significantly higher in the misdiagnosis group relative to the diagnosis group (85.8% vs 66.4%, $P < 0.001$) (Table 1).

There were no significant differences between the misdiagnosis and diagnosis groups in terms of age, gender, BMI, primary diseases requiring corticosteroids, methods of corticosteroid use, corticosteroid species, years of alcohol consumption, weekly alcohol consumption, type of trauma, and VAS for pain (Table 1).

Logistic Regression Analysis of Influencing Factors of Misdiagnosis

Misdiagnosis was used as the dependent variable, and the statistically significant factors were set as independent variables for logistic regression analysis. Among them, causes of ONFH and type of imaging examination at the initial visit are disorder classification data, expressed by dummy variables. Specific assignment criteria are shown in Table 2.

The following factors were identified in the logistic regression analysis as being significantly associated with misdiagnosis: whether symptoms are hidden ($P = 0.038$, OR = 1.546, 95% CI = 1.025–2.332), physician title at the initial visit ($P < 0.001$, OR = 3.324, 95% CI = 1.850–5.972), X-ray examination ($P < 0.001$, OR = 4.742, 95% CI = 3.159–7.118), corticosteroids ($P < 0.001$, OR = 0.295, 95% CI = 0.163–0.534), alcohol ($P < 0.001$, OR = 0.305, 95% CI = 0.171–0.546), and MRI examination ($P = 0.042$, OR = 0.649, 95% CI = 0.427–0.985). Trauma, onset side of the disease, pain side, and CT examination were not found to differ

significantly between the two groups in this analysis (all $P > 0.05$) (Table 3).

Discussion

Osteonecrosis of the femoral head is an orthopaedic disease with a very high disability rate. Both the joint replacement therapy of THA and the hip-preserving treatment of core decompression have make great progress[27, 28]. In mainland China, orthopaedic surgeons can also choose Chinese herbal medicine as one of the treatment methods for patients[26, 29]. However, accurate diagnosis of ONFH has not been studied as comprehensively as its treatment and few previous studies have reported the risk factors for the misdiagnosis of ONFH in a Chinese population. In 2017, we undertook a case–control study in Beijing, China to evaluate the situation for the misdiagnosis of ONFH. A total of 314 participants were enrolled, and the ratio of the misdiagnosis group to the diagnosis group was 1:2.21; 31.2% of ONFH cases were misdiagnosed[21]. Based on our previous findings, the study presented here was designed and conducted to evaluate the present situation and risk factors for the misdiagnosis of ONFH.

The Present Situation for the Misdiagnosis of Osteonecrosis of the Femoral Head

In this study, 303 patients with ONFH were misdiagnosed with other diseases; the misdiagnosis rate, of 20.6%, is lower than the rate we reported in 2017[21]. The reason may be related to the improvement of diagnostic techniques and the awareness of patients. Among the misdiagnosed cases, more than 90% were misdiagnosed as lumbar disc herniation, hip synovitis, hip osteoarthritis, or rheumatoid arthritis. This suggests that the symptoms and signs of ONFH are highly similar to those of chronic bone diseases in the spine and hip joints. ONFH and lumbar disc herniation may appear as, for instance, lower extremity soreness, functional limitation, or a limp. Misdiagnosis can easily occur without careful collection of patients' medical history and detailed physical examination. Hip synovitis may also appear as hip tenderness, Fabere sign positive, and other manifestations; however, there was no deformation and collapse of the femoral head, which could be identified with ONFH. The main distinguishing point between osteoarthritis of the hip and ONFH is that early X-ray radiographs show narrowing of the joint space but no collapse of the femoral head[30]. Rheumatoid arthritis occurs first in the small joints and later in the large joints; according to the erythrocyte sedimentation rate, C-reactive protein and other laboratory results can be differentiated from ONFH.

Relationships between Risk Factors and Misdiagnosis

Due to the onset of ONFH being hidden, patients may be asymptomatic. With the progression of the disease, inguinal pain would occur, even radiating to the knee, and then limited hip movement, with internal rotation of the pain aggravated. Nam et al.[31] reported that 94% of asymptomatic

FACTORS IN MISDIAGNOSIS OF OSTEONECROSIS

TABLE 1 Associations between various patient characteristics and misdiagnosis

Characteristic	Diagnosis group (N = 1168)	Misdiagnosis group (N = 303)	P-value	t/χ^2/Z-value
Age (years)	52.28 ± 12.01	51.47 ± 10.41	0.239	t = 1.178
BMI (kg/m^2)	23.45 ± 3.97	23.19 ± 5.26	0.441	t = 0.772
Gender			0.260	χ^2 = 1.269
Female (%)	339 (29.0%)	98 (32.3%)		
Male (%)	829 (71.0%)	205 (67.7%)		
Causes of ONFH			<0.001	χ^2 = 87.915
Corticosteroids (%)	408 (34.9%)	72 (23.8%)		
Alcohol (%)	491 (42.0%)	93 (30.7%)		
Trauma (%)	155 (13.3%)	110 (36.3%)		
Others (%)	114 (9.8%)	28 (9.2%)		
Primary diseases requiring corticosteroids			0.148	χ^2 = 8.155
Immune system diseases (%)	142 (34.8%)	23 (31.9%)		
Skin diseases (%)	78 (19.1%)	11 (15.3%)		
Urinary diseases (%)	43 (10.5%)	12 (16.7%)		
Blood diseases (%)	68 (16.7%)	8 (11.1%)		
Respiratory diseases (%)	42 (10.3%)	6 (8.3%)		
Other diseases (%)	35 (8.6%)	12 (16.7%)		
Methods of corticosteroid use			0.203	χ^2 = 3.190
Oral (%)	265 (65.0%)	40 (55.6%)		
Intravenous (%)	92 (22.5%)	18 (25.0%)		
Others (%)	51 (12.5%)	14 (19.4%)		
Corticosteroid species			0.142	χ^2 = 3.904
Medium (%)	196 (48.0%)	32 (44.4%)		
Long-lasting (%)	108 (26.5%)	14 (19.4%)		
Others (%)	104 (25.5%)	26 (36.2%)		
Years of alcohol consumption			0.125	Z = 2.359
≤10 years (%)	167 (34.0%)	37 (39.8%)		
>10 years, ≤20 years (%)	170 (34.6%)	35 (37.6%)		
>20 years, ≤30 years (%)	85 (17.3%)	11 (11.8%)		
>30 years (%)	69 (14.1%)	10 (10.8%)		
Weekly alcohol consumption			0.100	Z = 2.702
≤1500 mL (%)	40 (8.1%)	13 (14.0%)		
>1500 mL, ≤3500 mL (%)	320 (65.2%)	60 (64.5%)		
>3500 mL (%)	131 (26.7%)	20 (21.5%)		
Type of trauma			0.089	χ^2 = 4.846
Fracture of the femoral neck (%)	136 (87.7%)	86 (78.2%)		
Dislocation of the hip (%)	9 (5.8%)	14 (12.7%)		
others (%)	10 (6.5%)	10 (9.1%)		
Onset side of the disease			0.028	χ^2 = 4.815
Bilateral (%)	500 (42.8%)	151 (49.8%)		
Unilateral (%)	668 (57.2%)	152 (50.2%)		
VAS for pain	4.60 ± 0.75	4.85 ± 1.04	0.390	t = 0.870
Pain side			0.012	χ^2 = 6.290
Bilateral (%)	863 (73.9%)	245 (80.9%)		
Unilateral (%)	305 (26.1%)	58 (19.1%)		
Whether symptoms are hidden			<0.001	χ^2 = 60.745
Hidden (%)	417 (35.7%)	183 (60.4%)		
Obvious (%)	751 (64.3%)	120 (39.6%)		
Physician title at the initial visit			<0.001	Z = 6.606
Director physician or assistant director physician (%)	393 (33.6%)	43 (14.2%)		
Attending doctor or resident doctor (%)	775 (66.4%)	260 (85.8%)		
Type of imaging examination at the initial visit			<0.001	χ^2 = 160.521
X-ray	98 (8.4%)	106 (35.0%)		
CT	183 (15.7%)	24 (7.9%)		
MRI	585 (50.1%)	84 (27.7%)		
≥2 types	302 (25.8%)	89 (29.4%)		

BMI, body mass index; CT, computer tomography; MRI, magnetic resonance imaging; ONFH,; VAS, visual analogue scale/score.

ONFH cases gradually develop pain within 5 years. In our study, the results of the logistic regression analysis showed that patients with hidden onset were 1.546 times more likely to be misdiagnosed than those with obvious disease manifestations, and the probability of misdiagnosis was 3.324 times higher when the initial diagnosis was made by an attending doctor or a resident doctor rather than a director physician or an assistant director physician. Concealment

of ONFH and physician title may have an effect on misdiagnosis, which also reflects that the current level of clinicians in China is uneven; in particular, doctors with low-level professional titles are more likely to misdiagnose patients. The history of corticosteroid use OR = 0.295 and the history of alcohol abuse OR = 0.305, which shows that the history of corticosteroid use or alcohol abuse may be a protective factor of misdiagnosis; this also reflects that doctors' and patients' knowledge of corticosteroid use or alcohol abuse may result in a correct diagnosis of ONFH.

Because of the high rate of collapse of ONFH, the treatment strategy emphasizes early diagnosis and early intervention[32]. In our study, the results of the logistic regression analysis show that if only X-ray examination was performed at the initial diagnosis, OR = 4.742. In terms of MRI examination, OR = 0.649 shows that the imaging factor is a crucial factor for the patients misdiagnosed and MRI is effective in the diagnosis of early ONFH[33, 34]. However, if ONFH starts as asymptomatic, patient history of high-dose corticosteroid use or alcohol abuse should considered, and attention should be paid to physical examinations, with the definitive diagnosis not made only based on imaging examination. According to Kaushik et al.[35], medial thigh or groin pain with limitation of hip motion in patients less than 50 years of age should raise the suspicion of ONFH. In our opinion, clinicians' ability to diagnose ONFH is not entirely reflected in the level of physical examination of the hip and the ability to read X-rays, CT, MRI. The key to making a correct diagnosis is careful consideration of patient history, observing the clinical manifestation, and capturing the relevant information for an ONFH diagnosis.

Limitations

This retrospective study has several limitations. First, recall bias is a limitation of case-control studies with a retrospective study design. Second, there are 34 administrative areas (provinces or municipalities) in China, and this study only included patients from 11 administrative areas. In future, we will optimize and improve the various settings of the database, and design a prospective controlled trial to further elucidate related issues.

Conclusion

In conclusion, ONFH is easily misdiagnosed as lumbar disc herniation, hip synovitis, hip osteoarthritis, or rheumatoid arthritis. Patient history of corticosteroid use or alcohol abuse and MRI examination at the initial diagnosis may be protective factors for misdiagnosis. Hidden symptoms,

TABLE 2 Dummy variables definition for predisposing factors of misdiagnosis

Causes of ONFH	Corticosteroids	Alcohol	Trauma	Others
x1	1	2	3	4
x1 (1)	1	0	0	0
x1 (2)	0	1	0	0
x1 (3)	0	0	1	0

Type of Imaging examination at the initial visit	X-ray	CT	MRI	≥2 types
x6	1	2	3	4
x6 (1)	1	0	0	0
x6 (2)	0	1	0	0
x6 (3)	0	0	1	0

CT, computer tomography; MRI, magnetic resonance imaging; ONFH, osteonecrosis of femoral head.

TABLE 3 Multivariate logistic regression analysis of the association between screening factors and misdiagnosis

Screening factors	B	SE	Wald	P	OR	95% CI Lower	95% CI Upper
Causes of ONFH			45.359	<0.001			
Corticosteroids (yes, 1; no, 0)	−1.221	0.303	16.233	<0.001	0.295	0.163	0.534
Alcohol (yes, 1; no, 0)	−1.187	0.296	16.041	<0.001	0.305	0.171	0.546
Trauma (yes, 1; no, 0)	−0.282	0.322	0.769	0.381	0.754	0.402	1.417
Onset side of the disease (bilateral, 1; unilateral, 0)	0.223	0.146	2.356	0.125	1.250	0.940	1.663
Pain side (bilateral, 1; unilateral, 0)	0.342	0.185	3.434	0.064	1.408	0.980	2.021
Whether symptoms are hidden (yes, 1; no, 0)	0.436	0.210	4.316	0.038	1.546	1.025	2.332
Physician title at the initial visit (attending doctor or resident doctor, 1; director physician or assistant director physician, 0)	1.201	0.299	16.150	<0.001	3.324	1.850	5.972
Type of imaging examination at the initial visit			102.152	<0.001			
X-ray (yes, 1; no, 0)	1.556	0.207	56.428	<0.001	4.742	3.159	7.118
CT (yes, 1; no, 0)	0.325	0.308	1.108	0.293	1.383	0.756	2.532
MRI (yes, 1; no, 0)	−0.433	0.213	4.117	0.042	0.649	0.427	0.985

CT, computer tomography; MRI, magnetic resonance imaging; ONFH, osteonecrosis of femoral head; OR, odds ratio; SE, standard error; 95% CI, 95% confidence interval.

physician title at the initial visit as attending doctor or resident doctor and only X-ray examination at the initial diagnosis may be the risk factors for misdiagnosis. Therefore, in clinical diagnosis and treatment, we should consider the history, symptoms, signs, and imaging examination results to prevent the occurrence of misdiagnosis.

Acknowledgments

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