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Analysis of case characteristics and body weight factors of aseptic prosthesis loosening after total hip arthroplasty

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Abstract: *The aim of this study was to investigate the characteristics of aseptic prosthesis loosening after total hip arthroplasty (tha) and explore the risk factors of aseptic prosthesis loosening. Through inclusion and exclusion criteria, a total of 87 cases of aseptic prosthesis loosening after total hip arthroplasty diagnosed in the Second Affiliated Hospital of Guangxi Medical University from June 2012 to May 2023 were collected. The gender, occupation, age, prosthesis type, and body mass index of all patients were statistically analyzed. Among the 87 patients, 52 were male (59.8%) and 35 were female (40.2%), 46 were farmers (52.9%), 22 were civil servants (25.3%), 3 were teachers (3.4%), 6 were unemployed (6.9%) and 10 were other occupations (11.5%). 8 people aged 31-40 (9.2%), 13 people aged 41-50 (14.9%), 21 people aged 51-60 (24.1%), 25 people aged 61-70 (28.7%), 18 people aged 71-80 (20.7%), and 2 people aged 81-90 (2.3%). Most patients with aseptic prosthesis loosening after total hip arthroplasty are most common among farmers, aged 50-70 years old; the most prone to aseptic loosening in early and middle stages is acetabular prosthesis; osteolysis mainly occurs in the acetabular region I and the proximal femur; overweight is a risk factor for early aseptic prosthesis loosening.*

Keywords: *Total hip replacement, Aseptic prosthesis loosening, Case characteristics, Weight factors*

1. Introduction

With the advent of an aging society, the incidence of ischemic necrosis of the femoral head and loss of hip joint function caused by diseases such as femoral neck fractures and inflammatory hip joints is also increasing year by year [1-2]. In response to the disability, deformity, and even death caused by hip joint diseases, total hip arthroplasty (THA) has become a mature technology [3-4]. Currently, total hip arthroplasty is widely applied in clinical practice, but there are some issues with the surgery, such as aseptic prosthesis loosening occurring post-operation [5]. How to effectively prevent aseptic prosthesis loosening and avoid one or even multiple revision surgeries has become an important issue for orthopedic surgeons to address. In-depth research on clinical data can accurately understand the characteristics of cases of aseptic prosthesis loosening after total hip arthroplasty and take targeted measures to reduce the occurrence of loosening.

2. Materials and Methods

2.1 Inclusion and Exclusion Criteria

This study procured ten samples of radiotherapy-sensitive and ten samples of radiotherapy-tolerant colorectal cancer tissues from the Sixth People's Hospital of Nanning. These samples were preserved in an ultra-low temperature freezer at -80°C following ethical approval. The ethical approval number is LL2022010306.

2.2 Methods

Personnel from the research team collected cases from June 2012 to June 2023 at the Second Affiliated Hospital of Guangxi Medical University that met the inclusion and exclusion criteria. Collected data included the patient's gender, age, occupation, type of prosthesis, location of prosthesis loosening,

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Body Mass Index (BMI), X-ray radiographic data, etc. The data obtained were summarized and analyzed to draw conclusions.

2.3 Calculation Formulas and Observation Standards

Body Mass Index (BMI) is calculated as weight (kg) divided by height (m) squared, with units in kg/m^2, where $18.5 \leq BMI < 24$ is considered normal weight, and $BMI \geq 24$ is considered overweight [6]; X-ray radiography is based on Gruen's femoral zones and Delee/Charnley's acetabular zones to observe whether any bone resorption is present. Bone resorption refers to the presence of a radiolucent zone wider than 1mm at the prosthesis-bone or cement-bone interface [7]; Staging of prosthesis loosening: early loosening occurs within 5 years after total hip arthroplasty (<5 years), mid-term loosening occurs between 5-10 years after surgery (≥5 years, <10 years), and late loosening occurs more than 10 years after surgery (≥10 years).

2.4 Statistical Methods

Statistical analysis was conducted using Microsoft Excel (2008 edition, Bellevue, WA) and GraphPad software (La Jolla, CA). Quantitative data are expressed as x±s. Multifactor analysis was performed using logistic regression. Comparisons between groups were conducted using univariate analysis of variance, with $P < 0.05$ considered statistically significant.

3. Results

3.1 Basic Information

A total of 87 cases (87 hips) that visited the Second Affiliated Hospital of Guangxi Medical University from June 2012 to June 2023 and met the case inclusion and exclusion criteria were collected. Among these, there were 52 male cases and 35 female cases, with ages ranging from 31 to 82 years, and an average age of 59.01±13.16 years. The breakdown by hip was 47 left hips and 40 right hips. The primary diseases were ischemic necrosis in 61 cases, femoral neck fractures in 21 cases, and ankylosing spondylitis in 5 cases, as shown in Table 1.

Table 1: Basic Information and Proportional Distribution (%)

Basic Information	Number of Cases	Proportional Distribution
Male	52	59.8
Female	35	40.2
Left Hip	47	54
Right Hip	40	46
Ischemic Necrosis	61	70.1
Femoral Neck Fracture	21	24.1
Ankylosing Spondylitis	5	5.8

3.2 Occupational Distribution

Among the 87 cases, there were 46 farmers, 22 civil servants, 3 teachers, 6 unemployed individuals, and 10 people with other occupations, as shown in Table 2.

Table 2: Occupational Distribution and Proportional Distribution (%)

Occupation	Number of Cases	Proportional Distribution (%)
Farmers	46	52.9
Civil Servants	22	25.3
Unemployed	6	6.9
Teachers	3	3.4
Other Occupations	10	11.5

3.3 Age Distribution

The age distribution is as follows: 8 cases between 31-40 years old, 13 cases between 41-50 years old, 21 cases between 51-60 years old, 25 cases between 61-70 years old, 18 cases between 71-80 years

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old, and 2 cases between 81-90 years old, as shown in Table 3.

Table 3: Age Distribution and Proportional Distribution (%)

Age Group	Number of Cases	Proportional Distribution (%)
31-40	8	9.2
41-50	13	14.9
51-60	21	24.1
61-70	25	28.7
71-80	18	20.7
81-90	2	2.3

3.4 Distribution of Body Mass Index (BMI)

The distribution of BMI is as follows: 9 cases with BMI < 18.5 (underweight), 44 cases with 18.5 ≤ BMI < 24 (normal weight), 25 cases with 24 ≤ BMI < 28 (overweight), and 8 cases with BMI ≥ 28 (obese), as shown in Table 4.

Table 4: Distribution of Body Mass Index (BMI) and Proportional Distribution (%)

BMI	Early Loosening	Mid-term Loosening	Late Loosening
BMI < 18.5	1	4	4
18.5 ≤ BMI < 24	20	16	8
24 ≤ BMI < 28	12	5	9
28 ≤ BMI	1	3	4

3.5 Relationship between Body Mass Index and Aseptic Loosening

To further analyze the relationship between weight and loosening, the cases were divided into two groups: BMI < 24 and BMI ≥ 24, for discussion, as shown in Table 5. The incidence of early aseptic prosthesis loosening after total hip arthroplasty in overweight patients (BMI ≥ 24) was 44.1%, compared to 22.6% in non-overweight (BMI < 24) patients (OR = 2.7, P = 0.037), as shown in Table 6.

Table 5: Distribution of Body Mass Index (BMI) and Proportional Distribution (%)

BMI	Early Loosening	Mid-term Loosening	Late Loosening
BMI < 24	12	23	18
24 ≤ BMI	15	10	9

Table 6: Relationship Between BMI and Early, Mid-term, and Late Aseptic Prosthesis Loosening

Stage	BMI < 24	24 ≤ BMI	OR	95% CI	P-Value
Early Loosening	12/53	15/34	2.7	0.146-0.943	0.037
Mid-term Loosening	26/53	8/34	0.54	2.25-30.956	0.19
Late Loosening	12/53	13/34	0.7	0.184-1.216	0.46

3.6 Location of Prosthesis Loosening

Through reviewing revision surgery records and pre-operative X-ray anteroposterior pelvic films, it was found that among the cases included, there were 41 instances of acetabular prosthesis loosening, 11 instances of femoral prosthesis loosening, and 35 instances of both femoral stem and acetabular prosthesis loosening. Early and mid-term aseptic prosthesis loosening was more commonly observed in acetabular prostheses (P < 0.05), as shown in Table 7.

Table 7: Distribution of Prosthesis Loosening (%)

Stage	Acetabular Prosthesis	Femoral Prosthesis	Acetabular/Femoral Prosthesis
Early Loosening	18 (52.9%)	2 (5.9%)	14 (41.2%)
Mid-term Loosening	13 (46.4%)	6 (21.4%)	9 (32.1%)
Late Loosening	10 (40.0%)	12 (48.0%)	3 (12.0%)

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3.7 Periprosthetic Bone Resorption

Based on the Gruen femoral zones and Delee/Charnley acetabular zones, it was found that the incidence of bone resorption on the acetabular side was highest in Zone I, and on the femoral stem side, bone resorption was most prevalent in the femoral Zones 1, 6, and 7, as shown in Tables 8 and 9.

Table 8: Incidence Rate of Bone Resorption in Acetabular Prosthesis Loosening

Delee/Charnley Zone	I	II	III
Incidence Rate	91.0%	59.7%	40.3%

Table 9: Incidence Rate of Bone Resorption in Femoral Prosthesis Loosening

Gruen Zone	1	2	3	4	5	6	7
Incidence Rate	71.7%	56.5%	39.1%	36.9%	45.7%	67.4%	89.1%

4. Discussion

The Total hip arthroplasty is a primary method for restoring hip joint function lost due to inflammatory joint diseases (osteoarthritis, ankylosing spondylitis, rheumatoid arthritis, joint tuberculosis, etc.), femoral neck fractures, and developmental dysplasia of the hip, reducing hip pain, restoring walking ability, and significantly improving the quality of life [8-10]. Statistics show that the 10-year success rate of total hip arthroplasty has reached 90% or even higher [11]. However, with the acceleration of population aging, the group undergoing total hip arthroplasty is expanding, which means that the number of patients requiring revision surgery for various reasons is also increasing [12]. The most common complication after total hip arthroplasty is aseptic prosthesis loosening caused by bone resorption, accounting for 75%-83% [13].

Current research suggests that the occurrence of aseptic prosthesis loosening due to bone resorption is related to patient factors, prosthesis factors, and surgeon factors, such as the nature of the patient's primary disease, age, the material and design of the prosthesis, and the surgeon's control over the prosthesis placement angle and impact force, all of which can induce bone resorption [14-16]. In-depth research on clinical data can accurately understand the characteristics of cases of aseptic prosthesis loosening caused by bone resorption after total hip arthroplasty and take targeted measures to reduce loosening occurrences.

In this group of cases, we found that farmers were the most common among patients with aseptic prosthesis loosening, primarily occurring between the ages of 50 to 70. This is considered to be related to the large number of farmers, high labor intensity, and low education level leading to poor compliance, consistent with previous research results [17-18]. Furthermore, due to the low family income and weak employment ability of farmers, prosthesis loosening requiring revision surgery would inevitably impose a significant economic burden on them. Therefore, we should strengthen health education, guidance outside the hospital, and provide appropriate support for this group.

Moreover, by dividing the cases into groups with BMI < 24 and BMI ≥ 24 for discussion, we further found that being overweight (BMI ≥ 24) is a significant risk factor for early aseptic prosthesis loosening after total hip arthroplasty ($P=0.037$). Several research groups have retrospectively analyzed multicenter data and concluded that obesity is an independent risk factor for revision after total hip arthroplasty; obese patients have a significantly higher chance of requiring revision within 5 years after THA compared to non-obese patients [19-21]. Globally, over 500 million people suffer from hip dysplasia due to obesity [22]. In 2011, 35% of American adults were classified as obese, and this prevalence is continuing to increase [23]. Obesity is associated with an increased incidence of adverse outcomes and complications after total hip arthroplasty, including prosthesis loosening, infection, and dislocation [24]. Accompanying the expansion of the obese population is an increase in healthcare expenses [25-26]. Early guidance to control weight in this study, focusing on the overweight (BMI ≥ 24) group, concluded that being overweight is related to early revision surgery for aseptic loosening after total hip arthroplasty, with overweight patients having a greater chance of early loosening requiring revision. These results can guide patients to control their weight before undergoing replacement surgery, reducing their weight to normal, which is beneficial not only for obese individuals but also for those who are overweight.

Additionally, we evaluated all patients' X-ray anteroposterior pelvic films to assess the location of prosthesis loosening and the prevalent areas of bone resorption. Early and mid-term prosthesis loosening

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was commonly seen in acetabular prostheses, with bone resorption primarily occurring in the acetabular I zone and the femoral Zones 1, 6, and 7. It is evident that prosthesis stress is mainly concentrated in the acetabular I zone and the proximal femur, hence, during prosthesis placement, it's crucial to fully protect the bone quality in these areas.

5. Conclusions

In summary, this study found that farmers are commonly affected by aseptic prosthesis loosening, with a prevalence in individuals aged 50-70, and early and mid-term aseptic prosthesis loosening commonly involves acetabular prosthesis loosening. Bone resorption primarily occurs in the acetabular I zone and the proximal femur, with overweight being a risk factor for early aseptic prosthesis loosening. It is recommended to strengthen education and support for patients with low educational levels, high labor intensity, and poor compliance, such as farmers. Patients who are overweight are advised to reduce their weight to the normal range before surgery, and during surgery, surgeons should enhance the protection of bone quality in the acetabular I zone and the proximal femur.

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