

Effect of Timing of Weight-Bearing Training on Postoperative Recovery After Hip-Preserving Surgery for Femoral Head Necrosis: A Retrospective Analysis

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Abstract

Background: There is currently no clear consensus regarding whether and when weight-bearing should be initiated following hip-preserving surgery for osteonecrosis of the femoral head (ONFH). This study aimed to investigate the impact of the timing of weight-bearing training on postoperative recovery outcomes in patients undergoing hip-preserving procedures for ONFH.

Methods: A retrospective analysis was conducted on 42 ONFH patients (78 hips) who underwent hip-preserving treatment at the Fourth Medical Center of PLA General Hospital in 2023. Twenty patients (38 hips) were assigned to the control group (no weight-bearing for 8 months postoperatively, followed by partial weight-bearing), and 22 patients (38 hips) were assigned to the weight-bearing (WB) group (non-weight-bearing for 6 weeks postoperatively, then partial weight-bearing, progressing to full weight-bearing at 3 months). Radiographic progression and clinical outcomes were assessed over a minimum follow-up period of 16 months using the Association Research Circulation Osseous (ARCO) classification system.

Results: At 8 months postoperatively, the control group had a significantly lower radiographic progression rate compared to the WB group ($P < 0.05$). However, by the final follow-up, no statistically significant difference in progression rate was observed between the two groups ($P > 0.05$). All progressed hips were classified as Japan Investigation Committee (JIC) type C2. Kaplan–Meier survival analysis showed superior hip survival in the control group at 8 months ($P < 0.05$), though the difference became nonsignificant over time ($P > 0.05$). Functional assessment revealed better hip range of motion in the control group at 8 and 16 months postoperatively ($P < 0.05$), while the WB group demonstrated superior Harris Hip Score (HHS), general health, social function, and health change scores at 16 months ($P < 0.05$).

Conclusion: For patients with ARCO stage IIIA and JIC type C2 ONFH, postoperative weight-bearing should be avoided. In contrast, for patients with JIC types B and C1, appropriately timed weight-bearing training may enhance functional recovery.

Background

Osteonecrosis of the femoral head (ONFH) is a common clinical condition characterized by localized abnormalities in bone metabolism and severely compromises patients' quality of life^{1–4}. In China, the annual incidence is estimated at 75,000 to 150,000 new cases, with approximately 8.12 million individuals affected by non-traumatic osteonecrosis⁵. ONFH has a high disability rate and, if not treated in a timely manner, can rapidly progress to femoral head collapse⁶. In recent years, core decompression combined with stem cells or growth factors has become a mainstream treatment for ONFH, achieving favorable outcomes^{7–10}. However, while most studies have focused on surgical techniques, there remains no clear consensus regarding the optimal timing of postoperative weight-bearing rehabilitation.

Previous studies have suggested^{11–16} that early weight-bearing may enhance bone mineral density and promote osteogenesis. Conversely, other research has indicated¹⁷ that the biomechanical properties of the necrotic area are compromised, and sustained stress on the femoral head may accelerate collapse. From the perspectives of skeletal mechanobiology and Wolff's law, reducing mechanical loading might increase bone resorption, potentially accelerating the development of the crescent sign and the risk of femoral head collapse. On the other hand, from a biomechanical standpoint, weight-bearing restriction reduces mechanical forces on the femoral head and may help prevent structural failure¹⁸. Thus, whether postoperative weight-bearing is advisable after hip-preserving surgery for ONFH remains a controversial issue requiring further investigation.

In this study, we designed a protocol based on the most frequently adopted timeline in the literature^{19–21}, defining a 6-week non-weight-bearing phase, followed by partial weight-bearing, and transitioning to full weight-bearing at 3 months postoperatively in the weight-bearing (WB) group. The control group was restricted from weight-bearing for 8 months (primarily bed-based non-weight-bearing training), followed by partial weight-bearing thereafter. This study aimed to investigate the optimal timing and effects of postoperative weight-bearing training following hip-preserving surgery for ONFH, with the goal of improving patient recovery and quality of life.

Methods

Inclusion and Exclusion Criteria

This study was approved by the Medical Ethics Committee of the General Hospital of the People's Liberation Army (Approval No. 2024KY0147-KS001). The trial was conducted in accordance with the principles of the Declaration of Helsinki. All participants were fully informed of the study objectives and procedures and provided written informed consent prior to enrollment. A total of 42 patients (76 hips) with ONFH who underwent hip-preserving treatment at the General Hospital of the PLA in 2023 were included. Among them, 20 patients (38 hips) were assigned to the control group (complete non-weight-bearing for 8 months, primarily bed-based non-weight-bearing training, followed by partial weight-bearing), and 22 patients (38 hips) were assigned to the WB group (non-weight-bearing for 6 weeks postoperatively, followed by partial weight-bearing, and full weight-bearing starting at 3 months postoperatively).

Preoperative imaging evaluations included standard anteroposterior and lateral X-rays, bilateral hip CT scans, and MRI examinations. Disease staging was performed using the 2019 revised classification of the Association Research Circulation Osseous (ARCO), and only patients with stage I to IIIA lesions were included. Additionally, lesion types were classified according to the Japanese Investigation Committee (JIC) system²². Exclusion criteria were as follows: traumatic ONFH; follow-up duration less than 16 months (excluding patients who received total hip arthroplasty (THA) within 16 months); patients with severe systemic diseases or psychiatric disorders; those deemed ineligible by the attending physicians;

previous recipients of hip-preserving surgery; or individuals unable or unwilling to comply with the study protocol.

Surgical method

Using core decompression combined with bone repair materials and adipose-derived stromal vascular fraction (SVF) for hip preservation treatment.

Imaging and Clinical Assessment

Hip function recovery was evaluated using anteroposterior and lateral pelvic radiographs, as well as hip CT and MRI imaging. Based on the ARCO staging system, radiographic progression was defined as advancement of the disease stage by at least one grade in a given hip, and the progression rate was subsequently calculated.

At 4, 8, and 16 months postoperatively, hip range of motion (ROM) was assessed using a standard universal goniometer²³, Hip joint function was evaluated using the Harris Hip Score (HHS), while pain levels were measured using the Visual Analogue Scale (VAS). Health-related quality of life was assessed using the 36-Item Short Form Health Survey (SF-36)²⁴.

Statistical analysis

For normally distributed data, results were presented as mean (standard deviation); for skewed data, medians and inter quartile range (IQR) were reported. Between-group differences in ROM, HHS, VAS, and SF-36 scores were estimated using linear mixed-effects models. Independent sample *t*-tests and chi-square tests were used to compare group-level differences in continuous and categorical variables, respectively.

Kaplan–Meier survival curves were constructed to illustrate the proportion of patients without radiographic progression over time in each treatment group. Differences between groups were assessed using the log-rank test. All effect estimates were reported with 95% confidence interval (CI). All statistical tests were two-sided, and a significance level of $\alpha = 0.05$ was applied. Statistical analyses were conducted using R version 4.4.2 and SPSS version 25, with independent verification performed by a second investigator.

Results

Table 1
Baseline demographic characteristics of patients

	Control group (n = 38)	WB group (n = 38)	χ²/t value	P value
Age (years)	37.0(9.3)	38.2(10.2)	-0.57	0.574
Male/Female	17/3	20/2	0.46	0.497
BMI (kg/m ²)	25.0(2.9)	25.7(3.5)	-0.91	0.364
Follow-up time (month)	18.7(3.6)	17.6(5.2)	1.21	0.232
Hip involved			2.02	0.156
Unilateral	2(10%)	6(27.3%)		
Bilateral	18(90%)	16(72.7%)		
Total number	38	38		
Etiology			1.70	0.428
Idiopathic	22(57.8)	19(50.0)		
Alcohol	8(21.1)	13(34.2)		
Steroid	8(21.1)	6(15.8)		
ARCO Stage			1.89	0.388
Stage I	3(7.9)	1(2.6)		
Stage II	14(36.8)	11(30.0)		
Stage IIIA	21(55.3)	26(68.4)		
JIC type			2.82	0.245
B	4(10.5)	1(2.6)		
C1	11(29.0)	16(42.1)		
C2	23(60.5)	21(55.3)		

Baseline characteristics of the population

A total of 50 patients were initially recruited for this study. During the follow-up period, 8 patients were excluded due to loss to follow-up. Ultimately, 20 patients (38 hips) were included in the control group, and 22 patients (38 hips) were included in the WB group. The mean follow-up duration was 18 months (range: 13–23 months). There were no statistically significant differences between the two groups in

terms of age, sex, BMI, follow-up duration, number of affected sites, etiology, ARCO stage, or JIC type ($P > 0.05$) (Table 1).

Table 2
Comparison of the radiological progression rates between two groups

	Control			WB			<i>P</i> value
	Hips	Number of progress	Progress rate(%)	Hips	Number of progress	Progress rate(%)	
8 month	38	1	2.6%	38	6	21.1%	0.047
Final follow-up	38	7	15.8%	38	4	26.3%	0.589

Table 3
Preoperative ARCO staging and JIC classification of two groups of hip joint progress

	Control			WB		
	Hips	ARCO Stage	JIC type	Hips	ARCO Stage	JIC type
8 month	1	ⅡA	C2	6	ⅡA	C2
Final follow-up	7	ⅡA	C2	4	3ⅡAⅠⅢ	C2

At 8 months postoperatively, radiographic evaluation showed a progression rate of 2.6% (1/38) in the control group and 15.79% (6/38) in the WB group, with the control group demonstrating significantly better radiographic outcomes ($P < 0.05$). At the final follow-up, the progression rates were 21.05% (8/38) in the control group and 26.32% (10/38) in the WB group, with no statistically significant difference between the two groups ($P = 0.589$) (Table 2). Among the progressed hips, only one was classified as ARCO stage II preoperatively; the remaining cases were all ARCO stage IIIA. All progressed lesions were categorized as JIC type C2 (Table 3). (Fig. 1) shows the cases in the WB group that did not progress 24 months after surgery, while (Fig. 2) shows the cases in the WB group that progressed 8 months after surgery.

Kaplan–Meier survival analysis was performed to estimate radiographic survival of the hips at the 8-month follow-up, with radiographic progression as the event of interest. Within the first 8 months, the control group consistently showed a higher radiographic survival rate than the WB group, with a statistically significant difference between the two groups (log-rank test, $P = 0.049$) (Fig. 3). Over time, the radiographic survival rate of the control group gradually approached that of the WB group, and no statistically significant difference was observed between the groups at the final follow-up (log-rank test, $P = 0.462$) (Fig. 4).

Function result

Table 4
Comparison of hip joint range of motion between two groups of patients.

	Control		WB		Treatment effect, mean(95%CI)	<i>P</i> value
	Mean(SD)	No. of hips	Mean(SD)	No. of hips		
Flexion						
Baseline	104.32 (10.53)	38	101.87 (9.46)	38	2.45 (-2.13 ,7.02)	0.290
4 mo ^a	96.37 (14.87)	35	90.79 (11.88)	36	5.58 (-0.57, 11.73)	0.075
8 mo	107.26 (12.69)	35	99.68 (11.59)	36	7.58 (2.03,13.13)	0.008
16 mo	115.08 (11.07)	32	104.92 (14.15)	34	10.16 (4.35,15.96)	0.001
Extension						
Baseline	18.16 (8.97)	38	16.03 (12.03)	38	2.13 (-2.72, 6.98)	0.384
4 mo	18.82 (9.71)	35	15.42 (8.10)	36	3.39 (-0.69, 7.48)	0.102
8 mo	26.42 (10.13)	35	21.08 (9.67)	36	5.34 (0.82, 9.87)	0.021
16 mo	33.47 (12.32)	32	23.29 (12.81)	34	10.18 (4.44, 15.93)	0.001
Adduction						
Baseline	25.71 (13.65)	38	23.24 (13.33)	38	2.47 (-3.69, 8.64)	0.427
4 mo	26.13 (10.78)	35	16.89 (9.80)	36	9.24 (4.53, 13.94)	0.001
8 mo	34.71 (10.53)	35	25.53 (11.50)	36	9.18 (4.14, 14.22)	0.001
16 mo	36.92 (11.33)	32	28.39 (12.97)	34	8.53 (2.96, 14.09)	0.003
Abduction						
Baseline	32.18 (8.10)	38	30.00 (11.19)	38	2.18 (-2.28, 6.65)	0.333
4 mo	29.29 (10.69)	35	24.61 (11.21)	36	4.68 (-0.32, 9.69)	0.066
8 mo	37.50 (14.20	35	30.11 (12.45	36	7.39 (1.29, 13.50	0.018

	Control		WB		Treatment effect, mean(95%CI)	<i>P</i> value
	Mean(SD)	No. of hips	Mean(SD)	No. of hips		
	)		)		)	
1 mo	42.37 (14.08)	32	34.37 (12.67)	34	8.00 (1.88, 14.12)	0.011
^a mo refers to month						

We used a universal goniometer to measure the hip joint mobility of patients before surgery and at 4, 8, and 16 months postoperatively. There was no statistically significant difference between the two groups before surgery ($P > 0.05$). At 4 months postoperatively, the adduction mobility of the control group was better than that of the WB group ($P < 0.05$). At 8 and 16 months postoperatively, the hip joint mobility of the control group was better than that of the WB group ($P < 0.05$) (Table 4).

We compared the VAS scores and HHS scores of two groups of patients. The results showed that there was no statistically significant difference in VAS scores between the two groups ($P > 0.05$). At the 16-month follow-up, the HHS score of the WB group was better than that of the Control group, with a statistically significant difference ($P < 0.05$). The hips with radiological progression did not undergo THA at the final follow-up, as postoperative pain symptoms were alleviated, thereby delaying the need for THA (Table 5).

Table 5
Comparison of VAS and HHS scores between two groups of patients.

	Control		WB		Treatment effect, mean(95%CI)	<i>P</i> value
	Mean(SD)	No. of hips	Mean(SD)	No. of hips		
VAS ^b						
Baseline	4.32 (1.74)	38	4.03 (1.85)	38	0.29 (-0.53, 1.11)	0.485
4 mo	3.68 (1.53)	36	3.79 (1.45)	35	-0.11 (-0.79, 0.58)	0.759
8 mo	2.37 (1.55)	36	2.00 (1.27)	35	0.37 (-0.28, 1.02)	0.261
16 mo	1.24 (1.32)	34	1.24 (1.50)	34	0.00 (-0.65, 0.65)	1.000
HHS ^c						
Baseline	69.63 (16.51)	38	71.21 (12.23)	38	1.58 (-5.06, 8.22)	0.637
4 mo	56.11 (14.42)	36	60.66 (12.01)	35	4.55 (-1.51, 10.62)	0.139
8 mo	66.63 (14.00)	36	71.71 (10.30)	35	5.08 (-0.54, 10.70)	0.076
16 mo	74.84 (15.26)	34	81.79 (11.71)	35	6.95 (0.73, 13.16)	0.029
^b Based on an 11-point numerical pain scale (range, 0–10; higher scores indicate more severe pain).						
^c Based on the Harris hip score (scale range, 0-100; higher scores indicate more hip joint function).						

In terms of quality of life, at 8 months, the WB group showed better General health than the control group, with a statistically significant difference ($P < 0.05$). At 16 months, the WB group had better General health, Social function, and Health change than the control group, with a statistically significant difference ($P < 0.05$) (Table 6).

Table 6
Comparison of SF-36 scores between two groups of patients.d

	Control		WB		Treatment effect, mean(95%CI)	<i>P</i> value
	Mean(SD)	No. of hips	Mean(SD)	No. of hips		
Physical function						
Baseline	58.32 (16.02)	38	60.26 (13.40)	38	1.95 (-4.80, 8.70)	0.567
4 mo	31.45 (14.23)	36	37.37 (12.18)	37	5.92 (-0.13, 11.98)	0.055
8 mo	45.79 (19.50)	36	48.58 (16.89)	35	2.79 (-5.55, 11.13	0.507
12 mo	60.55 (17.97)	34	62.24 (16.75)	32	1.68 (-6.26, 9.63)	0.674
Role- physical						
Baseline	13.29 (22.70)	38	13.16 (20.74)	38	-0.13 (-10.07, 9.81)	0.979
4 mo	2.63 (9.71)	36	3.29 (10.35)	37	0.66 (-3.93, 5.24)	0.776
8 mo	11.18 (22.28)	36	10.53 (16.06)	35	-0.66 (-9.54, 8.22)	0.883
12 mo	30.26 (28.57)	34	36.45 (26.12)	32	6.18 (-6.33, 18.70)	0.328
Bodily pain						
Baseline	49.00 (18.46)	38	47.29 (14.81)	38	-1.71 (-9.36, 5.94)	0.657
4 mo	51.29 (16.45)	36	58.50 (17.41)	37	7.21 (-0.53, 14.95)	0.068
8 mo	64.74 (18.04)	36	69.29 (19.11)	35	4.55 (-3.94, 13.05)	0.289
12 mo	80.37 (16.94)	34	76.42 (22.54)	32	-3.95 (-13.06, 5.17)	0.391
General health						
Baseline	59.97 (16.80)	38	62.21 (13.34)	38	2.24 (-4.70, 9.17)	0.522

	Control		WB		Treatment effect, mean(95%CI)	<i>P</i> value
	Mean(SD)	No. of hips	Mean(SD)	No. of hips		
4 mo	61.37 (15.62)	36	69.05 (12.78)	37	7.68 (1.16, 14.21)	0.022
8 mo	66.55 (16.56)	36	73.82 (13.67)	35	7.26 (0.32, 14.20)	0.041
12 mo	68.45 (21.89)	34	78.18 (13.20)	32	9.74 (1.47, 18.00)	0.022
Vitality						
Baseline	63.29 (19.53)	38	63.03 (15.05)	38	-0.26 (-8.23, 7.71)	0.948
4 mo	52.50 (12.72)	36	53.32 (12.73)	37	0.82 (-5.00, 6.63)	0.781
8 mo	63.29 (12.10)	36	65.82 (12.76)	35	2.53 (-3.16, 8.21)	0.379
12 mo	76.58 (13.81)	34	75.87 (14.74)	32	-0.71 (-7.24, 5.82)	0.829
Social function						
Baseline	65.49 (22.19)	38	59.06 (20.03)	38	-6.43 (-16.09, 3.23)	0.189
4 mo	48.53 (17.41)	36	49.12 (18.92)	37	0.58 (-7.73, 8.89)	0.889
8 mo	98.83 (12.52)	36	104.18 (17.80)	35	5.35 (-1.69, 12.38)	0.134
12 mo	104.07 (15.23)	34	115.02 (11.26)	32	10.95 (4.83, 17.08)	0.001
Role- emotion						
Baseline	41.23 (39.08)	38	30.96 (28.10)	38	-10.26 (-25.82, 5.30)	0.193
4 mo	12.28 (26.19)	36	16.93 (27.56)	37	4.65 (-7.64, 16.94)	0.453
8 mo	33.59 (29.76)	36	32.80 (28.10)	35	-0.79 (-14.02, 12.44)	0.906
12 mo	54.65 (32.86)	34	60.79 (32.28)	32	6.14 (-8.75, 21.03)	0.414

	Control		WB		Treatment effect, mean(95%CI)	<i>P</i> value
	Mean(SD)	No. of hips	Mean(SD)	No. of hips		
Mental health						
Baseline	66.53 (17.58)	38	66.37 (15.14)	38	-0.16 (-7.66, 7.34)	0.967
4 mo	68.32 (15.20)	36	70.05 (14.53)	37	1.74 (-5.06, 8.53)	0.612
8 mo	72.21 (15.99)	36	73.16 (14.07)	35	0.95 (-5.94, 7.83)	0.785
12 mo	76.21 (17.09)	34	75.82 (14.50)	32	-0.39 (-7.64, 6.85)	0.914
Health change						
Baseline	9.87 (16.99)	38	8.55 (15.68)	38	-1.32 (-8.79, 6.16)	0.727
4 mo	59.21 (24.26)	36	71.05 (16.97)	37	11.84 (2.27, 21.41)	0.016
8 mo	73.95 (23.86)	36	83.55 (19.52)	35	9.61 (-0.36, 19.57)	0.059
12 mo	77.63 (24.52)	34	88.16 (17.18)	32	10.53 (0.85, 20.20)	0.033
^d Based on the Medical Outcomes Study 36-Item Short-Form Health Survey (scale range, 0-100; higher scores indicate a better health state).						

Adverse Events

No adverse events occurred.

Discussion

Our research indicates that at 8 months, the control group had only 1 hip joint progression, while the WB group had 6 hip joint progressions ($P < 0.05$), and all progressed hip joints were at ARCO⊠A stage, with JIC classification all being type C2. At the final follow-up, there was no statistical difference in progression rates between the two groups ($P > 0.05$), and among the progressed hip joints at the final follow-up, only 1 was at ARCO⊠ stage, while the others were all at ⊠A stage, with JIC classification all being type C2. Functional outcomes indicated that at the final follow-up, the WB group performed better than the control group. This suggests that patients at ARCO⊠ and ⊠ stages are not affected by weight-

bearing postoperatively, and patients at ARCO stage C1 can also bear weight postoperatively. Postoperative weight-bearing can improve clinical functional levels; however, for patients at ARCO stage C2, postoperative weight-bearing may accelerate femoral head collapse.

The cause of femoral head collapse is still unclear. Yang et al.²⁵ indicated that the collapse of necrotic femoral heads is caused by fatigue fractures, which occur due to continuous stress on the femoral head and the weakening of bone strength in the necrotic area, leading to microfractures in the primary region. The repair process is then activated, but due to ongoing risk factors, there may be an imbalance between repair and microfractures, resulting in collapse. Ma JX et al.¹⁷ suggested that enhancing bone strength may be an effective method for preventing and treating ONFH due to the internal structural and stress imbalances within the femoral head. Chen WH et al.²⁶ indicated that after stress relief in the femoral head, the revascularization of the femoral head accelerates, and the use of anti-osteoporosis medications can reduce bone resorption and promote bone repair in the femoral head. Therefore, for ARCO stage IIIA type C2 ONFH, it is advisable to avoid weight-bearing postoperatively, and taking medications that enhance bone strength may be a good option, with specific weight-bearing times assessed based on radiological results. Wen PF et al.²⁷ indicated that the cortical part of the lateral column is the main biomechanical support for the femoral head. Ma XL et al.¹⁷ noted that the biomechanical properties of the necrotic area are weaker, while the sclerotic area becomes stronger. In our study, there was no collapse observed in JIC type B and C1, and at the final follow-up, no collapse was noted, indicating that weight-bearing training can be performed postoperatively for types B and C1.

Research shows^{28,29} that during partial weight bearing after surgery, bilateral axillary crutches can reduce lower limb weight bearing by about 80%, while bilateral elbow crutches can reduce weight bearing on the affected limb by 40%. Therefore, in the first six weeks post-surgery, bilateral axillary crutches can be used, gradually transitioning to bilateral elbow crutches. When using a walker, it is important to avoid prolonged pressure to prevent vascular and nerve damage. Partial weight bearing (PWB) refers to the percentage of body weight supported by the affected lower limb. For example, a gait with 10% PWB means that the affected side bears 10% of the body weight, while the remaining weight is supported by the crutches³⁰. For the weight-bearing group, the first six weeks post-surgery should maintain a non-weight bearing status, then gradually increase weight bearing every two weeks, in sequence as 1/3 weight bearing, 1/2 weight bearing, and 2/3 weight bearing, with full weight bearing allowed after 12 weeks of treatment. The choice of gait for ONFH patients after surgery depends on whether the lesion is unilateral or bilateral, as well as the ARCO stage and JIC classification. After hip preservation surgery, using a three-point gait and a two-point gait can effectively achieve PWB. Subsequently, patients can adopt a bilateral crutch weight-bearing swing gait, and finally gradually walk without crutches.

The innovation of this study lies in the first systematic exploration of the impact of the timing of weight-bearing training on rehabilitation outcomes in patients with ONFH after hip preservation surgery. Although previous studies have proposed different viewpoints on the timing of weight-bearing training²¹,

we confirmed the effects of different weight-bearing strategies on postoperative radiological progression rates and clinical functional outcomes by retrospectively analyzing clinical data from 42 patients. These results provide important references for subsequent research and offer a new perspective for the formulation of clinical treatment plans.

The limitations of this study lie in the small sample size and the fact that it was conducted at a single center, which may affect the generalizability of the results. Additionally, the study did not explore biological mechanisms, and the follow-up period was relatively short, which may not fully reflect the long-term effects. Therefore, future research should expand the sample size and consider multi-center data support to enhance the reliability of the results. At the same time, the follow-up period should be extended to assess the effects of weight-bearing training in the long-term rehabilitation process. These improvements will help deepen the understanding of the long-term impact of weight-bearing training on different types of ONFH patients and provide a basis for more comprehensive clinical practice.

Conclusion

For patients with ARCO IIIA stage JIC type C2, weight-bearing should be avoided postoperatively, while patients of type B and C1 should initiate weight-bearing training appropriately after surgery.

Abbreviations

ONFH Osteonecrosis of the Femoral Head

WB Weight-bearing

ARCO Association Research Circulation Osseous

JIC Japan Investigation Committee

HHS Harris hip score

THA Total hip arthroplasty

SVF Adipose-derived stromal vascular fraction

ROM Range of motion

VAS Visual analogue scale

SF-36 36-Item Short Form Health Survey

IQR Inter quartile range

CI Confidence interval

Declarations

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Author contributions

Jiang peng designed the study. Tingjie zhao contributed to the data analysis. All authors reviewed the manuscript.

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Data availability

The datasets generated and/or analyzed during the current study are not

publicly available due to limitations of ethical approval involving the patient data and anonymity but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of the General Hospital of the People's Liberation Army of China.e (Approval No: 2024KY098-KS001,approval date: 2 September 2024). The experiment adheres to the principles set forth in the Declaration of Helsinki, and all participants were formally informed of the purpose and content of the research and signed an informed consent form.

Clinical trial number: Not applicable

Competing interests

The authors declare no competing interests.

Consent for publication

Not applicable

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Figures

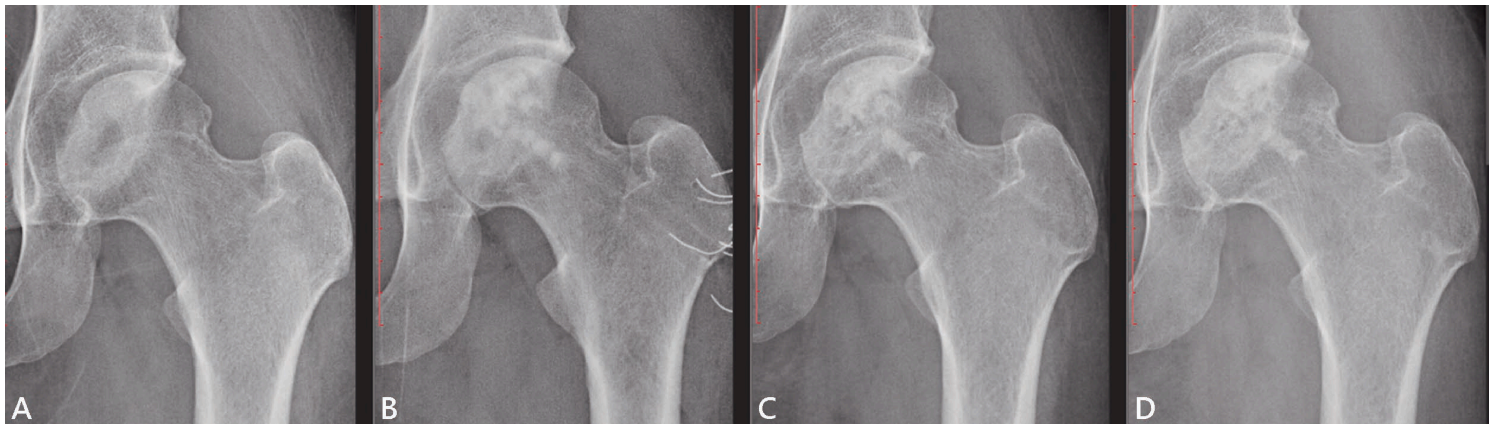


Figure 1

A case of a 29-year-old with left femoral head necrosis (ARCO stage IIIA, JIC type B), **A** is the preoperative X-ray, **B** is 3 days post-surgery, **C** is 12 months post-surgery, **D** is 24 months post-surgery, and the X-rays show no progression.

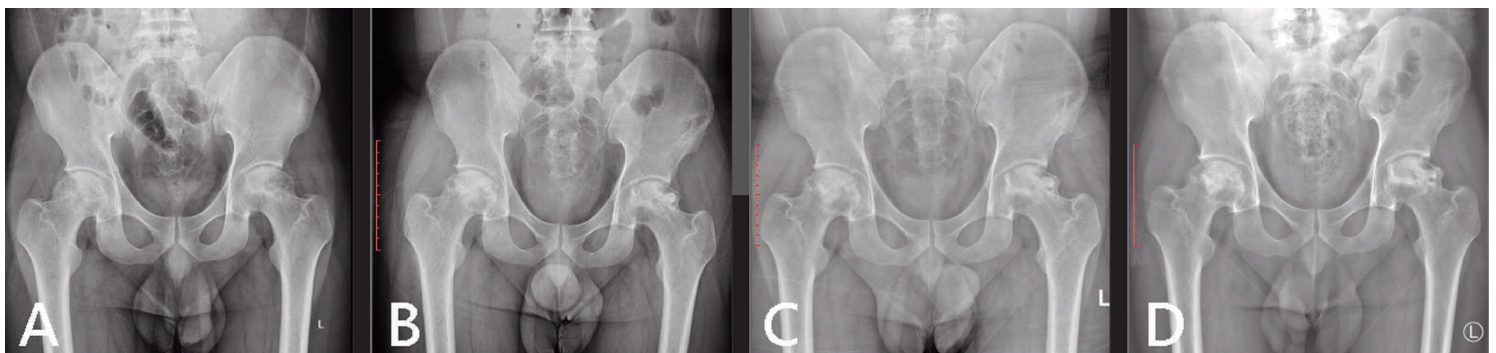


Figure 2

A case of a 24-year-old with bilateral femoral head necrosis (both sides are ARCO stage IIIA, JIC type C2), **A** is the preoperative X-ray, **B** is 6 days post-operation, **C** is 8 months post-operation, **D** is 12 months post-operation, the X-ray shows bilateral progression.

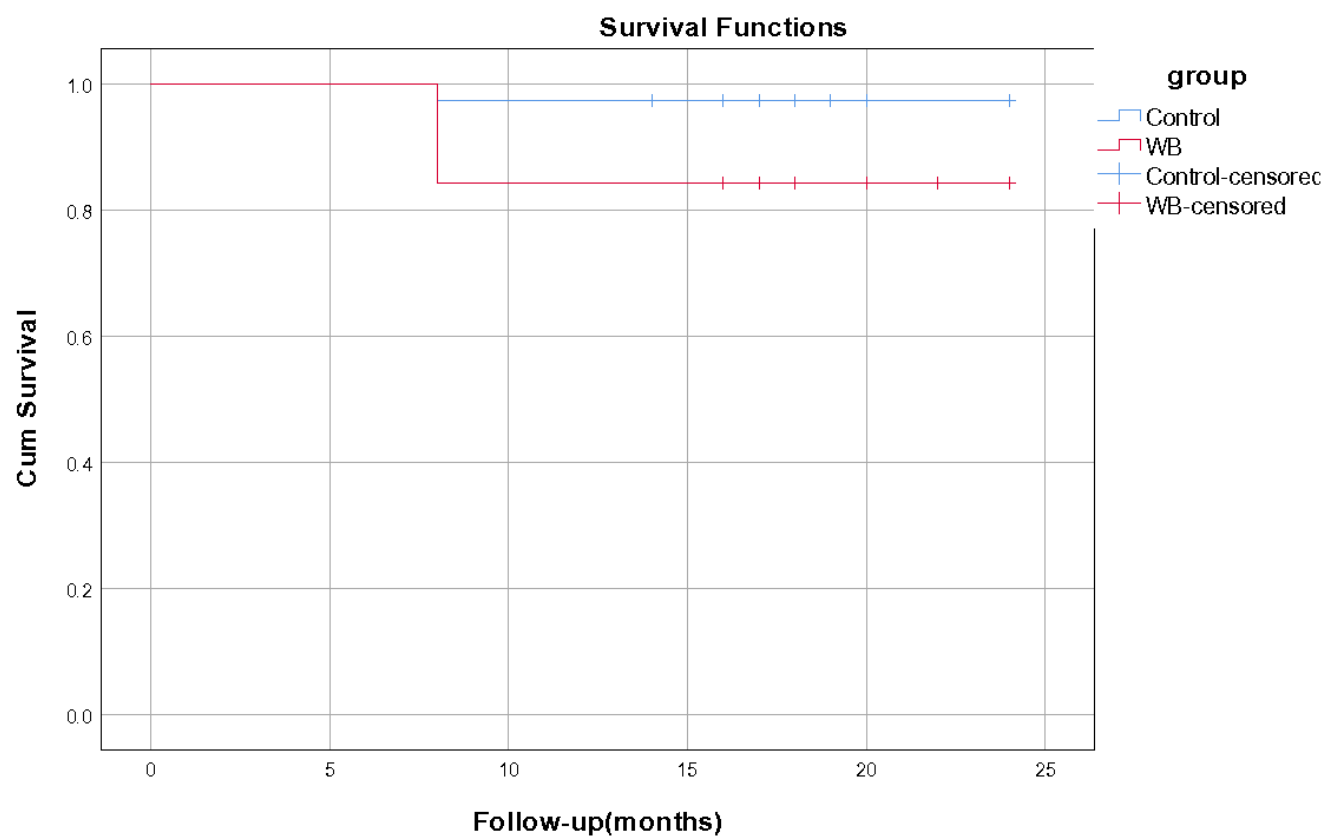


Figure 3

The cumulative proportion of patients with no progression in imaging at eight months

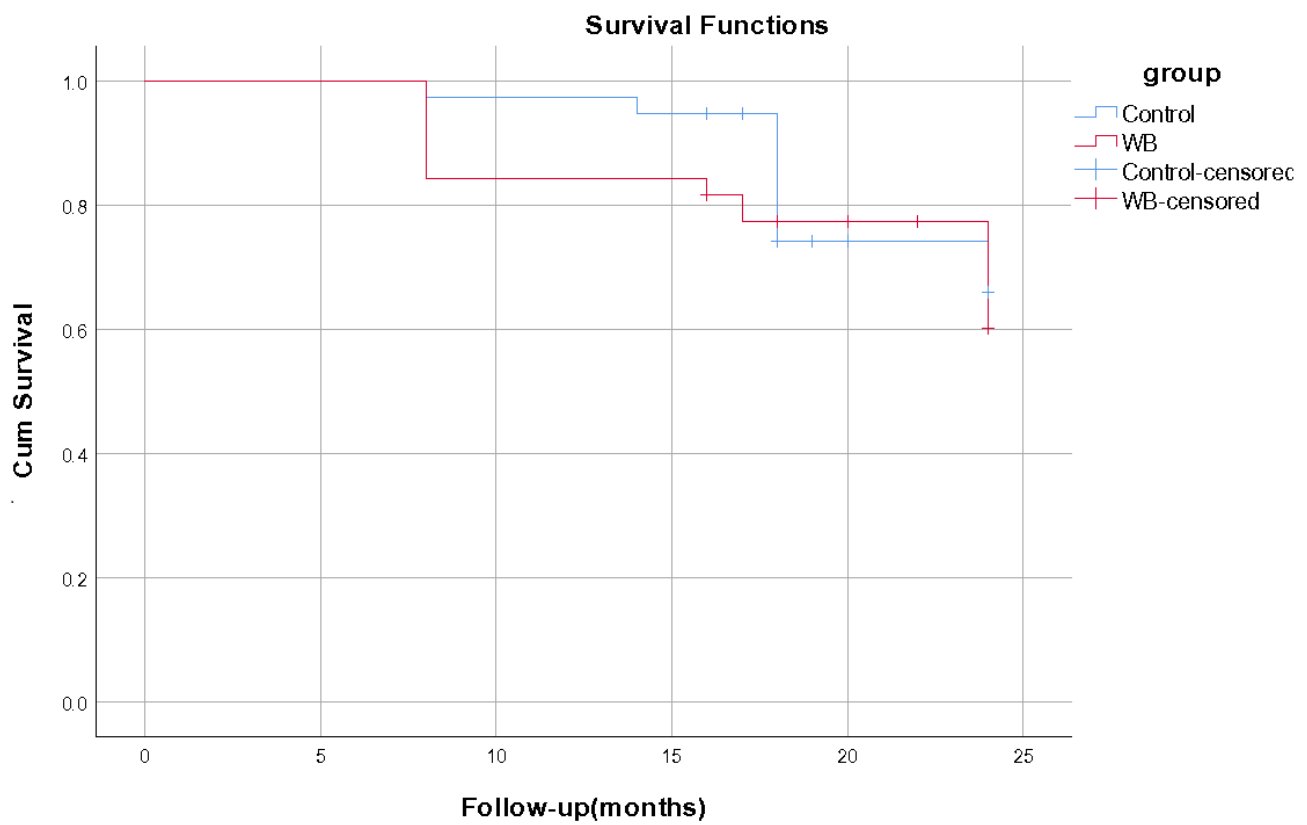


Figure 4

The cumulative proportion of patients with no progression in imaging at the final follow-up