

Conditions before Collapse of the Contralateral Hip in Osteonecrosis of the Femoral Head

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Background: Osteonecrosis of the femoral head is a disease which may cause rapid femoral head collapse in relatively young patients. Clinical results of prosthesis replacement in osteonecrosis patients are generally poorer than in age-matched patients with other diagnoses. The ultimate goal in treating these patients is therefore to preserve not replace the involved femoral head. The purposes of this study were to analyze outcomes by examining osteonecrotic hips before collapse and to justify the role of early surgical intervention for osteonecrosis of the femoral head.

Methods: Between 1993 and 1997, there were 275 consecutive patients with osteonecrosis of the femoral head who received joint replacement on 1 side. Among these patients, 100 contralateral hips with evidence of osteonecrosis in the stage before collapse were included in this study. Demographic information, laboratory data, and radiographs were reviewed and compared between patients whose collapse time was less than 1 year, between 1 and 2 years, and more than 2 years, and those who had no collapse at the latest follow-up.

Results: At the final follow-up, the overall collapse rate was 78%, and the collapse time was generally within 2 years. Patients with younger age (less than 50 years old), higher activity levels, and higher serum triglyceride levels were at higher risk of rapid collapse.

Conclusion: In conclusion, we found that the disease progression rate is high in patients who have bilateral femoral head involvement. Early surgical intervention to preserve the femoral head should be adopted to prevent early femoral head collapse in these patients. In addition, risk factors such as high activity levels and abnormal lipid metabolism should also possibly be addressed in the therapeutic modality.

(Chang Gung Med J 2002;25:228-37)

Key words: femoral head, hip replacement, osteonecrosis.

Osteonecrosis of the femoral head is a disease which may cause rapid, bilateral femoral head collapse in relatively young patients.^(1,2) A number of studies in the orthopedic literature consist of

attempts to describe the natural history of osteonecrosis. These attempts are frequently limited by the lack of uniformity of definition, by the selection criteria of patient populations, by

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Received: May 22, 2001; Accepted: Nov. 17, 2001

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differences in staging systems, and by the manner in which the results are reported.⁽³⁾ However, those studies still are good clinical references especially when they focus on a specific patient group,⁽⁴⁻⁹⁾ are based on a well-designed staging system,⁽¹⁰⁻¹³⁾ or use magnetic resonance imaging to predict subsequent collapse.⁽¹⁴⁻¹⁷⁾

Unfortunately, conclusions from different studies are often contradictory to one another. Jergesen and Shabi Khan, in a review of 75 patients with asymptomatic osteonecrosis of the femoral head, concluded that few hips with normal findings on initial radiographs are at risk for pain or radiographic abnormalities; they further concluded that when disease does develop, deterioration is slow and operative intervention is rarely indicated.⁽⁷⁾ On the other hand, Bradway and Morrey,⁽⁴⁾ Davidson et al.,⁽⁵⁾ and Lee et al.⁽⁹⁾ found that most patients with asymptomatic hips progress to symptomatic disease and may be candidates for early surgical intervention. In this study, we reviewed the disease progression rate in a specific group of patients who developed advanced osteonecrosis in one hip but had early disease in the contralateral hip. The purposes of this study were to analyze outcomes of osteonecrotic hips prior to collapse and to justify the role of early surgical intervention for osteonecrosis of the femoral head.

METHODS

Of 275 consecutive patients with advanced osteonecrosis of the femoral head who had prosthesis replacement on one hip from 1993 to 1997, 215 (78%) had evidence of bilateral femoral head osteonecrosis initially or during follow-up. Among these 215 patients, 100 hips in the stage prior to collapse were included in the study. All these patients were regularly followed-up at 3-month intervals for the hip prostheses; at the same time, radiographs of the pelvis in anteroposterior view and frog lateral view were taken. Each radiograph was reviewed and classified according to the International Association Research Circulation Osseous (ARCO) system⁽¹⁰⁾ (Table 1) and Ohzono's classification^(11,12) (Table 2) by two orthopedic surgeons on two separate occasions. If there were either interobserver or intraobserver inconsistencies concerning the classification, a decision was made after full discussion. The original definition of ARCO stage 0 osteonecrosis is based on

Table 1. International Classification (Association Research Circulation Osseous) of Osteonecrosis of the Femoral Head

Stage	Characteristics
0	Bone-biopsy results consistent with avascular necrosis; normal findings on all other tests
I	Positive scintiscan or magnetic image, or both; lesions subdivided into medial, central, or lateral depending on location of involvement of femoral head
IA	< 15% involvement of femoral head
IB	15%-30% involvement of femoral head
IC	> 30% involvement of femoral head
II	Radiographic abnormalities (mottled appearance of femoral head, osteosclerosis, cyst formation, and osteopenia); no signs of collapse of femoral head on radiographs or computed tomography; positive scintiscan and magnetic resonance image; no changes in acetabulum; lesions subdivided into medial, central, or lateral depending on location of involvement of femoral head
IIA	< 15% involvement of femoral head
IIB	15%-30% involvement of femoral head
IIC	> 30% involvement of femoral head
III	Crescent sign; lesions subdivided into medial, central, or lateral depending on location of involvement of femoral head
IIIA	< 15% crescent sign or <2-mm depression of femoral head
IIIB	15%-30% crescent sign or 2- to 4-mm depression of femoral head
IIIC	> 30% crescent sign or 4-mm depression of femoral head
IV	Articular surface flattened radiographically, and joint space shows narrowing; changes in acetabulum with evidence of osteosclerosis, cyst formation, and marginal osteophytes

bone biopsy results that are consistent with osteonecrosis. In this study, using the retrospective review of patients' radiographs, cases with initial normal radiographic findings which subsequently developed osteonecrosis of the femoral head were classified as ARCO stage 0. Diagnoses of osteonecrosis of the remaining cases were either confirmed by bone scan or magnetic resonance imaging.

Demographic data, etiology, amount of alcohol or steroid use, body weight, body mass index, activity levels, and laboratory data including hemogram, prothrombin time, partial thromboplastin time, liver and renal functions, and serum levels of albumin, amylase, cholesterol, and triglycerides were record-

Table 2. Ohzono's Classification of Avascular Necrosis of the Femoral Head

Type	Characteristics
I	Presence of a necrotic mass involving the zone of the femoral head in contact with the weight-bearing surface of the acetabulum
IA	< 1/3 of the weight-bearing zone of the femoral head
IB	1/3-2/3 of the weight-bearing zone of the femoral head
IC	> 2/3 of the weight-bearing zone of the femoral head
II	Equivocal osteosclerotic lines demarcating the necrotic bone mass and flattening of the weight-bearing surface of the femoral head but without radiographically recognizable osteoarthritic changes
III	Necrotic lesion with a cyst like appearance
IIIA	The subchondral cortical bone shell of the weight-bearing zone not involved
IIIB	The entire cystic area located just beneath the lateral 2/3 of the weight-bearing zone

ed. Activity levels were defined as low for sedentary jobs or housework; intermediate for jobs which required standing or walking less than 4 h/day and without the need to carry heavy objects during work; and high for jobs which required standing or walking for more than 4 h/day or having to carry heavy objects during work. The time period before radiographic evidence of collapse (ARCO Stage III) was defined as collapse time.

Statistical analysis

Demographic data and laboratory data were compared between collapsed- and non-collapsed-hip groups using logistic regression. Multivariate analysis of variance (MANOVA) and post-hoc Newman-Keuls multiple comparisons were used to compare groups of patients with different collapse times. Chi-

squared test was used to determine whether activity levels influenced the final outcomes of osteonecrosis of the femoral head. A *p* value of less than 0.05 was considered statistically significant.

RESULTS

Demographic data

One hundred hips were followed for an average of 31 months (range, 6 to 202 months). The most common etiology was alcohol-induced (58%) followed by idiopathic (27%), steroid-induced (13%), and radiation osteonecrosis (1%). The overall collapse rate was 78%; and was 83% for alcohol-induced ones; 68.8% for idiopathic; 78.6 % for steroid-induced,; and 100% for radiation.

ARCO Staging (Table 3)

Stage 0 Osteonecrosis

Thirty-one hips without evidence of osteonecrosis at the time of presentation were included. Two hips progressed to stage III, and 26 hips progressed to stage IV (total, 83.9%) with an average collapse time of 22.8 months. The remaining 3 hips progressed to stage II but were asymptomatic at the final follow-up.

Stage I Osteonecrosis

Five hips were in stage I at the time of the first examination. All 3 hips with stage IC involvement progressed to stage IV with an average collapse time of 14 months. The other 2 hips (stages IA and IB) were still in the stage prior to collapse at the final follow-up examination.

Stage II Osteonecrosis

Sixty-four hips presented with stage II disease

Table 3. Outcomes of Osteonecrosis According to the ARCO Classification

Final case no.	0	IA	IB	IC	IIA	IIB	IIC	III	IV	Collapse rate (%)	Collapse time (months)
Initial case no.											
0	31				1		2	2	26	83.9	22.8
IA	1	1								0	-
IB	1						1			0	-
IC	3								3	100	14.0
IIA	7				2	2		1	2	42.8	13.3
IIB	14		2			5		1	6	50.0	14.4
IIC	43						6	6	31	86.0	18.2

initially. Of these hips, 7 were in stage IIA. Three of these 7 hips (42.8%) progressed to stage III or IV with an average collapse time of 13.3 months. Fourteen hips were in stage IIB at the first examination, and 7 (50%) of them progressed to stage III or IV in an average of 14.4 months. There were 2 cases initially classified as in stage IIB which showed radiographic evidence of improvement during follow-up. (Fig. 1) The remaining 5 stage IIB cases remained at

the same stage. Forty-three hips were classified as stage IIC initially, and 37 (86%) of these progressed to stage III or IV in an average of 18.2 months (Fig.2).

Ohzono Classification (Table 4)

Ohzono Type I

One of the 3 Ohzono type IA hips collapsed after 28 months. Five hips were classified as



Fig. 1 Improvement in radiographic staging of osteonecrotic femoral head. (A) ARCO stage IIB and Ohzono type IB on initial radiographic examination. (B) Frog lateral view of the same hip. (C) At 6 months, the boundary of the osteonecrotic foci showing sclerotic changes. (D) At 1 year, improvement shown in radiographic staging of the involved femoral head (stage IB). The patient was free of symptoms.

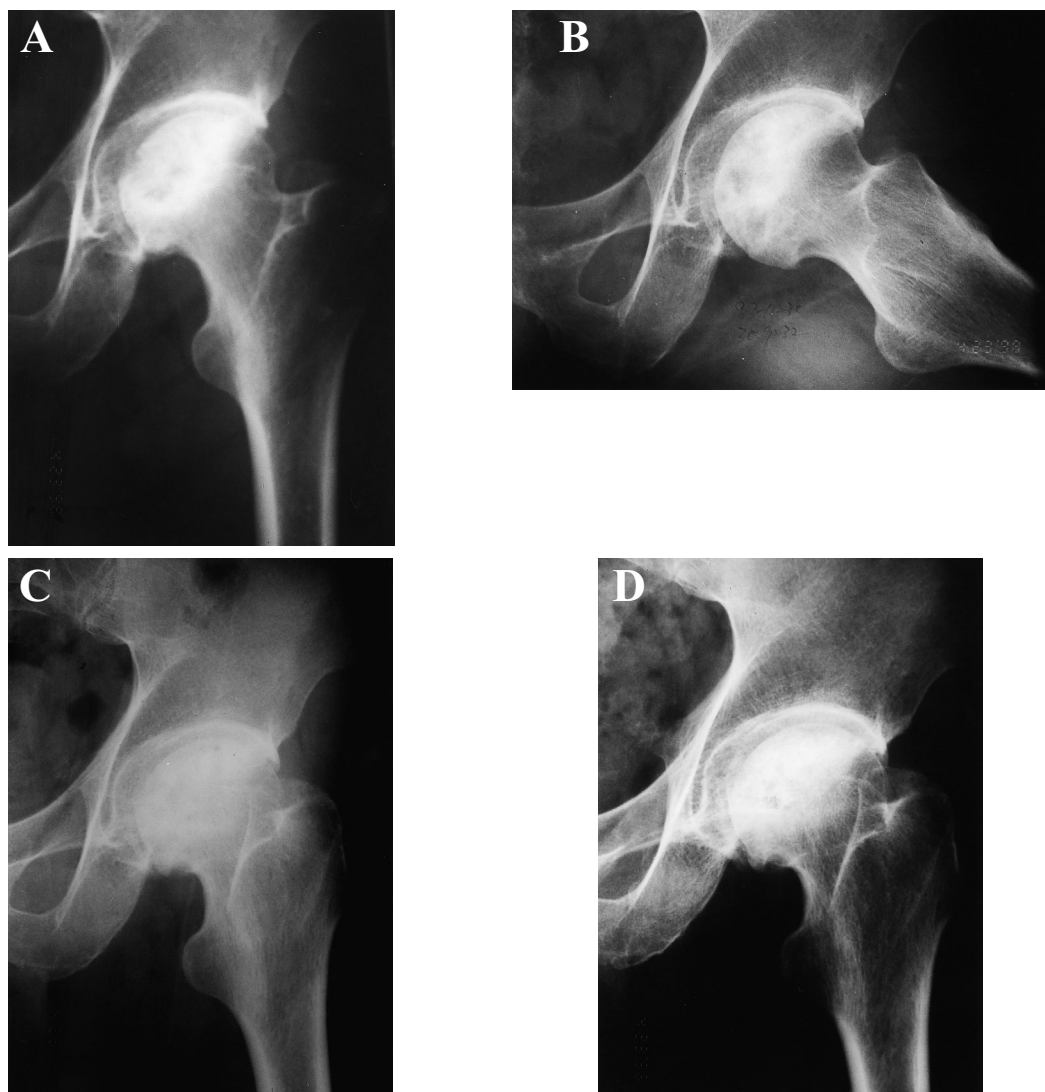


Fig. 2 Remodeling of the osteonecrotic femoral head with delayed collapse of the femoral head. (A) ARCO stage IIC and Ohzono type IC on initial radiograph. (B) Frog lateral view of the same hip. (C) The osteonecrotic femoral head had remained spherical after 2 years. (D) Remodeling of the femoral head with some osteophyte formation shown 5 years after the first visit. The patient was free of symptoms.

Table 4. Outcomes of Osteonecrosis According to Ohzono's Classification

Final case no.	IA	IB	IC	II	IIIA	IIIB	Collapse rate (%)	Collapse time (months)
Initial case no.								
IA	3							
IB	5							
IC	33							
II	31							
IIIA	8							
IIIB	20							
	2	3	6	1	4	6	33.3	28.0
			1	1			20	18
				27			81.8	19.1
				31			100	16.1
				4	4		50	20.8
				14			70	19.3

Ohzono type IB initially, and 1 of them collapsed after 18 months. Thirty-three hips were classified as Ohzono type IC initially, and 27 (81.8%) of them collapsed after an average of 19.1 months.

Ohzono Type II

All 31 hips initially classified as Ohzono type II progressed to collapse in an average of 16.1 months.

Ohzono Type III

There were 8 hips initially classified as Ohzono type IIIA. Four of them (50%) collapsed in an average of 20.8 months. Fourteen of the 20 (70%) Ohzono type IIIB hips collapsed after 19.3 months (Fig. 3).

Risk Factors (Table 5)

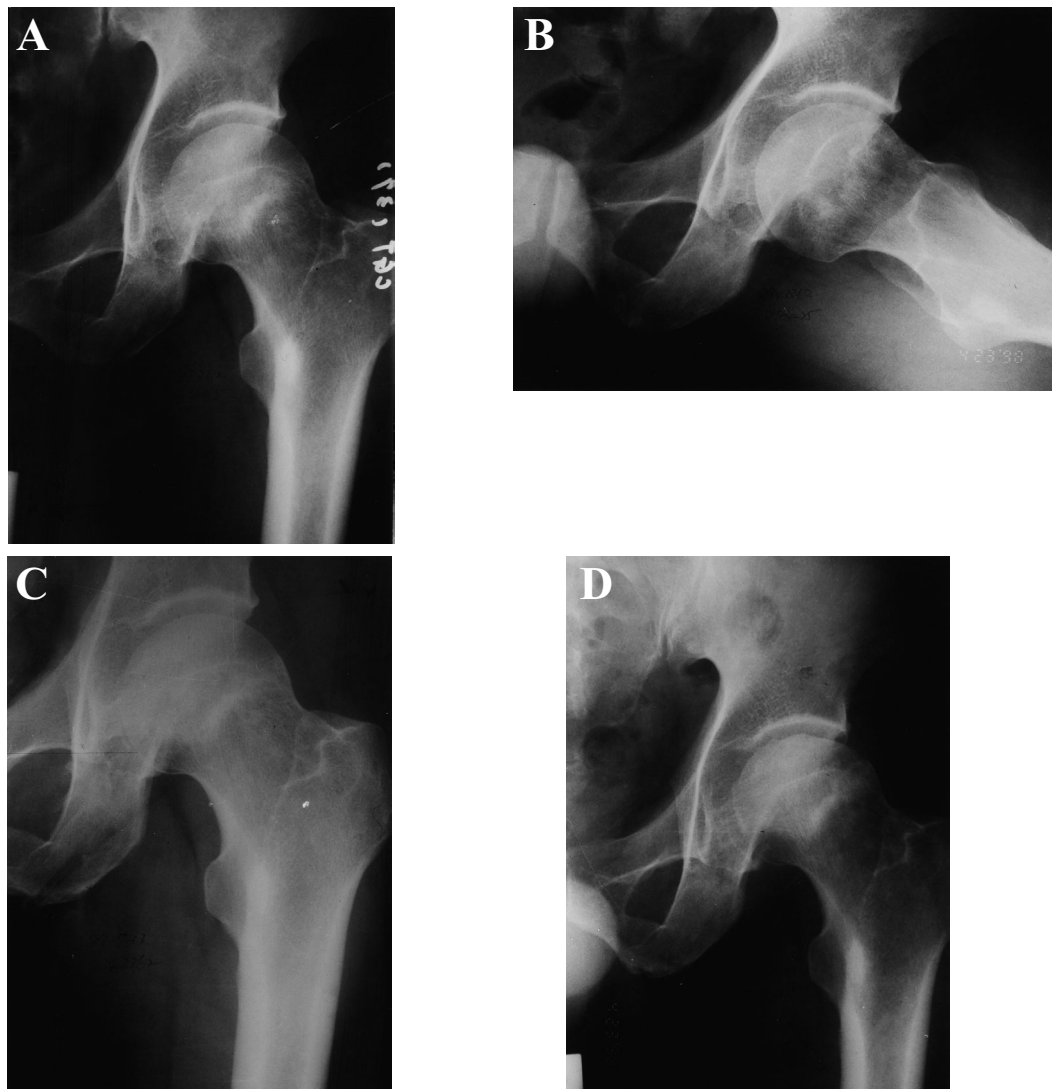


Fig. 3 Delayed collapse of the osteonecrotic femoral head. (A) ARCO stage IIC and Ohzono type IIIB on initial radiograph. (B) Frog lateral view of the same hip. (C) Two years later, the femoral head had remained spherical without collapse. (D) The hip eventually collapsed 4 years and 3 months after the first visit.

Table 5. Risk Factor Comparisons between Different Groups of Patients with Osteonecrosis

	Non-collapsed	Collapsed			<i>p</i>
		Early (< 1 yr)	1~2 yr	Delayed (> 2 yr)	
No. of hips	22	33	29	16	
Age (years)	53.7 ; 10.4 [†]	43.0 ; 11.7 [†]	46.3 ; 13.3	53.8 ; 10.2 [†]	0.041
Body wt. (kg)	61.2 ; 9.7	66.7 ; 10.7	63.5 ; 11.3	62.9 ; 9.8	0.006
Cholesterol (mmol/l)	5.28 ; 1.84	66.7 ; 10.7	60.8 ; 11.7	62.9 ; 9.8	0.450
Triglycerides (mmol/l)	1.76 ; 0.55 [†]	5.38 ; 1.68	5.15 ; 1.50	4.55 ; 0.96	0.133
Activity:		2.80 ; 1.95?	2.42 ; 1.57	1.78 ; 1.20	0.776
Low	12		2.33 ; 1.13		0.362
Intermediate	3				0.074
High	7				0.047
					< 0.05 [‡]

[†]: Statistically significant difference between groups using MANOVA and post-hoc Newman-Keuls multiple comparison test.

[‡]: Statistically significant difference between groups using Chi-square test.

Analysis showed the age of patients in the non-collapsed stage was younger than those in the group whose hip collapsed (by logistic regression, $p=0.041$). Patients whose hips had collapsed within less than 1 year were younger (43 years) than that of the group without collapse (53.7 years) or that of the group whose collapse was delayed (53.8 years) (by MANOVA, $p=0.006$). There was borderline significance of higher triglyceride levels in the collapsed-hip group than in the non-collapsed-hip group (by logistic regression, $p=0.074$). Serum triglyceride levels in the early-collapsed-hip group were significantly higher than those in the non-collapsed-hip group (by MANOVA, $p=0.047$). As to the other demographic data, body weight, body mass index, amount of steroid or alcohol use, and other laboratory data, there were no differences between the collapsed- and non-collapsed-hip groups. The level of activity was higher in the collapsed-hip group than in the non-collapsed-hip group (by chi-squared test, $p<0.05$).

DISCUSSION

The natural history of osteonecrosis of the femoral head is very difficult to describe because very few patients are studied prior to acquiring

symptoms. It has been tempting to define a "natural history" of the progression of the disease as a part of efforts to demonstrate the efficacy of treatment modalities.⁽³⁾ The accumulated clinical results of total hip replacements and hemiarthroplasty in patients who have osteonecrosis are generally poorer than those in age-matched patients with other diagnoses.⁽¹⁰⁾ The ultimate goal in treating osteonecrosis of the femoral head is thus to preserve not replace the involved femoral head. However, the rationale for early surgical intervention for the preservation of the femoral head can only be justified if the disease progression for untreated femoral head osteonecrosis is proven to be high.

Our results show that 78% of hips in bilaterally involved patients progressed to advanced disease within 2 years which is in agreement with results of Bradway and Morrey,⁽⁴⁾ Davidson et al.,⁽⁵⁾ Lee et al.,⁽⁹⁾ and most other studies.⁽¹⁸⁻²⁰⁾ However, the results of Jergesen and Shabi Khan⁽⁷⁾ show that very few hips with asymptomatic osteonecrosis deteriorate and warrant early surgical intervention. This is probably due to the "selection bias" of the patients among different studies. Jergesen and Shabi Khan limited their patients with true "asymptomatic" contralateral hips and included patients who had asymptomatic disease without evidence of radiographic involvement.⁽⁷⁾

Therefore, it is crucial to interpret the different results according to the criteria of patient selection, because we excluded 60 patients who had normal radiographs during follow-up examinations. If we recalculate the rate of disease progression reported by Jergesen and Shabi Khan, it would be 64% because only 5 of 22 patients with radiographic evidence of femoral head involvement remained asymptomatic, while another 3 patients received prophylactic core drilling. It is therefore more practical to conclude that most osteonecrotic hips with advanced disease on one side will progress to collapse on the other side.

Many studies have indicated that the site and extent of the necrotic lesion affect the fate of femoral head osteonecrosis.^(10-15,17) There is still controversy, however, as to which staging or classification system is more reliable for the prediction of final outcome, is more reproducible within and between observers, or is easier in terms of clinical application.^(15,21) Among them, Steinberg's staging system,⁽¹³⁾ the international classification proposed by the Association Research Circulation Osseous (ARCO),⁽¹⁰⁾ and Ohzono's classification^(11,12) are the most popular among orthopedic surgeons. In this study, we classified our patients based on radiographic findings using both the ARCO and Ohzono's classification systems. However, neither system was satisfactory in the prediction of final outcome.

Araon et al.⁽²¹⁾ presented an excellent report on the analysis of risk factors for rapid progression and suggested aggressive therapeutic intervention in all patients with osteonecrosis especially in patients younger than 40 years of age. In this study, we divided our patients into different groups using time to collapse of the hip. Interestingly, we found that in addition to patient age, serum triglyceride levels were also higher in those patients whose hips collapsed within 2 years. Abnormalities in lipid metabolism have been demonstrated in clinical^(2,22) and animal⁽²³⁾ studies. The finding of systemic abnormalities in lipid metabolism in association with poor clinical outcomes implies that aggressive therapeutic intervention should include not only surgery but also medication such as lipid clearing agents (e.g., lovastatin).

In conclusion, we found the collapse rate of the

femoral head in patients who have bilateral involvement is high. Early surgical intervention to preserve not replace the femoral head should be adopted to prevent early femoral head collapse. In addition, risk factors such as high activity levels and abnormal lipid metabolism should also be addressed in the therapeutic modality.

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對側尚未塌陷髖關節在股骨頭缺血性壞死的臨床追蹤

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背景： 股骨頭缺血性壞死經常發生在年輕的病人，而且其疾病的進展也相當的迅速。文獻報告指出股骨頭缺血性壞死的病患，使用人工關節置換治療後，其長期的效果相較於因為其他原因接受人工關節置換的病患差得許多。因此，如何保留病患自己的股骨頭而不用人工關節置換是骨科醫師所面臨的重要挑戰，然而對於是否需要早期手術治療以避免股骨頭進行性的崩塌這個問題，必須要能夠更清楚的瞭解股骨頭缺血性壞死的疾病發展情形。這篇文章是用回溯研究的方式探討股骨頭缺血性壞死影響到雙側髖關節的病患，其疾病的進展速度、疾病的最終結果、並且希望找出與疾病發展相關的危險因子。

方法： 從1993年到1997年，總共有275位病人因為股骨頭缺血性壞死接受人工髖關節置換，其中有215位病人在求診時或在追蹤過程中發現另一側股骨頭也有壞死的現象。在這群病人之中，有100個股關節於開始接受治療時尚未塌陷，因此登錄於此回溯研究。

結果： 這100例股關節之中有78%在隨後的兩年之內其股骨頭發生塌陷，從而造成進行性的關節病變。我們同時發現在年紀較輕 (>50歲)、有較高的活動力或從事粗重工作、或是血中之三酸甘油酯值較高的病人，其股骨頭發生塌陷的機會比對照的病人高出許多。

結論： 我們因此認為，對於屬於高危險群的病患，我們應該要更積極利用各種手術方法治療股骨頭缺血性壞死，同時對於這類的病患可能也應該建議減輕工作負擔與注意血脂肪的控制。

(長庚醫誌 2002;25:228-37)

關鍵字： 股骨頭，髖關節置換，骨頭缺血性壞死。