Idiopathic Osteonecrosis of the Femoral Head in the Elderly

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Summary: Idiopathic osteonecrosis of the femoral head (ION) is a disease prevalent in adulthood, and its development in elderly persons is known to show a low incidence. To clarify its characteristics in elderly patients, radiological and histological examinations were performed on 18 patients aged 60 years or older histologically diagnosed as having ION. On roentgenography, three characteristic points were observed, 1) progress of collapse in the femoral head within a short period (12 cases, 66.7%), 2) narrowing in the joint space within a short period (6 cases, 33.3%), and 3) rapid destruction and resorption of the femoral head (4 cases, 22.2%). The lesion expanded to the acetabular region, and a course similar to that of so-called rapidly destructive coxarthrosis (RDC) was developing in 3 cases (16.7%). However, in these 3 cases, changes in the acetabular region were mild, compared with ordinary RDC, and they were considered different from common RDC. These radiological characteristics were found more clearly in women than in men. In the histopathological examination, severe degeneration in the cartilage of the femoral head was found, while wide infiltration of repairing tissue into the necrotic area was seen from the early stage. When necrotic trabecula were collapsed markedly and degraded severely, then destruction and resorption of bone expanded to non-necrotic regions in some cases. Osteogenic sclerotic line (the demarcation line), which has been often seen in ordinary ION, was not developed in most cases. These characteristics were more prominent in women.

Key words osteonecrosis, femoral head, elder, rapidly destructive coxarthrosis

INTRODUCTION

A course of ION in elderly patients different from that in earlier adulthood has been reported by several workers. In 1972, Ficat [1] reported senile ION that started with narrowing in the joint space as ischemic coxopathy. In 1988, Inoue et al. [2] examined senile ION, and noted the possibility of mechanical weakness in the bone and cartilage as its characteristic. In the present study, we examined 18 patients who were suspected to have ION on roentgenogram, and confirmed histopathologically, and also discussed the relationship of the present cases to RDC proposed by Postel [3].

SUBJECTS AND METHODS

Subjects

Eighteen patients who were histologically diagnosed as having ION using specimens of the femoral head extracted at surgery were the subjects of this study. They were selected from 36 patients who were suspected to have ION clinically and radiologically at the age of 60 years or above, in the Department of Orthopaedic Surgery of Kurume University School of Medicine or related hospitals from August 1985 through July 1998. In detail, 8 men and 10 women aged 62-81 years old, with an average age of 69.7 years, were examined. Of these, 14 cases had a unilateral lesion, and 4 had bilateral lesions. The interval from the first examination to surgery was 1-39 months, with an average interval of 8.6 months.

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TABLE 1.

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**1** B: bilateral *2I: idiopathic; S: steroid; A: alcohol *3+: under 2mm; ++: under 5mm; +++: under 10mm; ++++: over 11mm *4 early: narrowing in the joint space occurs from the early stage *5 CH: cold in hot *6 hom: homogeneous low signal intensity centering around the necrotic area; HOMO: homogeneous low signal intensity was found all over the femoral head band: a low signal intensity band *7 ALD: alcoholic liver disease

Regarding the causative factor, 5 patients had a history of habitual drinking, 4 steroid administration, and 9 were true idiopathic. The underlying disease in each of the 4 steroidal cases was thrombocytopenia, asthma, rheumatic arthritis, and dermatomyositis (Table 1).

**Methods**

The extracted femoral head was immediately cut into two in the frontal plane, fixed in 10% formalin and decalcified in a neutral EDTA solution. Sections of 5 μm thick were prepared, stained by hematoxylin-eosin (HE) and examined using a microscope. Safranin-O staining was also performed on specimens from 5 cases. Diagnosis as ION was made, based on 1) finding of collapse in the femoral head radiologically and 2) observation of distinct necrotic trabecula as a mass in the non-loaded region of the subcartilaginous trabecula or in the bone marrow of the femoral head.

**RESULTS**

**Clinical symptoms**

Many patients complained of severe pain in the hip joint. Some had already started treatment for their chief complaint of lumbago. After once developing, this illness often progresses rapidly. Particularly in women, pain in the hip joint is aggravated within a short period resulting in dysbasia in many cases. The interval from onset (development of symptoms) to operation in men was 24.0 months on average, whereas in women it was 7.7 months and significantly shorter.

**Plain roentgenography**

The stages and types of ION in this study (Table 1) were according to the classification of the Japanese Ministry of Health and Welfare [4] (Tables 2 and 3). Stage of disease: In the first examination, 1 case was classified into Stage I (pre-radiological stage), 4 cases into Stage II (early stage), and the largest
TABLE 2.
Stages of idiopathic osteonecrosis of the femoral head

- Stage I: Pre-radiological Stage
  Radiographic are non-diagnostic. Diagnosis is based on MRI, bone scintigram, or bone biopsy.

- Stage II: Non-collapsed Stage
  Radiological changes are present, but there is little or no collapse of the femoral head.

- Stage III: Collapsed Stage
  Femoral head is clearly collapsed.

- Stage IV: Osteoarthritic Stage
  Osteoarthritic changes are established.

TABLE 3a.
Classification for grading idiopathic osteonecrosis of the femoral head

TYPE 1 (Formation of a sclerotic border)
Extent of the femoral head necrosis can be determined by the presence of a sclerotic border on a plain radiograph or tomogram. Type 1 can be divided into three subgroups of A, B, and C on the basis of the relative relationship on the frontal radiograph between the necrotic area and the weight-bearing segment of the acetabulum.

- Type 1-A: Extent of the femoral head involvement is less than the medial 1/3 of the weight-bearing segment of the acetabulum.
- Type 1-B: Extent of the femoral head involvement is greater than the medial 1/3 but less than 2/3 of the weight-bearing segment of the acetabulum.
- Type 1-C: Extent of the femoral head involvement is greater than the medial 2/3 of the weight-bearing segment of the acetabulum.

TYPE 2 (Irregularity of the articular surface of the femoral head)
Plain radiograph shows a less-clear demarcation line together with the flattening in the weight-bearing surface of the femoral head. Crescent sign is sometimes present. If the extent of the femoral head involvement can be clearly demonstrated on MRI, then the subclassification similar to Type 1 can be applied.

TYPE 3 (Cystic radiolucent changes)
Area of radiolucency is present without sclerotic changes. If the extent of the necrotic involvement can be demonstrated on MRI, then the subclassification similar to Type 1 can be applied.

TABLE 3b.

Fig. 1. a: Anteroposterior radiograph of the right hip of a woman who was first seen when she was sixty-eight years old because of idiopathic Stage-III avascular necrosis of the femoral head. Radiograph showing collapse of eleven millimeters.
b: At 11 weeks after the first examination.
number of 9 cases into Stage III (advanced stage), while 4 cases were already in Stage IV (late stage). At the time of operation, 7 cases were in Stage III, and the other 11 cases in Stage IV.

Type of disease: Identification of the type in the first examination was possible in 12 cases (66.7%). In the other 6 cases, the disease stage was already advanced by the time of the first examination, and identification of the type was impossible. Of the 12, 9 cases were classified into Type 2 (75.0%), 3 cases

Fig. 2. a: Anteroposterior radiograph of the left hip of a woman who was first seen when she was sixty-nine years old because of idiopathic Stage-III avascular necrosis of the femoral head.
b: At 2 months after the first examination, radiograph showing narrowing in the joint space just after or simultaneously with the start of the collapse in the femoral head.
c: At 5 months after the first examination.

Fig. 3. a: Anteroposterior radiograph of the right hip of a woman who was first seen when she was eighty-one years old because of idiopathic Stage-III avascular necrosis of the femoral head.
b: At 7 weeks after the first examination, radiograph showing narrowing in the joint space just after or simultaneously with the start of the collapse in the femoral head.
c: At 6 months after the first examination, rapid distraction and resorption of the femoral head were found.
into Type 1 (all were C), and no case into Type 3. All the 8 women whose disease type was classifiable were identified as belonging to Type 2.

In senile ION, 3 radiological characteristics, which showed differences from ION in adulthood, were found; (1) Progress in collapse of the femoral head within a short period; despite the observation period being short-7.6 months on average (from 1 to 39 months)-collapse greater than 6 mm was found in 10 cases (55.6%). Collapse larger than 11 mm was found in 5 cases (27.8%) (Fig. 1), and 4 of these were women. (2) Narrowing in the joint space within a short period: the interval from onset of symptoms until Stage IV (narrowing in joint space) was short. The interval in 11 cases who were observed up to Stage IV was 8.4 months on average (1-25 months). Particularly, the cases who showed narrowing in the joint space already in the first examination despite the onset of symptoms being only 1-3 months earlier (4 cases, 22.2%) and those who showed narrowing in the joint space just after or simultaneously with the start of the collapse in the femoral head (2 cases, 11.1%) (Fig. 2) were noteworthy. Five of these were women. (3) Rapid destruction and resorption of the femoral head: rapid destruction and resorption of the femoral head were found in 4 cases, and changes in the acetabular region were also found in 3 of these. Their course was similar to that of so-called RDC (Fig. 3). In these RDC-like cases, changes in the acetabular region were very slight compared with severe destruction and resorption of the femoral head, and acetabular changes occurred after progress in the destruction of the femoral head. All the patients were women.

**MRI**

MRI was performed on 2 cases in Stage II, 5 cases in Stage III and on 2 cases in Stage IV, for a total of 9 cases. On T1-weighted image, a low signal intensity band was found only in 1 case (Stage III male), and a homogenous low signal intensity centering around the necrotic area was found in 5 cases (in 2 at Stage II males, 2 at Stage III males, and in 2 at Stage III females). In comparison of the histological findings with the MR image, the low signal intensity area was wider than the actual necrotic area in many cases, and a low signal intensity was found all over the femoral head in 3 cases (in 1 at Stage II female and in 2 at Stage IV females) (Fig. 4).

**99mTc bone scintigraphy**

Scintigraphy was performed for 9 patients, and a typical “cold-in-hot” image was observed in only 4 cases, while a “hot” image was observed in the other 5 cases.

**Histopathology**

**Cartilage of the femoral head:** Mechanical weakness in the cartilage was suggested: partial or massive detachment or deficiency in the cartilage of the

*Fig. 4. a: Anteroposterior radiograph of the right hip of a woman who was first seen when she was seventy-three years old because of idiopathic Stage-II avascular necrosis of the femoral head. b: A low signal intensity surrounds the whole of the right hip on the coronal T1-weighted image.*
Fig. 5. In the necrotic area, active resorption of necrotic bone by the repairing tissue was observed.

Fig. 6. Normal trabeculae were resorbed by the repairing tissue.

femoral head centering around the loaded region was found in almost all the cases including cases of Stages II and III that indicated the absence of narrowing in the joint space. In the case of Stage IV, most of the cartilage of the femoral head was destroyed and lost. The remaining cartilage in the unloaded region in the femoral head was stained by safranin-O in 5 cases. Degeneration in the cartilage as well as osteonecrosis was found.

Necrotic area: In the necrotic area, active resorption of necrotic bone by the repairing tissue was observed (Fig. 5). Osteogenesis and osteoid formation were also seen in some regions. Necrotic trabeculae in the loaded region were severely collapsed, and necrotic bone on the surface lacking cartilage was detached and migrated into the joint capsule. Most necrotic bone in Stages III and IV was destroyed, and some was lost.

Boundary region: An osteogenic sclerotic layer, which is found in ION in earlier adulthood, was found in aged males, but generally only a little. Formation of this layer was particularly weak in females, and no formation was found in some cases. When destruction in the cartilage of the femoral head and necrotic region was distinct, normal trabeculae were exposed on the joint surface, and their destruction and resorption were also found (Fig. 6).

Non-necrotic area: Generally, thinning in the trabecula owing to osteoporosis was prominent, and fine bone fragments of trabecula and hemorrhage in the bone marrow were found in some cases. These changes in aged women were clearer than those in aged men.

DISCUSSION

In the diagnosis of senile ION, a few difficulties occurred in applying the diagnostic criteria of the Japanese Ministry of Health and Welfare. First, the absence of narrowing in the joint space or abnormal findings in the acetabulum were a prerequisite in the criteria on X-ray findings. Therefore, when collapse in the femoral head and a sclerotic band were found and ION was suspected in aged patients, the X-ray findings could not be determined as confirmed in cases when narrowing in the joint space or collapse accompanied by narrowing was already found in the first examination. On bone scintigraphy, a “cold-in-hot” image was observed in only 44.4%, and on MRI, the low signal intensity band in the femoral head was found at a further low rate of 11.1%. Hence, for a definite diagnosis as senile ION using the criteria of the Ministry of Health and Welfare [4], roentgenogram, bone scintigram and MRI may not be sufficient and bone biopsy is finally used in many cases. However, when collapse in the femoral head was progressed, and the femoral head was destroyed and resorbed, destruction in the necrotic region was distinct, and a small amount of remaining necrotic bone was seen only on the surface of the femoral head fragmentally. In addition, massive necrosis in the trabecula in the subcartilaginous trabecula in the unloaded region, and in the bone marrow of the femoral head, and repairing reaction such as fibrous tissue formation and additional osteogenesis in the boundary region in continuity with the unaffected area that occurred in adulthood ION were seen only a little or not at all in senile ION. After all, even when ION was most strongly suspected based on radiological observations during the course, physi-
Generally in ION, the low signal intensity band caused by weakness in the bone and cartilage. These difficulties may be said to characterize senile ION. On the first roentgenography, 36 hip joints were suspected to have ION, but histological evidence for ION could not be obtained in 18 hip joints. The overall number of cases of senile ION was therefore believed to be understated.

Based on the examinations of the clinical courses of senile ION using roentgenography, histology, MRI and RI, it was inferred that this disease developed due to progressing weakness in the bone and cartilage and to rapid and massive infiltration by repairing tissue into the necrotic regions.

Mechanical weakness in the bone and cartilage: Degeneration, detachment and deficiency in the cartilage of the femoral head centering around the loaded region, and thinning in the non-necrotic trabecula due to osteoporosis were found not only in Stage IV but also in Stages II and III in the histological stage classification. Therefore, senile ION was characterized by this occurrence of underlying mechanical weakness in the bone and cartilage.

Rapid and massive infiltration by repairing tissue: Generally in ION, the low signal intensity band (band, hereafter) on MRI (T1-weighted) is found from the relatively early stage. This is an ION-specific image and is highly valued for making the diagnosis and determining the prognosis [5,6]. It is said that the MR image of the necrotic area changes with time; high signal intensities are found in the early stage similarly to normal trabecula, and low signal intensities gradually develop according to infiltration by repairing tissue into the necrotic area [5]. In senile ION in contrast, the band was found in only 1 of 9 cases (11.1%) from the early stage. The findings that the necrotic area showed low signal intensity in most cases and that most scintigrams of senile ION did not show typical "cold-in-hot" image but "hot" image appeared to indicate massive infiltration by repairing tissue into the necrotic areas. This was also demonstrated histologically. In ordinary ION, if the necrotic area is relatively small, then collapse does not occur in the course in general. Even when the necrotic area is large and collapse takes place, the joint space remains for a while, and considerable time (in terms of years) passes until conversion to arthropathy, in many cases. However, in the development of senile ION, rapid and massive collapse in the necrotic area occurred together with infiltration by repairing tissue into the necrotic area, and the state seemed to progress rapidly. Mechanical weakness in the bone and cartilage, and massive infiltration by repairing tissue appeared to be involved in the destruction of the necrotic trabecula.

It was interesting that degradation in the trabecula expanded to the non-necrotic areas frequently in senile ION. In the comparison of these tissue pictures with the MR images, a low signal intensity area wider than the actual necrotic area was found in many cases, and a low signal intensity area was found all over the femoral head in 3 cases. Histologically, active infiltration by the repairing tissue into the necrotic area, a distinct picture of destruction and resorption of necrotic trabecula, fine fragments of trabecula in non-necrotic area, and hemorrhage in the bone marrow were observed. This tendency was stronger in cases that seemed to show the course of RDC, in particular. These characteristics were seen in aged women with ION more clearly than in men. Since the characteristics of ION such as prevalent unilateral occurrence are similar to those of RDC, some relation between them was suggested.

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REFERENCES

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