Recently, patients with homozygous *LRP5* gene disruption were reported [20]. There are many types of mutations affecting bone mass accrual during growth, causing the autosomal recessive disorder osteoporosis-pseudoglioma syndrome. Regarding the effect on the bone, these patients showed a marked decrease in their BMD. In addition, Kato et al. [21] created and characterized *LRP5* gene knockout mice. Interestingly, *LRP5* gene knockout mice showed lower bone mass density than wild-type mice because of decreasing osteoblast proliferation. In their report, Kato et al. [21] observed the presence of LRP5 protein in osteoblasts lining the endosteal and trabecular bone surfaces, but not in osteoclasts, by immunohistochemistry in wild-type mice. Recently, a gain-of-function mutation (G171V) in the *LRP5* gene was described in two kindreds with an enhanced bone density [22,23]. In vitro studies showed that the normal inhibition of Wnt signaling by another protein, Dickkopf-1 (Dkk1), was defective in the presence of this mutation, resulting in increased signaling due to unopposed Wnt activity. Thus, LRP5 may be one of the cellular mediators involved in bone formation, by regulating the proliferation and differentiation of osteoblasts.

In the present study, significant correlation was observed between BMD and a polymorphism in intron 17 (IVS17-1677C > A). To our knowledge, this is the first report that a common SNP in the *LRP5* gene affected BMD. However, it is still unclear how BMD is affected by this intronic polymorphism of the *LRP5* gene. For explaining this, three hypotheses could be proposed. (i) This intronic polymorphism may be linked with exon mutations and may contribute to changing LRP5 protein function. (ii) This polymorphism may be linked with mutations of regulatory elements and may affect the levels of expression through transcriptional regulation. (iii) The polymorphism in the *LRP5* gene may be linked with mutation of another unidentified gene adjacent to the *LRP5* gene which causes low BMD directly or indirectly.

In conclusion, our finding suggests that the *LRP5* gene may be a candidate for the genetic determinants of BMD in postmenopausal women. Examining *LRP5* gene variation will, it is hoped, enable us to understand one of the mechanisms of involutional osteoporosis. Wnt and LRP5 signaling have been implicated in other diseases, including cholesterol and glucose metabolism-related diseases [26]. The variant presented here may be involved in the risk of such diseases, as well as osteoporosis.

Acknowledgments. This work was partly supported by grants from the Japanese Ministry of Health, Labor and Welfare and the Japanese Ministry of Education, Culture, Sports, Science, and Technology.

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Total Hip Arthroplasty with Bulk Femoral Head Autograft for Acetabular Reconstruction in DDH

Surgical Technique

BY SENEKI KOBAYASHI, MD, PHD, NAOTO SAITO, MD, PHD, MASASHI NAWATA, MD, HIROSHI HORIUCHI, MD, RICHARD IORIO, MD, AND KUNIO TAKAOKA, MD, PHD

Investigation performed at the Department of Orthopaedic Surgery, Shinshu University School of Medicine, Matsumoto, Japan, and the Department of Orthopaedic Surgery, Lahey Clinic, Burlington, Massachusetts

The original scientific article in which the surgical technique was presented was published in JBJS Vol. 85-A, pp. 615-621, April 2003

ABSTRACT

BACKGROUND:
The long-term results of total hip arthroplasty performed with cement and use of a bulk autograft for acetabular reconstruction in patients with developmental dysplasia of the hip have varied considerably. We evaluated the results of total hip arthroplasties performed with acetabular bulk autograft to identify the factors that influence the results of this procedure.

METHODS:
Acetabular roof defects secondary to developmental dysplasia of the hip were reconstructed with a bulk femoral head autograft at the time of total hip arthroplasties performed with use of the Charnley technique and prosthesis. Thirty-seven hips in thirty patients (mean age at the time of the operation, fifty-seven years) were followed for ten to twenty-six years (mean, nineteen

continued

INTRODUCTION

The long-term results of total hip arthroplasty performed with cement and use of a bulk autograft for acetabular reconstruction in patients with developmental dysplasia of the hip have varied considerably. The reported series and literature reviews have indicated that total hip arthroplasties performed with such augmentation can provide excellent long-term results in patients forty-eight years of age and older when coverage of the socket by the graft does not exceed 50%. When it is not possible to achieve >50% coverage of the socket by the ilium at the level of the true acetabulum, more proximal placement of the socket is recommended to obtain adequate coverage. Here we describe the technical details of the avoidance of excessive (≥50%) graft coverage of the socket by additional proximomedial reaming, which is a compromise between the low anatomical placement of the socket with a bulk autograft[1] and the high-hip-center technique without restoration of bone stock[2].

SURGICAL TECHNIQUE

Preoperative radiographic planning with use of transparent socket templates is first performed to evaluate the position of the socket and its coverage by autograft (Fig. 1). When coverage of the most proximal point (apex) of the socket by the ilium cannot be achieved at the low anatomical level, a more proximal placement of the socket is considered to ensure that the apex is covered.

The original Charnley technique, including a lateral approach with a trochanteric osteotomy[3], is employed (Fig. 2). In the series that was the subject of our original report, the original Charnley prosthesis

ABSTRACT | continued

years). The Crowe classification of hip subluxation or dislocation was Group II for sixteen hips, Group III for seventeen, and Group IV for four.

RESULTS:

Coverage of the socket by the graft ranged from 5% to 49% (mean, 33%). Twenty-nine sockets were located within the true acetabulum, and eight were placed more proximally. At the time of the latest follow-up, all of the patients had an excellent clinical result, all of the grafts had united, and no hip had radiographic evidence of failure of the fixation.

CONCLUSIONS:

We found that total hip arthroplasty performed with cement and use of a bulk autograft to reconstruct an acetabulum with severe bone deficiency secondary to developmental dysplasia of the hip can provide long-term success in patients forty-eight years of age and older when coverage of the socket by the graft does not exceed 50%. When it is not possible to achieve >50% coverage of the socket by the ilium at the level of the true acetabulum, more proximal placement of the socket to obtain adequate coverage is recommended.

(Charles F. Thackray, Leeds, United Kingdom) was fixed with cement in each patient. An effort should be made to place the socket at the level of the true acetabulum. After reaming of the true acetabulum with the smallest reamer in the transverse direction down to the floor of the acetabular fossa and then maximizing the acetabulum within the limitation of its anteroposterior width with progressively larger reamers, a socket size-gauge is used to determine the coverage of the socket by iliac bone. If ≥5 mm of the superior portion of the socket cannot be contained by bone, the decision to use a graft is made, according to the recommendation of Charnley and Feagin[4].

However, when the assessment with the socket size-gauge indicates that the most proximal point (apex) of the socket cannot be covered by the ilium, proximomedial reaming is performed to obtain such coverage (Fig. 2, *C* and *D*). This additional reaming is accomplished by shifting the direction of a hemispherical reamer proximally, from medial (transverse) to proximomedial, until the most proximal point of the socket size-gauge is covered by the ilium. The radiographs, operative photographs, and their schematic representations in Figures 1 and 2 demonstrate how this additional proximomedial reaming allows coverage of the apex of the socket by the ilium. The defective part of the acetabulum (usually the superolateral aspect of the true acetab-

CRITICAL CONCEPTS

INDICATIONS:

During the index period, the decision to use a bulk femoral head autograft was made when ≥5 mm of the superior portion of the socket could not be contained by bone, according to the recommendation of Charnley and Feagin[4]. On discharge radiographs, all of the sockets in the study group were seen to be contained by a composite of iliac bone and autografted femoral head bone. After the index period, we expanded the indications for this procedure. Now, when both complete containment of the socket by bone and a horizontal cement-bone interface at the level of the acetabular roof cannot be obtained after reaming, we use a bulk autograft to obtain these goals. Complete osseous containment of the cemented socket has been shown to be important for durability[6]. The advent of a socket with a flange for high-pressure cement injection in 1979 allowed filling of bone deficiencies of the acetabular roof with cement as shown in the right hip in Figure 3. However, the long-term results revealed that this was a misusage of the flanged socket. Figure 3, *B*, shows the obliquity of the cement-bone interface in the roof part of the right acetabulum compared with the horizontal interface in the left acetabulum, which was reconstructed with a bulk autograft. When complete containment of the socket by bone and a horizontal area in the roof are not obtained after reaming, we recommend bone-grafting to obtain these goals.

CONTRAINDICATIONS:

When a bone defect is not localized superolaterally and diffuse, extensive bone loss is encountered in the acetabulum (as in revision cases), this procedure may not be sufficient to reconstruct the acetabulum. In that situation, larger, more structural grafts may be necessary to restore column integrity or acetabular reconstruction cages may be considered.

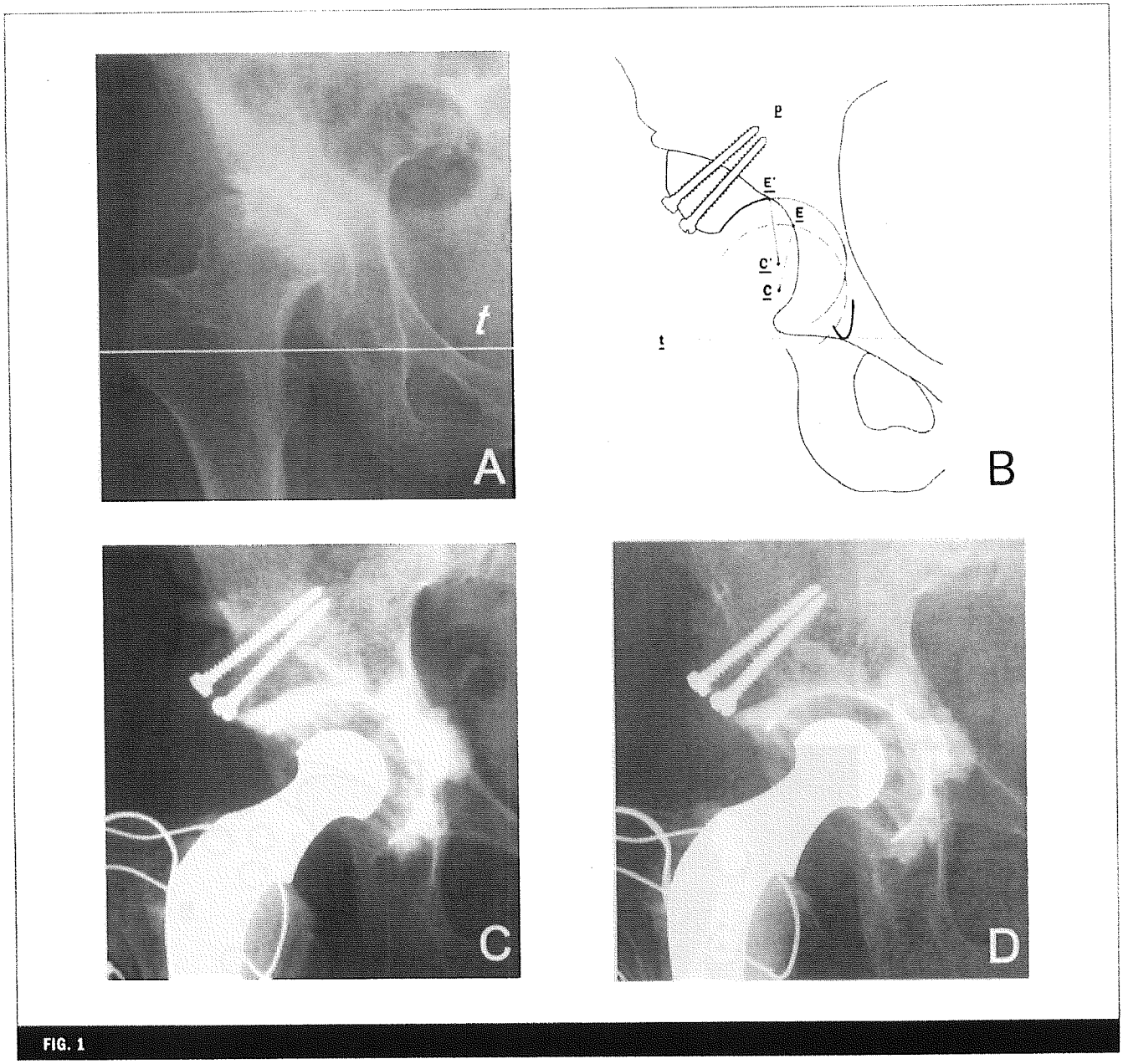
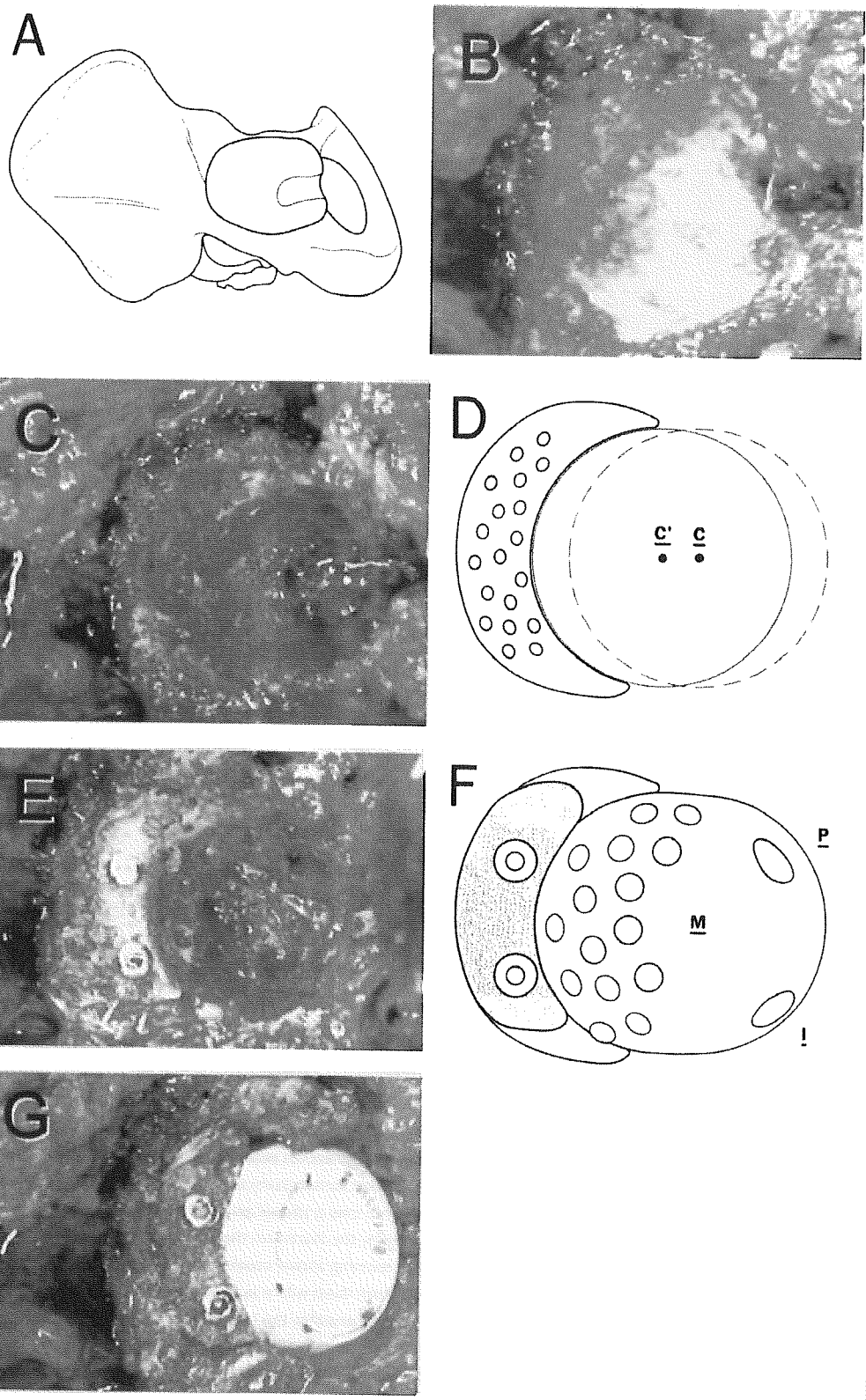


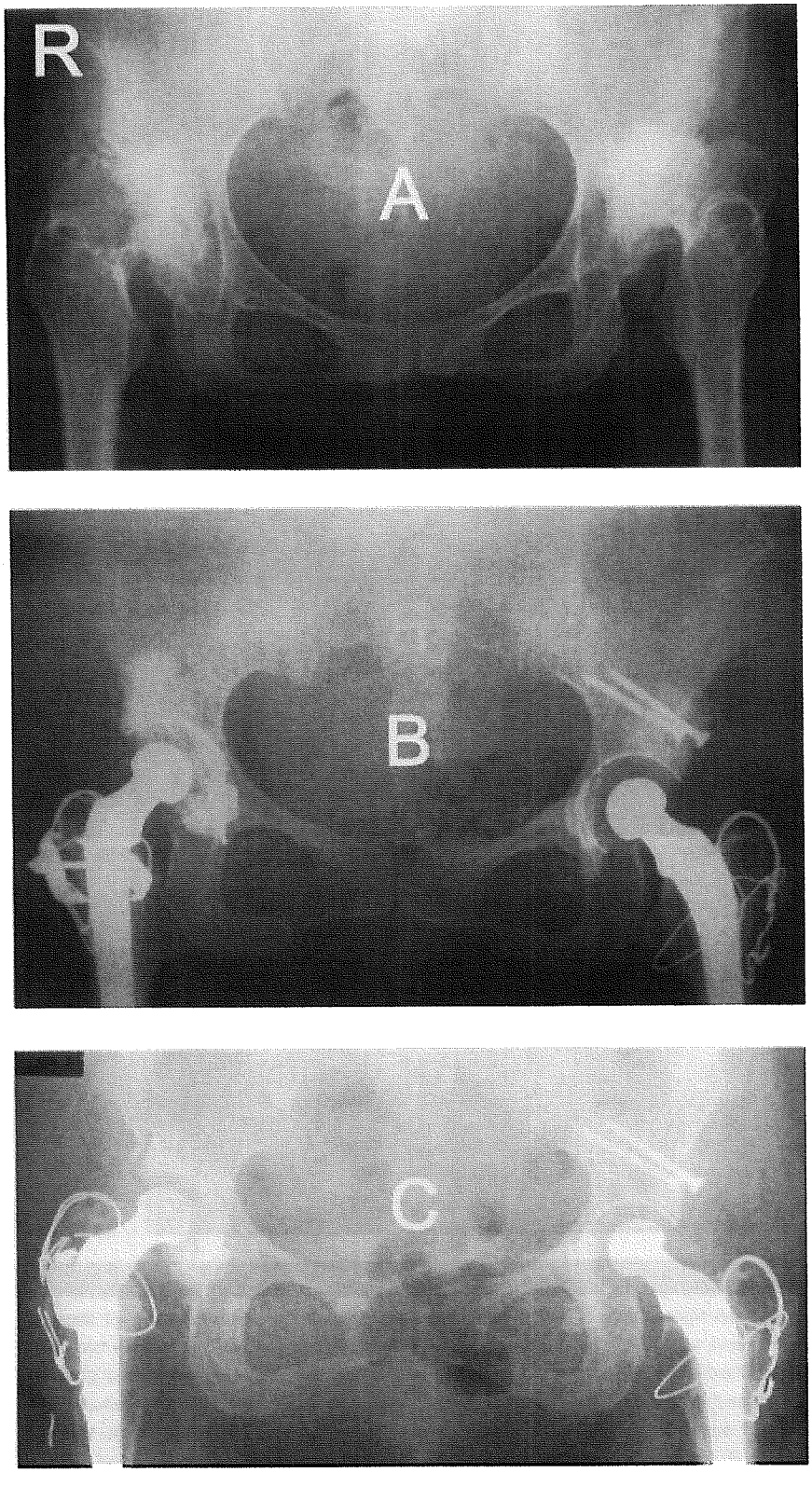
FIG. 1

A fifty-seven-year-old woman underwent a right total hip arthroplasty with acetabular bone grafting. *A:* Preoperative radiograph showing Crowe Type-II subluxation and normotrophic osteoarthrosis of the right hip (*t* = teardrop line [a line drawn through the distal ends of both teardrops]). *B:* Schematic representation of radiographs showing the expected socket position with acetabular reaming at the low anatomical level (dashed semicircle: C = hip center and E = proximal edge of the reamed acetabulum) and that with additional proximal reaming (solid semicircle: C' = hip center and E' = proximal edge of the reamed acetabulum). Line p (drawn perpendicularly to t and through the hip center) indicates that the most proximal point (apex) of the socket cannot be covered by the ilium with the low anatomical reaming and the socket center-edge angle becomes minus. It also indicates that additional proximal reaming allows coverage of the apex of the socket by the ilium with a plus socket center-edge angle. *C:* Discharge radiograph showing the socket fixed with a bulk autograft that covers 41% of it. Although the socket center-edge angle is 1°, the most proximal point of the socket is contained by the iliac bone via bone cement and is not supported by graft. The height of the hip center is 14 mm, and the socket is in the true acetabulum. *D:* Radiograph made twenty-three years after the index procedure, showing no demarcation around the socket (Hodgkinson Type 0). Polyethylene wear was measured to be 2.0 mm (wear rate, 0.087 mm/yr).

FIG. 2



Photographs of the right acetabulum during the procedure. With the patient in the supine position, the upper and right margins of each photograph are anterior and proximal to the acetabulum, respectively. *A:* Drawing of the lateral side of the pelvis, indicating the visual field of Figs. *B* through *G*. *B:* The exposed false acetabulum, which is flat and shallow. *C:* After reaming of the acetabulum and preparation of the acetabular roof for bone-grafting. *D:* Schematic representation of Fig. *C*. The dashed circle indicates reaming at the low anatomical level with its center at point C. The solid circle represents additional reaming with its center (C') shifted proximally. The lightly shaded area is the defective roof part of the false acetabulum, which has been prepared with surface reaming and drilling of multiple holes (2.8 or 3.2 mm in diameter). *E:* After fixation of a bulk autograft to the bone bed and drilling of multiple anchor holes. F: Schematic representation of Fig. *E*. The darkly shaded area is the autograft fixed with two screws. M = multiple anchor holes (6.0 mm in diameter). P = pubic anchor hole, and I = ischial anchor hole. *G:* After fixation of the socket with cement.



ulum that forms a portion of the false acetabulum) is prepared with surface reaming and drilling of multiple holes (2.8 or 3.2 mm in diameter) to obtain a bleeding bone bed. The cancellous portion of the resected femoral head is then trimmed to be congruent with the bone bed and is fixed with two cortical screws. The graft should be partially supported by the superior lip of the false acetabulum. A final reaming completes the shaping of the inner side of the graft (Fig. 2, *E* and *F*).

Multiple anchor holes are made in the reamed acetabulum but not in the grafted portion. Before 1979, only a few large an-

FIG. 3

A forty-eight-year-old woman underwent bilateral sequential total hip arthroplasty with acetabular bone-grafting (left hip) and without it (right hip) during the same hospitalization in 1983. *A:* Preoperative radiograph showing almost the same pathological findings (Crowe Type-II subluxation and hypertrophic osteoarthrosis) of both hips. *B:* Discharge radiograph showing flanged sockets fixed with bulk autograft (left) and without it (right). The graft coverage of the left socket is 48%, and the center-edge angle of that socket is 1°. The height of the hip center is 22 mm for the right socket and 18 mm for the left. The right socket is placed more proximally, and the bone deficiency of the acetabular roof is filled with cement. *C:* Radiograph made twenty years after the arthroplasties, showing migration of the right socket that requires revision, whereas there is no demarcation around the left socket (Hodgkinson Type 0). Polyethylene wear was measured to be 1.0 mm on the right and 1.3 mm on the left.

CRITICAL CONCEPTS | continued

PITFALLS:

Computed tomography scans of the hip are recommended for planning of this procedure. Computed tomography scans aid in the estimation of the size of the socket and the defects. It is possible that even the smallest off-the-shelf socket cannot be accommodated in an extremely small and deficient acetabulum. Knowledge of the thicknesses of the acetabular walls helps to avoid excessive reaming. Preoperative identification of the location of the external iliac vessels on computed tomography scans can help the surgeon to avoid injuring those vessels during drilling for graft fixation.

As we stated in our original article, the long-term success of the procedure depends on selection of a patient with an age of forty-eight years or older and on graft coverage of the socket of <50%. Younger patients should be educated about appropriate levels of activity. When it is not possible to achieve >50% coverage of the socket by the ilium at the level of the true acetabulum, excessive graft coverage should be avoided by means of additional proximomedial reaming (Fig. 4).

chor holes (12.5 mm in diameter and 1.0 cm deep or less) were bored in the iliac, ischial, and pubic bones (ten hips). Since that

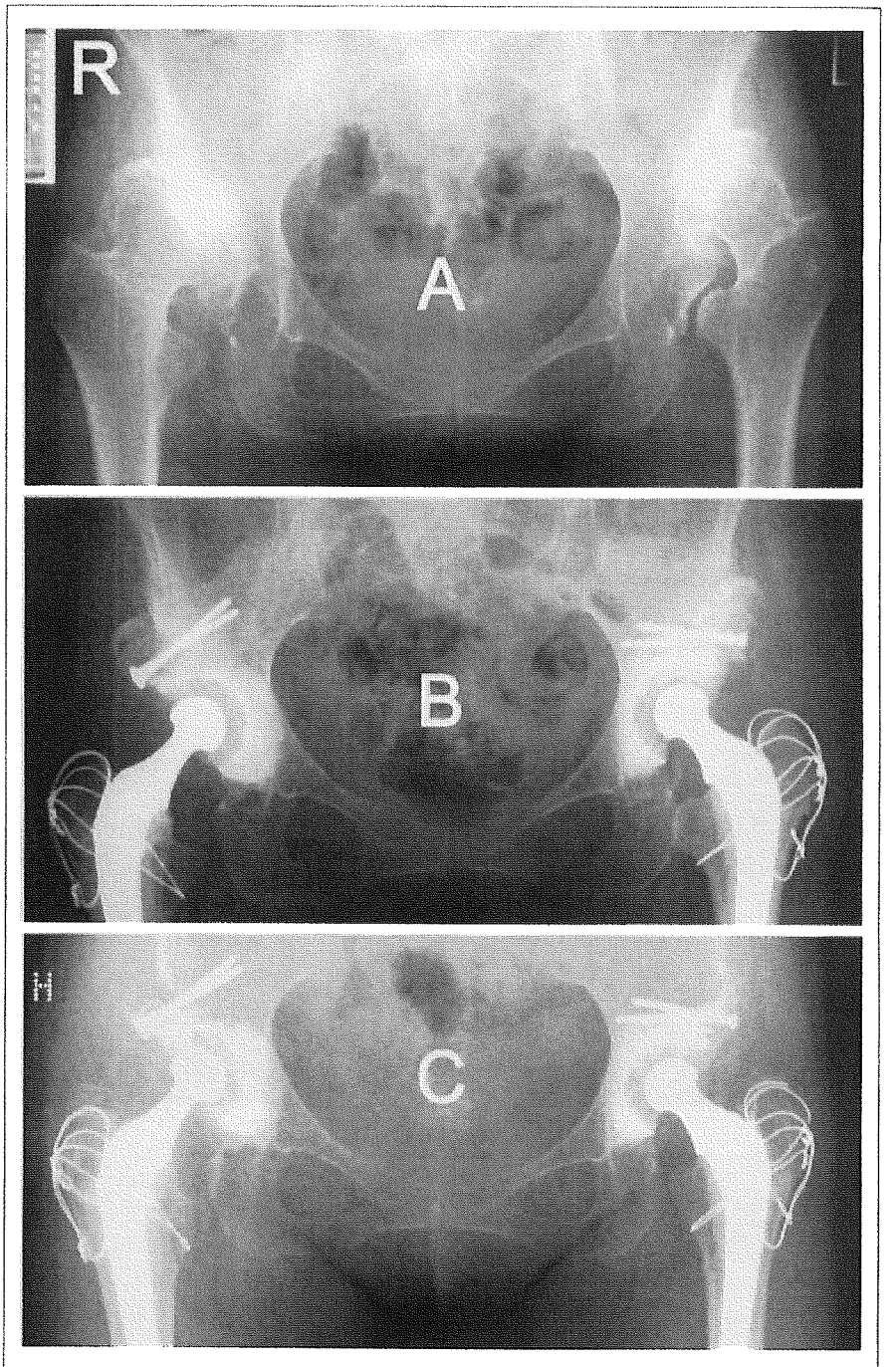


FIG. 4

A fifty-year-old woman underwent bilateral sequential total hip arthroplasty with acetabular bone-grafting. *A:* Preoperative radiograph showing Crowe Type-II subluxation and normotrophic osteoarthrosis of the right hip and Crowe Type-IV dislocation and hypertrophic osteoarthrosis of the left hip. *B:* Discharge radiograph showing sockets fixed with bulk autografts. For the right and left sockets, the graft coverage is 40% and 30%, the socket center-edge angle is 6° and 5°, and the height of the hip center is 25 and 27 mm, respectively. Although both sockets were placed a little proximally, they are nearly within the true acetabulum. *C:* Radiograph made seventeen years after the index procedure, showing no demarcation around the sockets (Hodgkinson Type 0). Polyethylene wear was measured to be 0.2 mm on the right and 0 mm on the left.

time, multiple small anchor holes (6.0 mm in diameter and 6.0 mm deep or less) have been made in addition to the large anchor holes. When a socket with a flange is used, the flange is trimmed to fit the acetabulum. A Charnley socket-holder is used to achieve correct alignment of the socket (inclined at approximately 45° to the transverse plane without anteversion)[4]. The acetabulum is irrigated with saline solution with use of a power-driven rotatory nylon brush and then is packed with hydrogen-peroxide-soaked gauze just before insertion of the cement. The socket is pushed into the cement-filled acetabulum, at first with its face directed more distally. When the inferior part of the rim reaches the full depth, the socket-holder is moved to achieve the final orientation of the socket while pressure is exerted firmly with a pusher on the face of the socket-holder[5]. Full pressure is maintained with the pusher and a thumb on the socket during hardening of the cement.

In the seventeen hips in our series that were treated before 1980, the femoral medullary canal was enlarged by removing weak cancellous bone, and a femoral prosthesis was fixed with cement, without occlusion of the distal part of the medullary canal (the so-called first-generation cementing technique). In the twenty hips treated since 1980, the so-called second-generation cementing technique, which included brushing, insertion of an intramedullary plug, and use of a vent tube, has been employed. With both methods, cement was introduced into the femoral canal in the doughy state by the so-called double-thumb packing technique[3].

Note: The authors thank Dr. Kazuo Terayama for his contribution to the cases.

Seneki Kobayashi, MD, PhD
Naoto Saito, MD, PhD
Masashi Nawata, MD
Hiroshi Horiuchi, MD
Kunio Takaoka, MD, PhD
Department of Orthopaedic Surgery, Shinshu University School of Medicine, Asahi 3-1-1, Matsumoto 390-8621, Japan. E-mail address for S. Kobayashi: seneki@hsp.md.shinshu-u.ac.jp

Richard Iorio, MD
Department of Orthopaedic Surgery, Lahey Clinic, 41 Mall Road, Box 541, Burlington, MA 01805

The authors did not receive grants or outside funding in support of their research or preparation of this manuscript. They did not receive payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated.

The line drawings in this article are the work of Joanne Haderer Müller of Haderer & Müller (art@ilustracao-biomedica.com).

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CRITICAL CONCEPTS | continued

AUTHOR UPDATE:

The following modifications were made after the index period.

- As described above, we expanded the indications for the procedure to allow complete osseous containment of the acetabular component and a horizontal cement-bone interface at the acetabular roof.
- We no longer bore the large (12.5-mm-diameter) central pilot hole before reaming or the large anchor hole in the iliac bone after reaming.
- The trimmed surface of the bulk autograft now is coated with a thin (about 1.0-mm-thick) layer of bone debris (obtained during the latter part of acetabular reaming) before it is applied to the prepared bone bed. This technique has been found, on postoperative radiographs, to be effective in eliminating any gap between the graft and the ilium.
- Instead of cortical screws, cancellous screws (4.0 or 6.5 mm, depending on the size of the graft) have been used to fix the bulk autograft since 1996.
- Since 1996, cement has been introduced into the femoral canal with a cement gun, instead of with the so-called double-thumb packing technique[3].
- Although we still use the flanged Charnley socket with cement, we currently use the continuous triple-tapered polished cemented stem (C-stem; DePuy, Leeds, United Kingdom).

J Orthop Sci (2004) 9:119–121
DOI 10.1007/s00776-003-0757-0

Journal of
Orthopaedic Science

Original articles

Osteonecrosis of the femoral head in Japanese adults after liver transplantation: a preliminary report

Hiroshi Horiuchi[1], Yasuhiko Hashikura[2], Kenji Hisa[1], Naoto Saito[1], Toshihiko Ikegami[2], Yuichi Nakazawa[2], Osamu Karakida[3], Seneki Kobayashi[1], Masashi Nawata[1], Seiji Kawasaki[2], and Kunio Takaoka[4]

[1]Department of Orthopaedic Surgery, Shinshu University School of Medicine, 3-1-1 Asahi, Matsumoto 390-8621, Japan
[2]The First Department of Surgery, Shinshu University School of Medicine, Matsumoto, Japan
[3]Department of Radiology, Shinshu University School of Medicine, Matsumoto, Japan
[4]Department of Orthopaedic Surgery, Graduate School, Osaka City University, Osaka, Japan

Abstract Patients who are treated with high-dose corticosteroids as an immunosuppressive therapy are at high risk of developing osteonecrosis, especially in the femoral head. We examined whether symptomatic osteonecrosis of the femoral head (ONFH) would be a clinical problem after liver transplantation. From June 1990 to December 2001, a total of 169 patients underwent liver transplantation at the Shinshu University Hospital. Within this group, 65 patients were more than 18 years old at the time of surgery, and all were enrolled in the present study. All patients were referred to the Orthopaedic Department of Shinshu University Hospital when they experienced musculoskeletal symptoms, including hip or groin pain. In addition, they were informed of the potential risk of osteonecrosis associated with immunosuppressive therapy after the liver transplant. As result, the patients were advised to have a magnetic resonance imaging (MRI) check for osteonecrosis after transplant surgery. In terms of outcomes, none of the patients presented with symptomatic hip difficulties due to osteonecrosis. Additional clinical investigation revealed that of the 18 patients who underwent MRI screening, only one was found to have asymptomatic unilateral ONFH. In conclusion, ONFH after liver transplantation has not been a clinical problem for our patients.

Key words Osteonecrosis · Femoral head · Liver transplantation · MRI

Introduction

Liver transplantation has become a common procedure for treating patients in Japan with severe chronic hepatic disorders. However, due to allogeneic transplantation, postoperative immunosuppressive regimens are required for the survival and normal function of the transplanted liver. Corticosteroids are effective immunosuppressants, although it is also well known that the use of these agents can lead to disruption of normal bone function over time and eventually osteonecrosis of the femoral head or other bones. Therefore, liver transplant patients are at potential risk for bone loss.

Surveys to determine the prevalence of osteonecrosis in liver transplant cases are limited, particularly in Japan. The purpose of this preliminary study was to determine the incidence of symptomatic and asymptomatic osteonecrosis of the femoral head in liver transplant patients undergoing treatment with immunosuppressive agents including corticosteroids.

Patients and methods

Between June 1990 and December 2001 a series of 169 patients underwent liver transplantation at Shinshu University Hospital. The age distribution of the recipients was as follows: 104 were younger than 17 years (pediatric patients), and 65 were older than 18 years old (adult patients). The adult patients were the subjects for the present study. Because babies accounted for a large number of our liver transplant patients, infants were excluded from this study.

All patients were examined for or questioned about musculoskeletal symptoms by interviews at hospital visits. If there were complaints of musculoskeletal symptoms, including hip or groin pain, the patients were referred to the orthopedic surgeon. For these patients, roentgen grams and magnetic resonance imaging (MRI) studies were used as needed to confirm the diagnosis of osteonecrosis of the femoral head (ONFH).

Additionally, patients who did not show evidence of symptomatic hips during the posttransplant periods were interviewed by surgeons, who explained the purpose of our prospective study. After the patient agreed

Offprint requests to: H. Horiuchi
Received: May 22, 2003 / Accepted: November 27, 2003

to participate in the study, MRI was performed to screen for ONFH. For these patients, an MRI apparatus with a 1.5-tesla magnet (Signa Advantage; General Electric Medical System, Milwaukee, WI, USA) was used to obtain both T1- and T2-weighted images in coronal planes. All images were assessed by two orthopedic surgeons (H.H. and K.T.) and a radiologist (O.K.) independently. The MRI diagnosis of osteonecrosis was made on the basis of criteria established in previous studies.[13,16]

Postoperative immunosuppressive regimen

The immunosuppressive regimen for the patients presented here has been described elsewhere.[3,4] Before August 1993, the major immunosuppressants consisted of intravenous or oral cyclosporine to maintain a serum level of 250–300 ng/ml (measured by the fluorescence polarization immunoassay) and corticosteroids. Since September 1993, intravenous tacrolimus at a serum level of 15–20 ng/ml (microparticle enzyme immunoassay) during the first 2 weeks, 10–15 ng/ml on days 15–21, and 5–10 ng/ml thereafter was added to the regimen. Methylprednisolone was started at 20 mg/kg/day the morning of the operation and gradually tapered over 7 days to 0.5 mg/kg/day and then to 0.06 mg/kg/day by 6 months. These protocols for methylprednisolone use were unchanged since Jun 1990.

Acute allograft rejection was monitored histopathologically in most cases by percutanous liver biopsy. Initial treatment consisted of intravenous methylprednisolone at 10–20 mg/kg body weight, tapering over 5 days to the maintenance dose.

Results

Of the 65 adult patients, 2 (2.9%) presented with hip pain and visited the orthopedic clinic of Shinshu University Hospital. One of these patients (1.5%) had stumbled and fallen from a standing position 1 year after the liver transplant procedure. Upon radiographic examination, a right femoral neck fracture was noted, but the patient could not undergo total hip arthroplasty because of her poor general condition. Another patient developed mild left hip pain 4 months after receiving a new liver. On further examination with radiography and MRI, no abnormal findings suggestive of osteonecrosis were defined, and the pain subsided within a few days with no residual functional disability.

Altogether, 18 patients (9 men, 9 women), including the two symptomatic cases described above, underwent MRI (Table 1). These patients had no history of alcohol abuse or other common risk factors for ONFH, except glucocorticoid use. The average age at the time of MRI was 39.6 years. The average follow-up periods after transplantation, at the time of MRI, was 2 years 6 months (range 2 months to 9 years 10 months). Among these patients, only one presented a typical image of osteonecrosis of the femoral head. This patient's postoperative course resembled that of the other cases; there was no severe allograft rejection and no additional high-dose methylprednisolone use. The patient's hip

Table 1. Clinical data for 18 liver transplant patients who underwent MRI

Patient	Interval from LT to MRI (months)	Duration of steroid use (months)	Cumulative dose of steroid (mg)	Additional pulse therapy	Other risk factors
1	23	23	7213	Y	N
2	34	34	8075	Y	N
3	11	11	3781	N	N
4	4	4	6779	Y	N
5	20	20	9321	Y	N
6	4	4	5528	Y	N
7	2	2	3045	N	N
8	2	2	5922	Y	N
9	6	6	5319	N	N
10	3	3	3386	N	N
11	5	5	5835	Y	N
12	14	14	6054	Y	N
13	14	14	6345	Y	N
14	3	3	5612	Y	N
15	110	110	16817	N	N
16	78	78	16452	Y	N
17	48	48	8422	N	N
18[a]	2	2	3380	N	N

LT, liver transplant; MRI, magnetic resonance imaging; N, no; Y, yes
[a] Osteonecrosis

was asymptomatic at the time of diagnosis and at the most recent follow-up.

Discussion

Corticosteroids are known to induce osteonecrosis, especially in the femoral head. The compromised vasculature and subsequent ischemic bone necrosis may result from a steroid-induced hypercoagulation state,[6] abnormal lipid metabolism as a result of corticosteroid use,[7,17] or a fat embolism.[5,6] However, the precise pathophysiological mechanism by which steroids cause bone necrosis in patients with immunological disorders such as systemic lupus erythematosus, asthma, or nephritis is yet to be elucidated. In terms of the risk of transplantation-related osteonecrosis, several studies have looked at patients receiving bone marrow or kidney transplants. The prevalence of osteonecrosis of the femoral head in renal[2,8,14] and bone marrow[1,12,15] transplant patients was 3%–23%. Torii et al. reported Japanese patients with osteonecrosis of the femoral head after bone marrow transplantation and indicated that the risk factors for bone necrosis were the patient's age at the time of transplantation, chronic graft-versus-host disease, and pulsatile administration of steroids.[15] In the present study, it was not possible to run this type of analysis because of the low incidence of bone necrosis.

A few studies have reported on the prevalence of osteonecrosis after liver transplantation. Papagelopoulos et al. reported that 23 (8.1%) of 285 liver transplant recipients developed symptomatic osteonecrosis after surgery, and 7 patients required joint arthroplasties (total hip arthroplasty 5, total knee arthroplasty 2).[10] In another report, 4 (2%) of 203 patients were diagnosed with osteonecrosis of the hip; these authors noted that, overall, this condition was rare and would not require MRI screening.[9] In addition, Porayko et al. reported that 12 (8.2%) of 142 patients who underwent liver transplantation developed osteonecrosis of the femoral head.[11] In the current study, despite the use of high-dose corticosteroids for immunosuppression, none of the patients presented with symptomatic ONFH, and only 1 of 36 hips in 18 patients screened by MRI screening developed asymptomatic ONFH.

Because of the delay in the start of organ transplant medicine in Japan, the total number of transplant patients and those with MRI data are limited. However, ONFH after liver transplantation has not been a clinical problem for our patients.

Lieberman et al. also noted the lower prevalence of osteonecrosis after liver transplant surgery.[9] This group proposed that the difference may be explained in part by the underlying metabolic bone disease associated with chronic renal failure. Clearly, the organ-specific incidence of ONFH requires closer examination.

Although this is the first epidemiological report of osteonecrosis associated with liver transplants in Japan, the data presented in this study are retrospective and incomplete. A more accurate estimate of the incidence of ONHF or potential risk for ONFH in liver transplanted patients will be possible when larger numbers of cases with prospective clinical data and long-term follow-up are available.

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The Journal of Arthroplasty Vol. 19 No. 3 2004

Continuous Local Cooling for Pain Relief Following Total Hip Arthroplasty

Naoto Saito, MD, Hiroshi Horiuchi, MD, Seneki Kobayashi, MD, Masashi Nawata, MD, and Kunio Takaoka, MD

Abstract: This study is the first to evaluate whether continuous cryotherapy can relieve pain soon after total hip arthroplasty (THA). Patients who had undergone THA for osteoarthritis were divided into 2 prospective, randomized groups: the cryotherapy group was fitted with a computer-controlled cooling device for 4 days, and the control group was not. The pain scores measured on a visual analog scale between days 1 and 4 following surgery were significantly lower for the cryotherapy group than for the control group. Furthermore, postoperative analgesic use by the cryotherapy group was significantly lower than by the control group. The results of this study support the potential benefit of a cold compressive device for pain reduction during the postoperative recovery of patients undergoing THA. **Key words:** cryotherapy, total hip arthroplasty, pain, visual analog scale, analgesic.

Past studies have shown that local cooling is effective for the relief of postoperative pain following surgery in areas near to the skin, such as the knee joint [1–6]. However, there have been no reports dealing with the efficacy of postoperative cryotherapy for pain relief as applied to the hip joint. This is because it was thought unlikely that the cooling action on the skin surface would extend to the deeper hip joint region [7]. This study is the first to demonstrate directly that postoperative local cooling is extremely effective for relieving postoperative pain after total hip arthroplasty (THA). We believe that the application of cryotherapy in this manner will reduce postoperative pain, relieve stress, and thus result in more rapid ambulatory rehabilitation.

From the Department of Orthopedic Surgery, Shinshu University School of Medicine, Matsumoto, Japan.
Submitted November 29, 2002; accepted October 12, 2003.
No benefits or funds were received in support of this study.
Reprint requests: Naoto Saito, MD, Department of Orthopedic Surgery, Shinshu University School of Medicine, Asahi 3-1-1, Matsumoto 390-8621, Japan.

0883-5403/04/1903-0012$30.00/0
doi:10.1016/j.arth.2003.10.011

Materials and Methods

Forty-six patients (37 females, 9 males) underwent primary cementless THA for osteoarthritis and were randomly divided into a cryotherapy group (23 subjects) and a control group (23 subjects). The same prosthesis (S+G Implants, ESKA, Lübeck, Germany) was used for THA via a posterolateral approach with the patient in a lateral position under general anesthesia. Both the socket and the stem implants were fixed without cement. Mepivacaine hydrochloride for pain relief at a dose of 250 mg or less was routinely administered to both groups via a continuous epidural tube for 24 hours after surgery, followed by an additional dose until 72 hours after surgery for patients with continuing complaints of pain. In Japan, postoperative epidural anesthesia is commonly used in THA. As an adjunct analgesic, diclofenac sodium at a daily dose of 50 mg or less was administered. In the cryotherapy group, an adhesive bandage was applied to the suture wound and covered with 10 layers of gauze. A cooling pad (23 × 33 cm) wrapped in a waterproof cover then was applied to the gauze immedi-

ately after surgery, and the surgical wound was fixed with a cloth anchor band (Prepants, Sigmax, Tokyo, Japan). A computer-controlled cooling device (Icing System 2000, Sigmax) was started up in the operating room immediately after surgery and was run continuously for 4 days with the cooling temperature set to a constant 5°C. The same procedure was used for the control group, including fixation of the surgical wound with the cloth anchor band for 4 days, but not the cooling procedure.

Blood loss 12 hours and 24 hours after surgery, as well as the final gross amount of blood loss, were measured. Blood was collected on postoperative days 1, 4, and 7 to determine creatine kinase (CK) and C-reactive protein (CRP) levels. Total doses of mepivacaine hydrochloride and diclofenac sodium used for pain relief also were measured. Postoperative pain of the hip was scored from 0 (no pain) to 10 (worse possible pain) by using a visual analog scale. The patients recorded their pain scores on a visual analog scale questionnaire by themselves on consecutive postoperative days 1 to 7. During this period, all patients remained hospitalized.

The unpaired *t*-test was used for all statistical analyses of the results as well as for comparisons between the cryotherapy and control groups, except for the analysis of analgesic use and pain scores, for which the Mann-Whitney *U* test was used. A 2-tailed *P* value of less than .05 was considered statistically significant.

Results

Of the 23 patients who underwent cryotherapy, cooling was suspended for 1 patient on postoperative day 1 because of discomfort experienced as a result of cooling the surgical site. No other complications such as skin problems or neuroparalysis were observed. As a result, findings for 22 patients in the cryotherapy group and 23 patients in the control group were compared. There were no differences in age (59.3 ± 11.4 years vs 59.0 ± 11.2 years; $P = .989$), body weight (53.7 ± 9.5 kg vs 55.4 ± 11.0 kg; $P = .913$), body height (1.54 ± 0.07 m vs 1.52 ± 0.08 m; $P = .368$), duration of surgery (111 ± 12 minutes vs 118 ± 24 minutes; $P = .144$), or blood loss during surgery (412 ± 130 g vs 444 ± 206 g; $P = .786$) between the cryotherapy and the control group.

There were no significant differences between the 2 groups in the amount of postoperative blood loss, CK levels, or CRP levels. However, the total dose of mepivacaine hydrochloride used as the main analgesic was significantly lower for the cryotherapy than for the control group. On the other hand, the total dose of diclofenac sodium administered as an adjunct analgesic was not significantly different (Table 1).

Table 1. Comparison of Postoperative Blood Loss, CK Level, CRP Level, and Analgesic Use Between Cryotherapy and Control Groups

Variables	Cryotherapy (n = 22)	Control (n = 23)	*P*
Postoperative blood loss (mL)			
Hour 12	611 ± 301	658 ± 333	.633*
Hour 24	733 ± 389	755 ± 334	.812*
Total	1,110 ± 685	1,123 ± 436	.972*
Postoperative CK level (U/L)			
Day 1	556 ± 360	592 ± 342	.510*
Day 4	237 ± 149	254 ± 215	.561*
Day 7	109 ± 65	98 ± 46	.481*
Postoperative CRP level (mg/L)			
Day 1	46.2 ± 20.6	48.9 ± 26.8	.361*
Day 4	59.9 ± 42.4	50.1 ± 24.1	.571*
Day 7	29.0 ± 25.3	24.5 ± 15.3	.347*
Total dose of mepivacaine hydrochloride (mg)	295 ± 99	489 ± 160	<.001†
Total dose of diclofenac sodium (mg)	58 ± 54	60 ± 50	.529†

NOTE. Plus-minus values are means ± SD.
*Unpaired *t*-test.
†Mann-Whitney *U* test.

Pain scores measured postoperatively from day 1 to day 4 were significantly lower for the cryotherapy group than for the control group. On postoperative days 5, 6, and 7, pain scores for the cryotherapy group were lower, but not significantly so (Fig. 1). Pain had disappeared by postoperative day 3 in more than half of the cases of the cryotherapy group, whereas it took up to 5 days for the pain to disappear for more than half of patients in the control group.

Discussion

In recent years, computer-controlled cooling equipment that continuously cools the local region at a constant temperature has been developed and tested for efficacy in an objective manner. However, the pain-relief efficacy of postoperative cryotherapy has been recognized only for regions near the skin, as in knee –surgery [16], but not in cases involving deeper hip surgery, except for one study that found a reduction in hospitalization time for THA patients

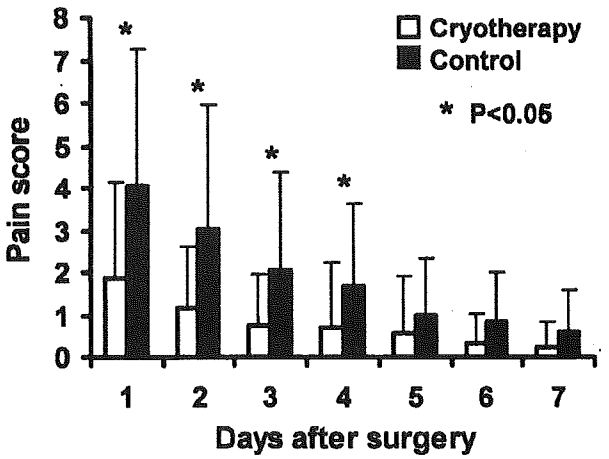

Fig. 1. Comparison of pain relief between cryotherapy and control groups after THA. Pain scores measured postoperatively from day 1 to day 4 were significantly lower for the cryotherapy group than for the control group.

undergoing cryotherapy for undetermined reasons [8]. This is because the effects of cutaneous cooling are thought to penetrate only several centimeters below the skin surface [7]. In fact, our study did not find the reduction in blood loss as a result of cooling observed after total knee arthroplasty [1]. Moreover, cryotherapy for THA has no effect on CK or CRP levels, indicating that it has no inhibitory effect on muscle damage or inflammation. Nevertheless, this study is the first to demonstrate that postoperative pain is substantially relieved even in hip surgery.

The mechanisms by which postoperative local cooling relieves pain are thought to result in large part from 2 sets of coordinate actions [9–13]. The first involves the effects on tissue metabolism. Cryotherapy relieves bleeding and edema by constricting blood vessels. It also reduces the tissue metabolic rate, thus curbing nutrients needed for tissues, and relieves inflammation by suppressing enzymatic activity and preventing secondary tissue damage. For the second set of actions, cryotherapy is thought to exert a local anesthetic action that may elevate the pain threshold and restrain muscle tissue spasms, thereby reducing pain. If the cooling action does not reach the deeper hip regions yet results in pain reduction, this may indicate that the major part of pain experienced following THA is less associated with the deeper joint than with the soft tissues ranging from the skin to the shallow subcutaneous tissues.

Postoperative pain represents a large burden for postoperative ambulatory rehabilitation. If early pain management through cryotherapy is successful, it is clear that early-stage rehabilitation can be performed efficiently. Consequently, the risk of postoperative thromboembolism [14,15] can be expected to decrease.

In this study, the cooling procedure was not used for the control group. Patients in the control group with the cooling pad set at a nontherapeutic temperature could recognize that they were not being cooled and thus were not in the therapeutic group. Therefore, we could not obtain a completely blinded control for the cryotherapy. A placebo effect seems to be unavoidable with this type of trial.

Postoperative continuous cryotherapy is a simple, noninvasive, and effective approach for pain management following THA. Furthermore, diminished stress and accelerated ambulatory rehabilitation suggest that cryotherapy has broad therapeutic benefits. We are confident that the results of this study will lead to the adoption of continuous cryotherapy as a routine procedure after THA.

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Mod Rheumatol (2004) 14:184–186
DOI 10.1007/s10165-004-0289-2

CASE REPORT

**Hiroshi Horiuchi · Masashi Nawata · Tetsuyoshi Kamijo
Naoto Saito · Shigeyuki Wakitani · Seneki Kobayashi
Tominaga Shimizu · Hiroyuki Kato**

Locking of the knee caused by localized pigmented villonodular synovitis: a case report

Received: July 15, 2003 / Accepted: October 28, 2003

Abstract Pigmented villonodullar synovitis (PVS) occurs in two forms: diffuse PVS and localized pigmented villonodular synovitis. In this report, a 40-year-old woman presented with a history of recurrent episodes of knee locking and pain. Arthroscopy revealed a nodular pedunculated mass occupying the area anterior to the intercondylar notch of the femur. Histological examination of the tissue confirmed the diagnosis of PVS. After surgery, the patient's symptoms of pain and recurrent locking promptly resolved.

Key words Arthroscopy · Knee · Pigmented villonodular synovitis (PVS)

Introduction

Pigmented villonodullar synovitis (PVS) occurs in two forms: diffuse and localized (LPVS). The knee joint is the site most commonly affected, although lesions have been described in a variety of other joints. Most consider PVS to be a benign inflammatory process, whereas others think that the pathological characteristics of some lesions suggest a neoplastic condition.[1] We present a case of LPVS of the knee that caused it to lock recurrently. Arthroscopic procedures to remove the lesion were performed, and no recurrence was observed.

Case report

A previously healthy 40-year-old woman presented with a 1-year history of pain in her left knee. It began when the patient started to kneel and felt her left knee lock, preventing full extension. She saw her local physician immediately, who manipulated the knee into extension. Approximately 3 months after the initial injury, the patient again experienced locking of her left knee while running. During this second occurrence, the patient was unable to unlock her knee, and she visited her local physician for treatment. One week after her second injury, the patient visited our hospital. She had no history of remarkable swelling or hemarthrosis of the left knee joint.

Examination revealed a slight limp and restricted range of motion in the knee joint. There was no ligamentous abnormality, and she had no typical meniscus tear signs. No biochemical disorders in the blood examinations were seen. Radiographs did not reveal any abnormal shadows. However, magnetic resonance imaging (MRI) did reveal a mass in the anterior intercondylar space near the insertion of the anterior cruciate ligament. She had experienced both medial and lateral knee pain, which was exacerbated by squatting, standing, and walking. Prior to surgery, her symptoms worsened after prolonged standing, and she could not squat or fully extend her left knee because of pain.

Arthroscopy revealed a nodular pedunculated mass occupying the area anterior to the intercondylar notch of the femur (Fig. 1). The mass was round with a smooth surface and yellow-brown pigmentation. The remaining synovium was seen within the joint space, and all structures were noted to be normal. No other similar lesions were detected. The entire lesion was completely removed through the anteromedial portal. Histological examination of the lesion demonstrated the presence of multinucleated giant cells, hypercellularity, fibroconnective tissue, and pigmentation (Fig. 2). These features established the diagnosis of PVS.

The patient's symptoms of pain and recurrent locking promptly resolved. At her 7-month postoperative follow-up, the patient remains symptom-free and has returned to a low level of sports participation.

H. Horiuchi (✉) · M. Nawata · T. Kamijo · N. Saito · S. Wakitani · S. Kobayashi · T. Shimizu · H. Kato
Department of Orthopaedic Surgery, School of Medicine, Shinshu University, 3-1-1 Asahi, Matsumoto 390-8621, Japan
Tel. +81-263-37-2659; Fax +81-263-35-8844
e-mail: horiuchi@hsp.md.shinshu-u.ac.jp

Discussion

Pigmented villonodular synovitis occurs in large joints, bursa, or tendon sheaths. The etiology is unknown. It occurs in two forms: a diffuse pigmented villonodular synovitis involving the entire synovium or a localized pigmented villonodular synovitis.

The localized form of PVS is a rare pathological condition. The knee joint is most commonly affected, and the disease is generally characterized by the presence of a single pedunculated nodular lesion. The patient occasionally presents with various symptoms such as pain, swelling, or a palpable mass in the knee.[2,3] There are a few previous case reports of localized PVS lesions producing meniscal symptoms.[4–6] In the present case, prior to surgery the patient had a recurrence of her knee locking, such as might occur with a locking bucket handle tear of the meniscus.

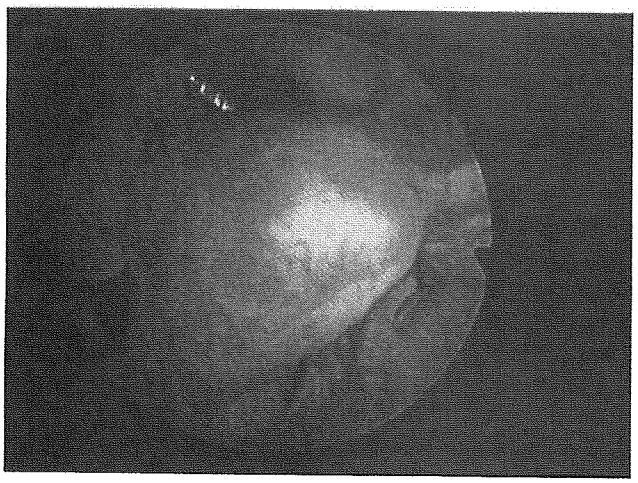

Fig. 1. Localized pigmented villonodular synovitis lesion located anterior to the intercondylar notch

Histologically, PVS is characterized by a fibrous stroma, proliferation of round histiocytic cells or spindle cells, and hemosiderin deposits in macrophages and synovium. The lesions are predominantly villous or nodular in appearance, and in some cases both are seen. The degree of pigmentation ranges from barely yellow to dark brown.[1]

Although radiographic findings are usually normal when examined in localized PVS, a soft tissue mass is occasionally seen. In patients with a diffuse form of PVS, bony changes are observed in a few cases and consist of cyst formations, cortical erosions, and osteopenia.[4,5] The MRI finding of a localized form of PVS is relatively specific, and the signal intensity is similar to that of the diffuse form of PVS, which is characterized by a hypointense area on both T1- and T2-weighted images. This pattern correlates with intralesional deposits of hemosiderin. However, this appearance is not specific for the localized form of PVS and can be confused with synovial chondromatosis or fibroxanthoma.[7]

The localized form of PVS has a good prognosis, in contrast to the diffuse form. Recurrence has been reported but appears to be uncommon.[1,8] Although there is a paucity of literature on localized PVS, arthroscopy can be used as an effective diagnostic method to identify localized PVS in the knee.[9–11]

Conclusions

We described a case of localized PVS of the knee presenting as a recurring locked meniscal tear in a 40-year-old woman. The patient was treated via arthroscopy to remove the mass, and the diagnosis was confirmed by histological findings. At her most recent follow-up, the patient is doing well, is symptom-free, and has returned to low-level sports participation.

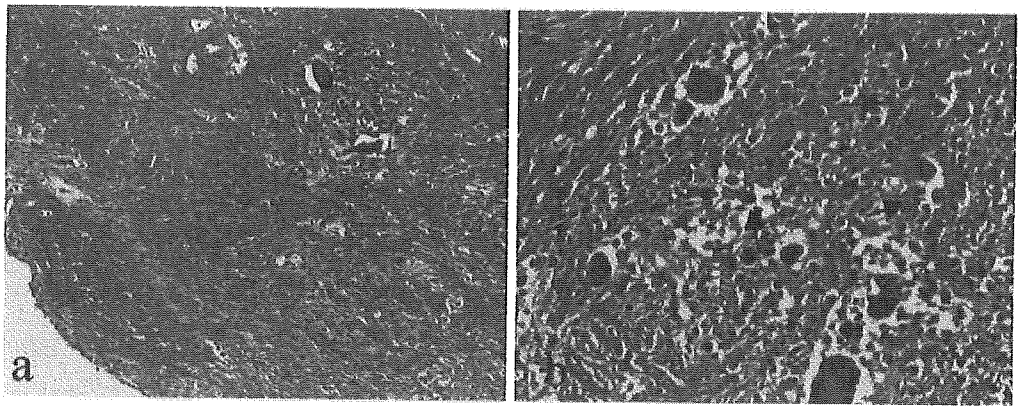

Fig. 2. **a** Pathology of localized pigmented villonodular synovitis demonstrates multinucleated giant cells, hypercellularity, and fibroconnective tissues. **b** At higher magnification, pigmentation (*arrows*) is seen to be present. H&E. **a** ×100, **b** ×200

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特発性大腿骨頭壊死症に対する人工骨頭・人工関節置換術の適応と限界

小林千益　久保俊一　高岡邦夫

Key words：bipolar femoral head replacement, total hip arthroplasty, idiopathic osteonecrosis of the femoral head, hip joint

はじめに

特発性大腿骨頭壊死症(ION)患者は一般的に青壮年期成人で，就労者が多く活動性も高い。したがって，その外科的治療にあたっては骨頭温存手術が望ましいとされている。しかし骨頭壊死範囲が大きい場合やすでに病期が進行し，高度の股関節症変化のある場合はやむなく人工骨頭人工関節置換に至ることも多い。ION患者に行う人工物置換術は患者の年齢，生活環境からみて，とくに長期耐用性が優れているべきである。したがって人工骨頭か人工関節の選択，またその機種の選択については慎重であるべきである。その根拠をえるために厚生労働省難治性疾患克服研究事業：骨・関節系調査研究班：特発性大腿骨頭壊死症調査研究分科会(研究代表者：平成11～15年度は高岡邦夫，平成16年度からは久保俊一)で，IONに対する人工骨頭置換術とTHAの治療成績を12施設共同で調査を行った(**表1**)[1]。その結果を紹介するとともに，IONに対するこれらの治療法について概説する。

厚労省特発性大腿骨頭壊死症調査研究班での調査研究

1986～1995年に本症で人工骨頭置換術かTHA(再置換術を除く)を行った549関節を対象とした。

手術時年齢は，平均49歳(17～87歳)で，男性が56%を占めた。

本症背景因子は，ステロイド剤使用48%(ステロイド対象疾患は頻度順にSLE：34%，腎移植：7%，ネフローゼ症候群：7%など)，アルコール多飲：29%，両者なし：23%であった。

Charnleyカテゴリーは，A(片側罹患)：26%，B(両側罹患)：71%，C(股関節以外の障害もあり)：3%であった。

術後患者活動性レベルがGustilo Ⅱ(non-

Bipolar femoral head replacements and total hip arthroplasties for idiopathic osteonecrosis of the femoral head

0286-5394/04/¥400/論文/JCLS

S.Kobayashi：信州大学医学部運動機能学；T.Kubo：京都府立医科大学大学院医学研究科・医学部運動機能再建外科学；K.Takaoka：大阪市立大学大学院医学研究科・医学部整形外科