TECHNICAL NOTE

Spherical Periacetabular Osteotomy-Inspired Extra-Articular Hip Resection

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Received: 22 August 2025 *Accepted: 3 November 2025*

Abstract

Extra-articular hip resection (EAHR) for malignant bone tumors is a challenging procedure. Conventional approaches often require resection of both the anterior and posterior columns of the acetabulum, leading to instability of the pelvic ring. In this paper, we report on EAHR, inspired by periacetabular osteotomy, using a spherical periacetabular osteotomy (SPO) technique characterized by the preservation of the medial pelvic cortex. Unlike SPO, the attachment of the rectus femoris tendon and the anterior acetabular column are preserved. The tumor is resected, and a total hip arthroplasty is performed. This method not only provides mechanical stability to the pelvic ring but also leaves enough bone for placement of an acetabular implant cup.

Level of evidence: IV

Keywords: Acetabulum, Hip joint, Osteosarcoma, Osteotomy, Reconstructive surgical procedures

Introduction

Extra-articular resection of the hip (EAHR) is an en bloc resection method of the proximal femur and acetabulum used for the intra-articular excision of malignant tumours.[1] EAHR is a complex and technically challenging procedure. When anterior, medial, and posterior acetabular columns are resected, a disruption of the continuity of the pelvic ring occurs, and reconstruction is more difficult. Moreover, preservation of the posterior column alone is insufficient to provide the postoperative pelvic ring stability necessary to reduce the rate of mechanical complications.[2,3] In a previous report, a method of EAHR for the proximal femur preserving the pelvic ring is reported, but it causes a defect in the anterior acetabular column. Moreover, the procedure of cutting the medial and inferior periacetabular lines was not described in detail.[4]

Periacetabular osteotomies are used for joint preservation in cases of developmental dysplasia of the hip and early osteoarthritis. Spherical periacetabular osteotomy (SPO) is characterized by preservation of the medial pelvic cortex through an anterior approach. The anterior approach osteotomy originated as the Bernese periacetabular osteotomy[5] and curved periacetabular osteotomy.[6] Different from other types of periacetabular osteotomy, such as the RAO (Rotational Acetabular Osteotomy) or CPO (Chiari Pelvic Osteotomy),[7,8] SPO is characterized by preservation of the medial pelvic cortex (internal surface of the ilium or quadrilateral surface) and allows spherical rotation of the acetabulum. SPO also requires cutting the inferior periacetabular line.[9] However, there is still a problem applying SPO to EAHR, which makes a bone defect on the anterior acetabular column.

This report describes a novel technique of EAHR for a proximal femoral tumour, preserving the pelvic ring. The SPO technique uses specific chisels to remove the acetabular bottom. Unlike SPO, the rectus femoris tendon attachment and anterior acetabular column are preserved.

Surgical Technique

A novel surgical method

With the patient in the lateral position, a skin incision is made from the iliac crest through the anterior superior iliac spine to the lateral thigh. The inguinal ligament is cut to expose the anterior iliac bone. This procedure reduces the risk of femoral nerve palsy during the operation. The anterior iliac crest to the anterior inferior iliac spine is exposed. If navigation is used, these exposed areas are used for registration.

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Using fluoroscopic imaging or navigation, the periacetabular cut line is marked approximately 7 to 10 mm away from the articular edge by inserting 6 to 8 Kirschner wires of approximately 1.5 mm diameter. The cortical bone at the periacetabular line is cut with a 2-3 mm high-speed bur or ultrasound bone cutter (Sonopet ultrasonic aspirator, Stryker, USA) to a depth of 15 mm. The inferior acetabular line is not cut, because the line is difficult to identify [Figure 1A].

Under fluoroscopic imaging, the Köhler line is brought into alignment with the medial edge of the teardrop line.[9] A fenestration hole measuring about 5 × 30 mm is made at the anterior surface of the pubis (medial acetabulum) close to the inner pelvic margin [Figure 1B]. Through the fenestration hole, cancellous bone is cut to a depth of 15 to 20 mm with a blunt-edged straight chisel (Mizuho Corporation, Japan). Then, a thin-edged curved chisel is inserted to separate the acetabular bottom from the medial pelvic cortex to a depth of 4 to 5 cm from the anterior pubic surface [9] [Figure 1C]. If further deepening is necessary, a flexible curved chisel is used to increase the depth. Unlike SPO, the posterior acetabular cortex is not cut from the fenestration hole because the cutting is performed directly from the posterior.

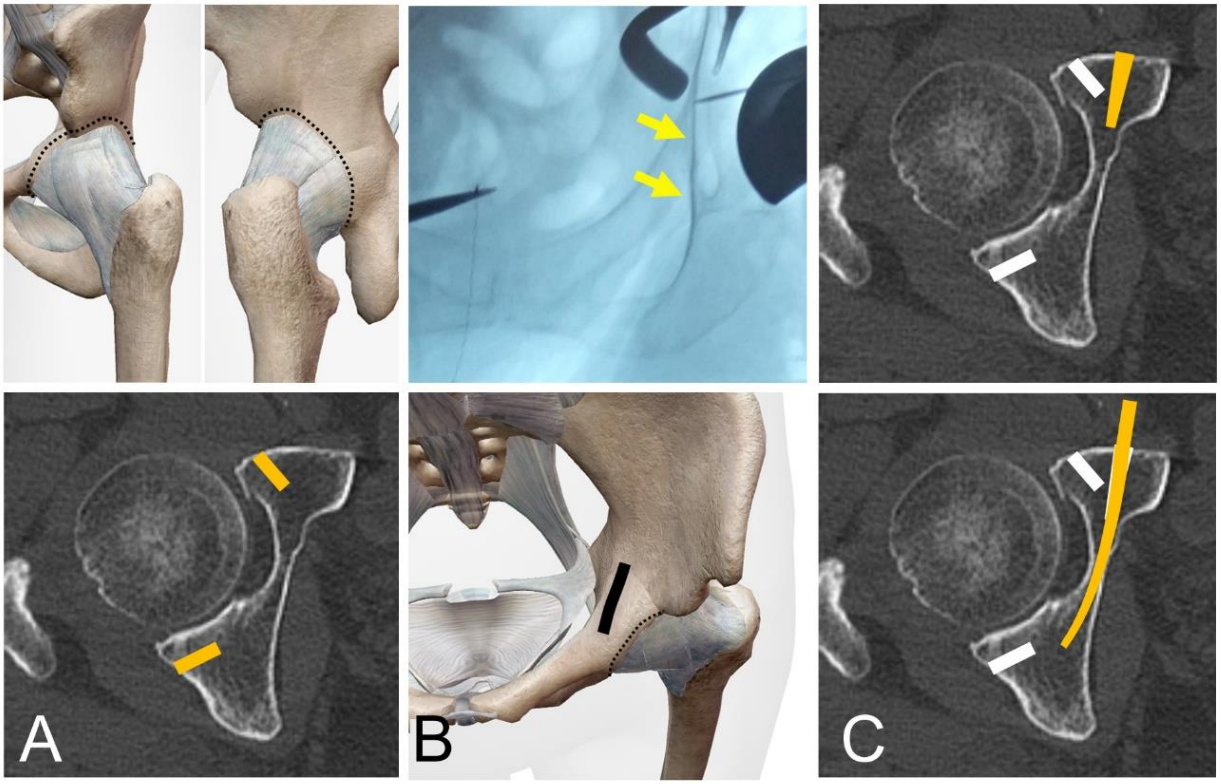

Figure 1. The acetabular cut lines (dotted lines, A-top) are determined using radiography or navigation, and the cortical bone is cut to a depth of 15 mm (orange lines, A-bottom). Fluoroscopic imaging was used to identify the alignment of the Köhler line and the medial teardrop line (yellow arrows, B-top). A fenestration hole is made at the medial acetabular column (black line, B-bottom). A blunt straight chisel is inserted into the bottom of the acetabulum (orange line, C-top). A thin-bladed curved chisel is used to separate the acetabular bottom from the medial cortex of the pelvis (orange lines, C-bottom) (Visible Body Suite, Argosy Publishing, Inc., USA)

In cutting the inferior acetabular line through the fenestration hole of the medial acetabulum, a narrow-edged curved chisel is inserted towards the inferior acetabulum, cutting to the inferior acetabular cutting line, preserving the anterior cortex of the pubis [Figure 2A]. During the procedure, fluoroscopic imaging is used to prevent the chisel from protruding into the pelvic cavity. The fenestration hole at the medial acetabulum can be filled with autogenous or artificial bone at a later time. Finally, from the periacetabular cutting line, EAHR is completed by removing cancellous bone with a curved chisel [Figures 2B and 2C]. Using pleural chisels is useful in a tandem manner along the cutting line. During the procedure, fluoroscopic imaging is helpful to prevent invasion into the pelvic cavity.

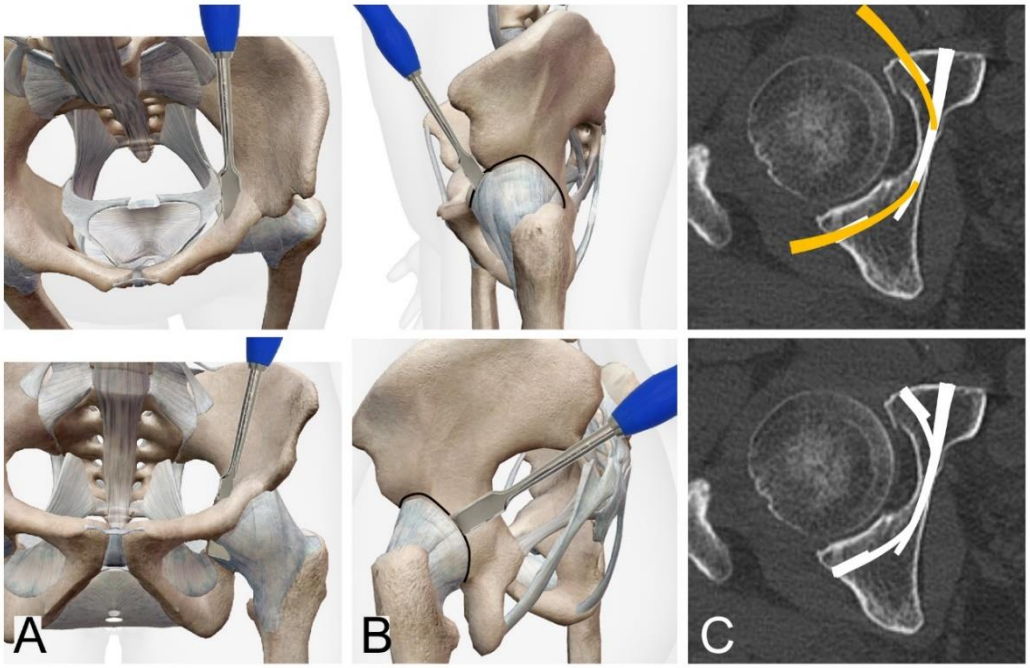

Figure 2. The inferior periacetabular line is cut through the fenestration hole at the pubis (A). From the periacetabular cut line, full resection is completed using a curved chisel (black lines, B; orange lines, C-top). Final cut lines are shown as white (C-bottom) (Visible Body Suite, Argosy Publishing, Inc., USA)

Case presentation

At the initial treatment, a 61-year-old female presented with left hip pain. Diagnosis of femoral head malignancy was made using imaging, and wide resection with artificial head replacement was performed. The pathology of the resected specimen was consistent with a diagnosis of a telangiectatic osteosarcoma. Postoperatively, chemotherapy with four doses of 60 mg/m^2 Adriamycin was used [Figure 3].

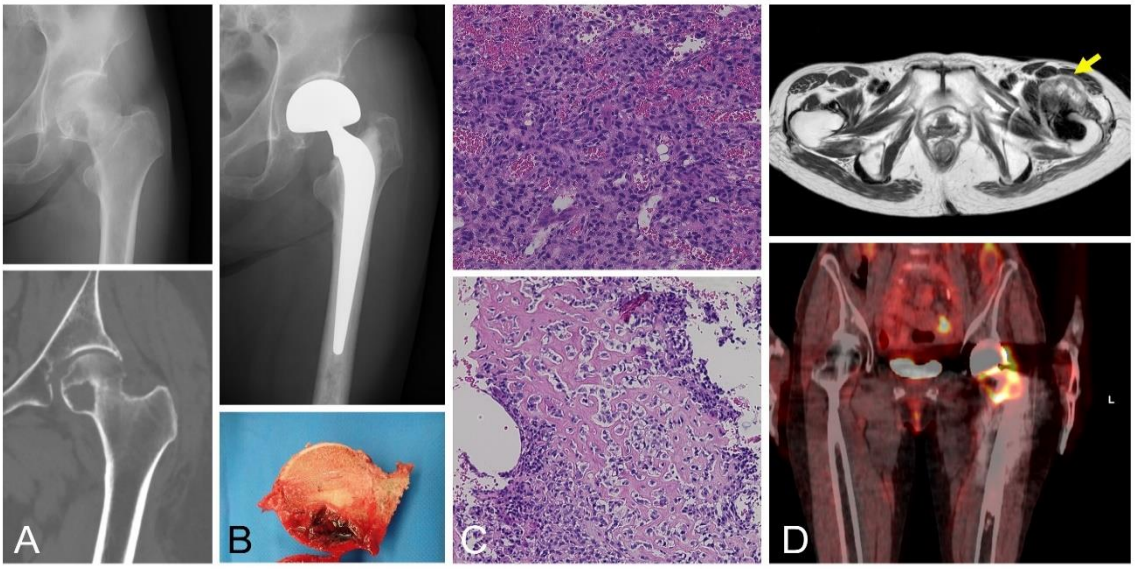

Figure 3. Telangiectatic osteosarcoma of the femoral head was observed as an osteolytic lesion using plain radiography (A-top) and computed tomography (A-bottom) when the patient was 61 years old. Resection and hemiarthroplasty were performed (B-top). The resected femoral head is shown (B-bottom). The histological examination shows telangiectatic osteosarcoma with a proliferation of atypical spindle-shaped tumour cells (C-top) and osteoid formation (C-bottom) (Hematoxylin and eosin, scale bar = 200 µm). Four years later, when the patient was 65 years old, MRI revealed a recurrent tumour of the anterior proximal femur with high internal signal intensity on T2-weighted images (yellow arrow, D-top). PET-CT showed high SUVmax in the hip joint (D-bottom)

Approximately four years after surgery, magnetic resonance imaging (MRI) revealed a recurrent lesion in the anterior aspect of the proximal femur. 18F-fluorodeoxyglucose positron emission tomography (FDG-PET) showed that the tumour extended into the joint [Figure 3], and resection of the recurrent tumour was performed. General and epidural anaesthesia were administered, and the patient was placed in the lateral position. EAHR and resection of the proximal femur were performed. Navigation reference markers were fixed to the iliac crest, and registration was performed (Brain Lab, USA). The attachment of the rectus femoris was preserved. Reconstruction was performed using the GMRS (Stryker's Global Modular Replacement System, Stryker, USA) system and a dual-modality acetabular cementless cup (Trident II Tritanium cup, Trident X3 Polyethylene Insert, Stryker, USA).

A Leeds-Keio artificial ligament (Yufu Itonaga, Co. Ltd., Japan) was wrapped around the femoral stem and sutured to the acetabular bone with anchors (JuggerKnot, Zimmer Biomet, USA). The total operative time was 8 hours and 27 minutes, with an estimated blood loss of 270 ml [Figure 4]. Histological examination demonstrated recurrent osteosarcoma. The surgical margin was negative. Unfortunately, an early postoperative dislocation occurred within one month, and then was stabilized with an orthopaedic brace. Low-dose ICE chemotherapy (ifosfamide, carboplatin, etoposide) was administered for four cycles. There was no recurrence or metastasis one year after the last surgery.

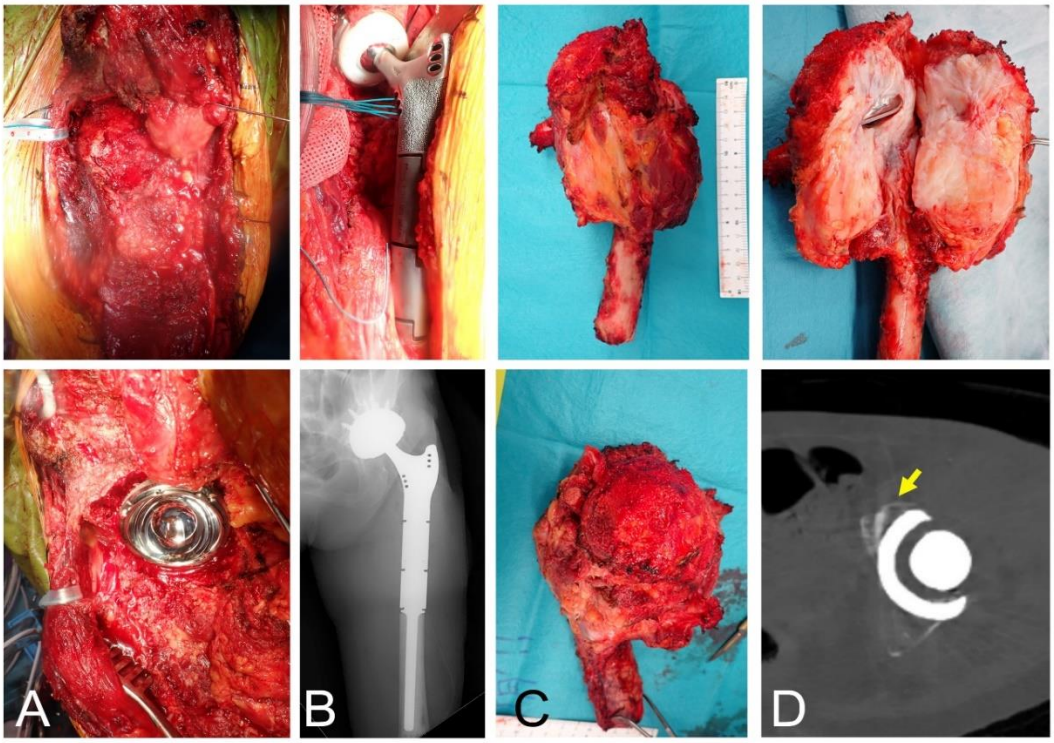

Figure 4. After complete acetabular resection (A-top), a cementless acetabular outer cut was made (A-bottom). A prosthesis was implanted (B-top; its postoperative plain radiograph is shown, B-bottom). The resected tumour was covered by soft tissue and bone (from anterior: C-top; superior-posterior: C-bottom). The cut surface shows that the tumour extended into the hip joint (D-top). Computed tomography shows the preserved anterior acetabular column (yellow arrow), and the defect is filled with beta-TCP (D-bottom)

Discussion

This new surgical technique combines extra-articular resection[4] with globular acetabular osteotomy,[9] further refined through additional modifications. Preserving the acetabular bone may result in a thin surgical margin at the acetabulum. There is a possibility of fracture in the cartilage of the acetabulum, with the risk of contamination in the surgical field and increased risk of tumor recurrence. To avoid acetabular cartilage fracture, the use of thin chisels specialized for SPO and navigation is required.

SPO is a method of spherical rotation of the acetabulum in which the anterior acetabular column is cut and rotated,[9] leaving a bone defect on the anterior acetabular column when the SPO cut line is used for EAHR. In a previous report of EAHR preserving the pelvic ring, the method of cutting the anterior acetabular column was not described in detail, and the anterior column was not completely preserved.[4] The current novel EAHR preserves the anterior acetabular column, or proximal anterior pubic cortex, by using different cut lines of the acetabular bottom and medial periacetabular line. The method retains the mechanical stability of the pelvic ring and leaves enough bone for the acetabular cementless cup.

It has been reported that only 27% of patients have

sufficient bone thickness (space between the inner and outer cortices >1 mm) for preserving the medial pelvic cortex by resecting the acetabular bottom in EAHR, as evaluated by computed tomography (CT).[4] SPO is characterized by preservation of the medial pelvic cortex. In the SPO technique, an original thin curve chisel separates the medial pelvic cortex from the acetabular bottom.[9] Even using the original SPO chisels, the preservation of the medial pelvic cortex is difficult in patients with insufficient space between the medial pelvic cortex and the acetabular bottom. In the current EAHR, fluoroscopic imaging is necessary to avoid intrusion into the intrapelvic space. The use of navigation systems is helpful in pelvic tumour resection procedures to reduce complications. In EAHR, fluoroscopic imaging or navigation systems are also useful for determining the periacetabular cut line, as the acetabular joint line may be difficult to identify due to the tumor and surrounding soft tissue. When cutting periacetabular bone, adequate working space is necessary. Therefore, this new surgical procedure is not suitable for large proximal femoral tumors but should only be used for smaller tumors.

This report describes a novel EAHR method for a malignant tumour. The method preserves the continuity of the pelvic ring, especially the anterior acetabular column, which allows the mechanical stability of the pelvic ring, while leaving enough bone for the acetabular implant cup.

At present, only one case has been reported, with a relatively short follow-up period of one year. The new surgical technique, therefore, should be regarded as preliminary. It should be tested on a larger number of patients and further cases with longer follow-up to accumulate data on safety, oncological outcomes (including tumor recurrence), and functional results.

Acknowledgement

We are especially grateful to Dr. Toshiyuki Kawai, Dr. Takashi Noguchi and Dr. Yaichiro Okuzu, who are orthopaedic surgeons in Kyoto University Hospital, for his invaluable guidance and support throughout this research.

Authors Contribution: Authors who conceived and designed the analysis: Akio Sakamoto/Authors who collected the data: Akio Sakamoto, Toshihiko Hara, Shuichi Matsuda/Authors who contributed data or analysis tools: Akio Sakamoto, Toshihiko Hara, Shuichi Matsuda/Authors who performed the analysis: Akio Sakamoto, Toshihiko Hara, Shuichi Matsuda/Authors who wrote the paper: Akio Sakamoto

Declaration of Conflict of Interest: The authors declare no conflict of interest related to this work.

Declaration of Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Ethical Approval for Study: The study was approved by the Institutional Review Board of Kyoto University Hospital (Approval No. R2499; June 15, 2020).

Declaration of Informed Consent: The patient represented in this study was informed that the data from their case would be de-identified and used in a journal publication.

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