

CASE REPORT

Nagoya J. Med. Sci. **81**, 159–163, 2019
doi:10.18999/nagjms.81.1.159

Computed tomography evaluation of the periacetabular gap of a porous tantalum acetabular component

Shuji Asai, Yasumori Sobue, Nobuyuki Asai, Nobunori Takahashi, Tatsuo Watanabe, Takuya Matsumoto, Naoki Ishiguro, and Toshihisa Kojima

Department of Orthopaedic Surgery, Nagoya University Graduate School of Medicine, Nagoya, Japan

ABSTRACT

The periacetabular gap is an inherent consequence of the peripheral rim press-fit of the porous tantalum acetabular component. The circumference of the prosthesis is clearly depicted with computed tomography (CT) images that have been optimised to reduce metal artefacts. This case report highlights the utility of single-energy metal artefact reduction (SEMAR) for CT evaluation of the periacetabular gap by comparing CT images with and without SEMAR. A 70-year-old woman with a 5-year history of rheumatoid arthritis underwent total hip arthroplasty with a porous tantalum modular acetabular component. A periacetabular gap was suspected by plain radiography 2 weeks postoperatively. The metal artefacts rendered evaluation of the circumference of the acetabular component difficult in CT images acquired without SEMAR. In contrast, there were fewer metal artefacts, and a periacetabular gap (depth of 6.5 mm in DeLee and Charnley zone 2) was clearly depicted in CT images with SEMAR 2 weeks postoperatively. The porous surface of the acetabular component was in contact with the anterior and posterior rims of the acetabulum. Gap filling with bone and bone ingrowth into the porous surface were observed on CT images with SEMAR 24 weeks postoperatively. In conclusion, SEMAR reduces metal artefacts and improves CT image quality around the circumference of the acetabular component. The periacetabular gap and its filling with bone are clearly depicted in CT images with SEMAR, but not without SEMAR.

Keywords: artefact, computed tomography, rheumatoid arthritis, tantalum, total hip replacement

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INTRODUCTION

The success of long-term fixation of the cementless acetabular component in total hip arthroplasty (THA) depends on biological fixation with bone. Initial stability and bone ingrowth around the prosthesis are important for this fixation.¹ The large pore diameter and high-volume porosity of porous tantalum have recently been shown to contribute to extensive bone ingrowth.² Additionally, tantalum has a higher friction coefficient compared to other conventional orthopaedic implant coating materials.³ The porous tantalum acetabular component (Trabecular Metal Modular Acetabular cup, Zimmer Inc., Warsaw, IN, USA) has a hemi-ellipsoid shape, and is inserted using

Received: March 9, 2018; accepted: July 11, 2018

Corresponding Author: Shuji Asai, MD, PhD

Department of Orthopaedic Surgery, Nagoya University Graduate School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya, Aichi 466-8550, Japan

Tel: +81-52-741-2111, Fax: +81-52-744-2260, E-mail: asai@med.nagoya-u.ac.jp

the press-fit technique. The high friction coefficient and elliptic shape can contribute to initial fixation in the component. However, as an inherent consequence of the peripheral rim press-fit, partial contact results in the formation of a gap between the acetabular component and acetabular bone.⁴ The periacetabular gap could potentially be a space for accumulation of wear debris and macrophage proliferation, which can cause osteolysis and implant loosening.⁵ Therefore, evaluating the gap is important for predicting the long-term fixation of the acetabular component.

Computed tomography (CT) is useful for the evaluation of organs when plain radiography is insufficient for diagnosis or to assist in clinical decision making. However, metal artefacts are a major problem when evaluating metal materials by CT. Recently, single-energy metal artefact reduction (SEMAR, Toshiba Medical Systems, Tochigi, Japan), a raw data- and image-based technique, was developed. Metal artefact-free CT images can be obtained by reconstructing images scanned as usual using this algorithm. A recent study showed that SEMAR improved the image quality of peri-artefact structures in patients with hip and dental prostheses and embolization coils.⁶

Here we report a case in which the gap between the porous tantalum acetabular component and acetabular bone was evaluated by CT with SEMAR. This case report highlights the utility of SEMAR for CT evaluation of the periacetabular gap by comparing CT images with and without SEMAR. Written informed consent was obtained from the patient for publication of this case report and accompanying images.

CASE DESCRIPTION

A 70-year-old woman who had a 5-year history of rheumatoid arthritis and sustained clinical remission had been treated with methotrexate, sulfasalazine, and glucocorticoids. She complained of right hip pain that began 6 months before surgery. She experienced night pain and her pain-free walking distance was 200 metres. On physical examination, the right hip demonstrated a slightly limited range of motion. Pain was exacerbated by hyperflexion and flexion-internal rotation. The manual muscle test grade of the right hip abductor and right knee extensor was 4/5. There were no symptoms in joints other than the right hip. Plain anteroposterior radiograph of the hip demonstrated the lack of joint space, osteophyte formation on the femoral head and acetabulum, and partial collapse of the femoral head (Fig. 1A).

The patient underwent THA via a posterior approach. A porous tantalum modular acetabular component with a polar diameter of 50 mm was used with a highly cross-linked polyethylene acetabular liner. The acetabulum was prepared with a hemispherical reamer. The diameter of the final reamer was the same as the polar diameter of the acetabular component and 2 mm smaller than the equator diameter. The acetabular component was implanted in a press-fit manner, and fixed with two screws. An uncemented tapered femoral component (Versys, Zimmer Inc., Warsaw, IN, USA) with a cobalt chrome alloy femoral head with a diameter of 28 mm was implanted. Postoperatively, full weight bearing was allowed after 3 days depending on the degree of pain. No complications were encountered during the postoperative period. She had complete resolution of the preoperative hip pain and was ambulating without a cane 3 weeks postoperatively.

In radiographic evaluation, the periacetabular gap was defined as an area in which the porous surface of the acetabular component did not contact acetabular bone. The depth of the gap was corrected for magnification using the known diameter of the equator of the acetabular component. The periacetabular gap was suspected by plain anteroposterior radiographs of the hip 2 weeks postoperatively (Fig. 1B). Further radiographic evaluation was performed using CT because the quality of plain radiography was insufficient for evaluating the gap. CT scan was performed on

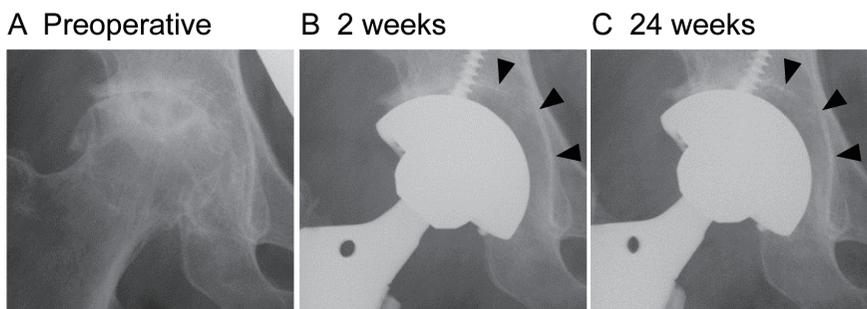


Fig. 1 Plain anteroposterior radiographs of the hip

(A) before surgery, (B) 2 weeks after surgery, and (C) 24 weeks after surgery. Arrowheads: periacetabular gap

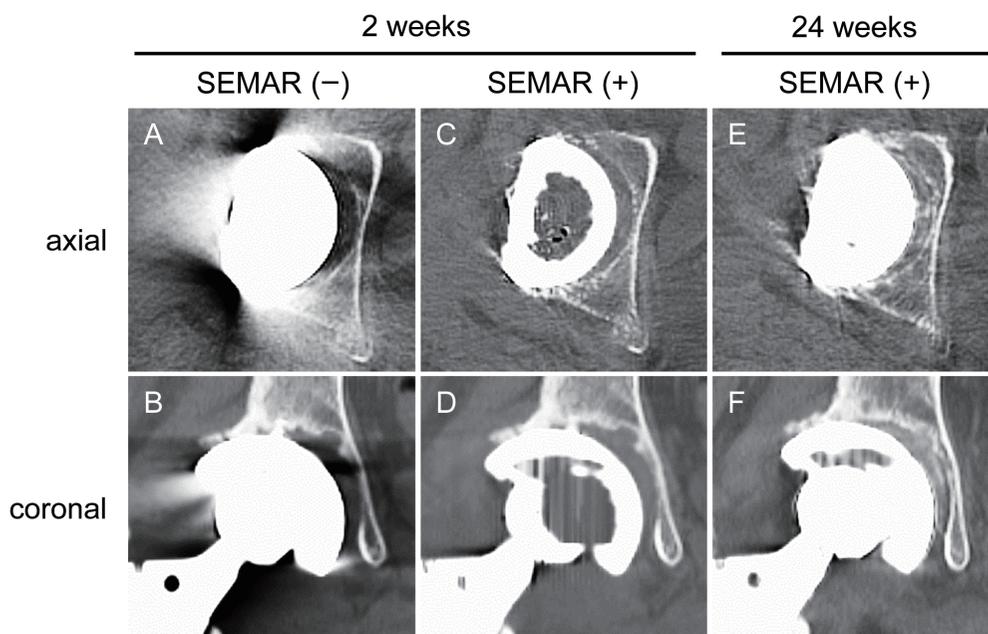


Fig. 2 T images without SEMAR

(A, B) 2 weeks after surgery, and with SEMAR (C, D) 2 weeks after surgery and (E, F) 24 weeks after surgery. SEMAR: single-energy metal artefact reduction.

a 320-detector CT scanner (Aquilion ONE, Toshiba Medical Systems, Tochigi, Japan), and the scanned images were reconstructed with and without SEMAR.

Metal artefacts rendered evaluation of the circumference of the acetabular component difficult in CT images acquired without SEMAR (Fig. 2A, B). In contrast, metal artefacts were reduced, and the periacetabular gap was clearly depicted, in CT images with SEMAR 2 weeks postoperatively (Fig. 2C, D). The gap had a maximum depth of 6.5 mm in DeLee and Charnley zone 2. The porous surface of the acetabular component was in contact with anterior, posterior, and superior rims of the acetabulum (Fig. 2C, D). At 24 weeks postoperatively, gap filling with

bone and bone ingrowth into the porous surface were observed by CT images with SEMAR (Fig. 2E, F), but not by plain radiography (Fig. 1C).

DISCUSSION

SEMAR reduced metal artefacts and improved CT image quality around the circumference of the acetabular component. Gaps and contact between the acetabular component and acetabulum were clearly depicted in CT images with SEMAR, but not in CT images without SEMAR due to metal artefacts. Interestingly, CT images with SEMAR revealed the periacetabular gap to be filled along with bone ingrowth into the tantalum porous surface of the acetabular component within 24 weeks postoperatively. To our knowledge, this is the first report describing the evaluation of the periacetabular gap using CT with SEMAR.

The high friction coefficient and hemi-ellipsoid shape of the porous tantalum acetabular component can create a periacetabular gap due to the peripheral rim press-fit. A recent study using plain radiography reported an incidence of gaps in the porous tantalum modular acetabular component of 18.3%, with a significantly higher incidence in cases with an undersized or same-sized reamer, compared to cases with an oversized reamer.⁴ The cause of the periacetabular gap in the present case was likely the peripheral rim press-fit following same-size reaming. Use of a final reamer that is one size larger than the selected acetabular component could be one way to prevent the occurrence of a periacetabular gap. However, previous evaluations by plain radiography revealed that periacetabular gaps are filled within 1 year postoperatively, and this did not alter the longevity of the porous tantalum acetabular component.⁴ In the present case, the periacetabular gap was not filled in at 24 weeks postoperatively, as assessed by plain radiography. Further follow-up may be necessary to confirm gap filling with this modality. Another possibility is that plain radiography is inadequate for evaluating the periacetabular gap.

Plain anteroposterior radiography of the hip is the standard imaging modality for evaluating THA. A previous study compared plain radiography with histological findings of the periacetabular gap and bone ingrowth into the porous surface. In that study, plain radiographs underestimated the presence of gap areas and overestimated the occurrence of bone apposition.⁷ Thus, plain radiography may be unreliable for evaluating the periacetabular gap. This is partially attributable to inherent limitations associated with using two-dimensional radiographs to evaluate patterns over a three-dimensional surface. Loss of the denser line in the unloaded void behind the component is considered gap filling on plain radiographs, and thus it is uncertain whether the periacetabular gap is actually filled with bone. Moreover, potential errors (e.g., patient positioning) can occur with evaluations based on plain radiography. For example, subsequent patient positioning can mask the original gap.

CT overcomes the above limitations of plain radiography by eliminating overlapping shadows that can obscure or simulate disease. Moreover, CT is not affected by patient positioning to the extent that plain radiography is. In the present case, CT images clearly showed the gap and gap filling with bone, whereas plain radiographs did not. However, compared to plain radiography, CT has the drawbacks of radiation exposure and cost. Thus, plain radiography should be the initial imaging modality of choice for prosthesis evaluation due to its simplicity, availability, and minimal expense. Our findings suggest that CT is useful for the evaluation of periacetabular gaps when plain radiography is insufficient.

Various attempts have been made to reduce metal artefacts in CT images. For example, while dual-energy CT images are often subjected to projection-based metal artefact reduction in order to improve their quality, this can complicate the acquisition protocol and increase the radiation

dose.⁸ In contrast, the SEMAR algorithm uses a simple acquisition protocol and can be applied to single-energy CT, and thus can reduce radiation exposure. Moreover, SEMAR has been shown to reduce metal artefacts more effectively than dual-energy CT-based monochromatic images in patients with total knee arthroplasty.⁹ In the present case, gaps and contact between the acetabular component and the acetabular bone were clearly depicted in CT images with SEMAR, whereas they were not in CT images without SEMAR due to metal artefacts. Tantalum reportedly has more intense artefacts than other metals.¹⁰ Nonetheless, SEMAR can effectively reduce these artefacts. The present case report suggests that SEMAR could be useful for evaluating the circumference of prostheses, including the periacetabular gap, regardless of the material used. More generally, CT images with SEMAR has the potential to accurately identify problems associated with prostheses such as periarticular fracture, implant fracture, and implant loosening, as well as the periacetabular gap. Further studies on the utility of SEMAR are warranted.

In conclusion, SEMAR reduces metal artefacts and improves CT image quality around the circumference of the acetabular component. The periacetabular gap and its filling with bone are depicted clearly in CT images with SEMAR.

CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

REFERENCES

- 1 Illgen R, Rubash HE. The optimal fixation of the cementless acetabular component in primary total hip arthroplasty. *J Am Acad Orthop Surg.* 2002;10(1):43–56.
- 2 Levine B, Della Valle CJ, Jacobs JJ. Applications of porous tantalum in total hip arthroplasty. *J Am Acad Orthop Surg.* 2006;14(12):646–655.
- 3 Zhang Y, Ahn PB, Fitzpatrick DC, Heiner AD, Poggie RA, Brown TD. Interfacial frictional behavior: cancellous bone, cortical bone, and a novel porous tantalum biomaterial. *J Musculoskeletal Res.* 1999;3Z:245–251.
- 4 Nakashima Y, Mashima N, Imai H, et al. Clinical and radiographic evaluation of total hip arthroplasties using porous tantalum modular acetabular components: 5-year follow-up of clinical trial. *Mod Rheumatol.* 2013;23(1):112–118.
- 5 Zwartelé RE, Olsthoorn PG, Pöll RG, Brand R, Doets HC. Primary total hip arthroplasty with a flattened press-fit acetabular component in osteoarthritis and inflammatory arthritis: a prospective study on 416 hips with 6–10 years follow-up. *Arch Orthop Trauma Surg.* 2008;128(12):1379–1386.
- 6 Sonoda A, Nitta N, Ushio N, et al. Evaluation of the quality of CT images acquired with the single energy metal artifact reduction (SEMAR) algorithm in patients with hip and dental prostheses and aneurysm embolization coils. *Jpn J Radiol.* 2015;33(11):710–716.
- 7 Engh CA, Zettl-Schaffer KF, Kukita Y, Sweet D, Jasty M, Bragdon C. Histological and radiographic assessment of well functioning porous-coated acetabular components. A human postmortem retrieval study. *J Bone Joint Surg Am.* 1993;75(6):814–824.
- 8 Gondim Teixeira PA, Meyer JB, Baumann C, et al. Total hip prosthesis CT with single-energy projection-based metallic artifact reduction: impact on the visualization of specific periprosthetic soft tissue structures. *Skeletal Radiol.* 2014;43(9):1237–1246.
- 9 Kidoh M, Utsunomiya D, Oda S, et al. CT venography after knee replacement surgery: comparison of dual-energy CT-based monochromatic imaging and single-energy metal artifact reduction techniques on a 320-row CT scanner. *Acta Radiol Open.* 2017;6(2):2058460117693463.
- 10 Köhler M, Burg MC, Bunck AC, Heindel W, Seifarth H, Maintz D. Dual-source CT angiography of peripheral arterial stents: in vitro evaluation of 22 different stent types. *Radiol Res Pract.* 2011;2011:103873.