

## SUBSPECIALTY PROCEDURES

## MODIFIED SCARF OSTEOTOMY WITH MEDIAL CAPSULAR INTERPOSITION IN GREAT TOE AND METATARSAL SHORTENING OFFSET OSTEOTOMY IN LESSER TOES FOR RHEUMATOID DEFORMITY

Makoto Hirao, MD, PhD, Kosuke Ebina, MD, PhD, Hideki Tsuboi, MD, PhD, Akihide Nampei, MD, PhD, Shigeyoshi Tsuji, MD, PhD, Takaaki Noguchi, MD, PhD, Hajime Owaki, MD, PhD, Hideki Yoshikawa, MD, PhD, Jun Hashimoto, MD, PhD

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**Abstract**

**Background:** Arthrodesis of the first metatarsophalangeal (MTP) joint has been recommended for severe hallux valgus deformity in patients with rheumatoid arthritis. We developed an alternative procedure that preserves motion of the first MTP joint while restoring alignment and balance to the forefoot. This procedure was shown to be effective in a series of 60 patients with a 3-year follow-up.

**Description:** We perform a modified Scarf osteotomy, with the longitudinal first metatarsal cut parallel to the sole of the foot and with shortening of the metatarsal to realign the first ray. This is combined with an interpositional capsular arthroplasty of the first MTP joint and shortening offset osteotomies of the lesser metatarsals.

**Alternatives:** Alternatives include arthrodesis of the first MTP joint combined with resection arthroplasty of the lesser MTP joints, or of all 5 MTP joints, or perhaps interpositional (total) joint arthroplasty for severe rheumatoid forefoot deformity/destruction.

**Rationale:** The purpose of the modified Scarf osteotomy is preservation of motion of the first MTP joint and protection against destruction of the rheumatoid joint. The metatarsal shortening offset osteotomy provides rigid stabilization at the site of osteotomy after dynamic correction to make the transverse arch.

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## Introductory Statement

Modified Scarf osteotomy combined with metatarsal shortening offset osteotomy of the lesser toes provides stable forefoot realignment with preservation of the motion of the first metatarsophalangeal (MTP) joint.

## Indications & Contraindications

### Indications

- Symptomatic rheumatoid arthritis and deformity of the forefoot, specifically the first ray.

### Contraindications

- Problems (e.g., pes planus, hallux flexus, and inversion deformity) that require creation of a medial arch structure, for which plantar flexion osteotomy of the first metatarsal bone is preferable.
- Pencil deformity of the metatarsal head of the lesser toes due to progression of rheumatoid disease.

## Step-by-Step Description of Procedure

### Step 1: Preoperative Planning

*On a standing anteroposterior radiograph, plan the resection of the first metatarsal as the amount equal to the overlap of the first metatarsal and the base of the proximal phalanx, and plan to resect enough length of the lesser metatarsals to allow reduction of the MTP joints while keeping these metatarsals longer than the first.*

- Use a preoperative standing anteroposterior foot radiograph to plan the osteotomies.
- Define the amount of resection of the first metatarsal as being equal to the amount of overlap of the first metatarsal and the base of the proximal phalanx (designated by double-headed arrow 1 in Fig. 1) as seen on a standing anteroposterior radiograph. Avoid leaving the first metatarsal longer than the second.
- Plan to resect enough length of the lesser metatarsals to allow reduction of the MTP joints while keeping these metatarsals longer than the first (the dotted line in Fig. 1 indicates the new position of the shortened first metatarsal). The actual length of the shortening osteotomy of the metatarsals in the lesser toes is 3 mm less than the preoperatively measured length. (The offset correction site is fixed [hooked] into 3-mm-deep grooves of the cortical bone). For example, if 10 mm of shortening is measured preoperatively, the actual length of the shortening osteotomy will be 7 mm.



Fig. 1

**Fig. 1** Preoperative planning. The amount of bone resection required was calculated using a preoperative standing radiograph of the foot. The maximum length of the overlap between the first metatarsal bone and the base of the proximal phalanx in the longitudinal direction of the first metatarsal bone (defined by double-headed arrow 1) was the amount of resection required. With care taken not to make the second metatarsal head shorter than the head of the newly formed first metatarsal (dotted line), enough length to clear the overlap of the lesser-toe MTP joints (double-headed arrows 2 through 5) was resected from the metatarsal shafts of the lesser toes.

## Step 2: Operating Room Setup (Fig. 2)

*With the patient supine, and a fluoroscope in place to later check alignment and correction, ensure that full knee joint flexion is possible so that the foot can be placed parallel to the operating table.*

- The operation is performed under tourniquet control with the patient in the supine position.
- Fluoroscopy is set up, as it will be used to check alignment after the osteotomy and correction.
- Drape the whole lower limb on the affected side.
- Ensure that full knee joint flexion is possible so that the foot can be placed parallel to the operating table.

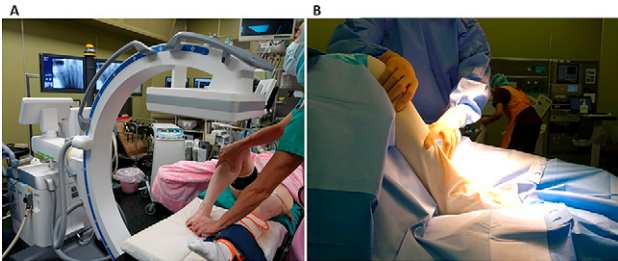


Fig. 2

**Figs. 2-A and 2-B** Operating room setup. **Fig. 2-A** The operation was performed with the patient supine. Fluoroscopy was set up to check the reduction after the osteotomy and correction. An air tourniquet was set at 250 mm Hg of pressure. **Fig. 2-B** Before surgery is started, it is necessary to check that the knee joint can be fully flexed so that the affected foot is parallel to the operating table.

### Step 3: Incisions (Fig. 3)

#### *Make the incisions.*

- Make a 2-cm longitudinal dorsal incision between the first and second metatarsal heads.
- Make a 7-cm longitudinal incision medially from the midportion of the first proximal phalanx to the base of the first metatarsal, parallel to both.
- Confirm the position of the first tarsometatarsal (TMT) joint (arrow in Fig. 3-B).
- Make 3 to 4-cm longitudinal dorsal incisions between the second and third and the fourth and fifth metatarsal heads.
- If there is a claw toe deformity, add a 1.5-cm longitudinal skin incision on the proximal interphalangeal (PIP) joint.



Fig. 3

**Figs. 3-A and 3-B** Skin incisions. **Fig. 3-A** Longitudinal skin incisions (3 to 4 cm) were placed on the dorsal side of the foot between the second and third metatarsals and between the fourth and fifth metatarsals. A longitudinal dorsal incision (2 cm) was made between the first and second metatarsals. **Fig. 3-B** On the medial side (for the great toe), a 7-cm longitudinal incision (dotted line) was made medially from the midportion of the first proximal phalanx to the base of the first metatarsal, parallel to both. The first TMT joint (arrow) should be confirmed manually.

### Step 4: Approach

*Approach the lesser toes through the lateral 2 dorsal toe incisions and the great toe through the dorsal first web space incision.*

#### Lesser Toes (Fig. 4-A)

- Through the lateral 2 dorsal incisions, expose the neck of each of the 4 lesser metatarsals in preparation for osteotomy.
- Identify the extensor digitorum longus (EDL) tendon and extensor digitorum brevis (EDB) tendon.
- Retract the EDL medially and the EDB laterally.
- Incise the periosteum longitudinally (arrow in Fig. 4-A-2) and retract it to expose the metatarsal neck.

#### Great Toe (Fig. 4-B)

- Through the dorsal first web space, dissect the adductor hallucis tendon from the base of the proximal phalanx and secure its stump with a heavy suture (triple mattress).
- Release the transverse metatarsal ligament and incise the lateral capsule between the first metatarsal head and the lateral sesamoid longitudinally from the proximal phalanx to the midpart of the first metatarsal shaft to facilitate reduction of the sesamoids later.
- Through the medial incision, after retracting and protecting the medial dorsal hallucal nerve, use the medial capsule of the first MTP joint to create a 10-mm-wide proximally based flap (Fig. 4-C).
- Keep the flap moist with a saline solution-soaked sponge.

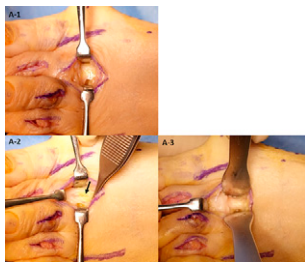


Fig. 4-A

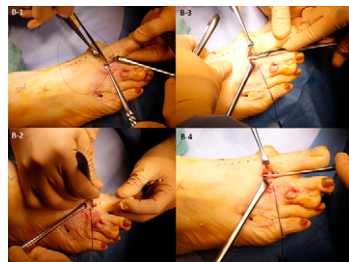


Fig. 4-B

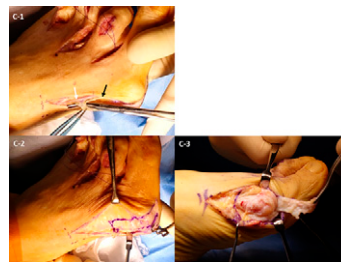


Fig. 4-C

**Figs. 4-A, 4-B, and 4-C** Approaches. **Fig. 4-A** The shaft of the metatarsal bone in the lesser toes was exposed to prepare for the osteotomy. **Fig. 4-A-1** The EDL and EDB tendons were identified and retracted medially and laterally and preserved. **Fig. 4-A-2** Soft tissue including periosteum was cut longitudinally (arrow) using a scalpel. **Fig. 4-A-3** The periosteum was split with a rasp and then retracted medially and laterally. **Fig. 4-B** **Fig. 4-B-1** The adductor hallucis tendon was dissected from the base of the proximal phalanx. The end of the dissected adductor hallucis tendon was marked by thread. **Fig. 4-B-2** The transverse metatarsal ligament was then released, and the lateral capsule between the first metatarsal and the lateral sesamoid was opened by a scalpel longitudinally. **Fig. 4-B-3** Then, a split was added longitudinally from the proximal phalanx to the midpart of the first metatarsal shaft using scissors. **Fig. 4-B-4** The split was also made using a rasp. **Fig. 4-C** **Fig. 4-C-1** Detecting and retracting the medial dorsal hallucal nerve (black arrow) and vein (white arrow). **Fig. 4-C-2** A 10-mm-wide flap for opening the medial capsule was designed. **Fig. 4-C-3** The medial capsule of the first MTP joint was opened with a 10-mm-wide flap.

## Step 5: Osteotomy and Reduction

Resect a sufficient amount of each lesser metatarsal neck to allow reduction of the respective MTP joint (Fig. 5-A); to correct the hallux valgus deformity, perform sufficient shortening and translation of the first metatarsal shaft through a horizontal longitudinal osteotomy (Fig. 5-B).

### Lesser Toes

- Retract the soft tissue, including the periosteum, medially and laterally from the metatarsal neck.
- Make a first saw cut perpendicular to the neck and 1.5 cm proximal to the metatarsal head.
- Note the length of the neck to be resected as measured on the preoperative radiographs.
- Make a second cut at the measured length proximal to the first cut.
- After resecting the free bone segment, pull the distal metatarsal head fragment proximally and open the MTP joint capsule using a scalpel.
- Debride inflamed synovial tissue and release any soft-tissue adhesions within the MTP joint.
- Partially release the insertions of the medial and lateral collateral ligaments sharply as necessary to achieve an adequate reduction of each MTP joint.

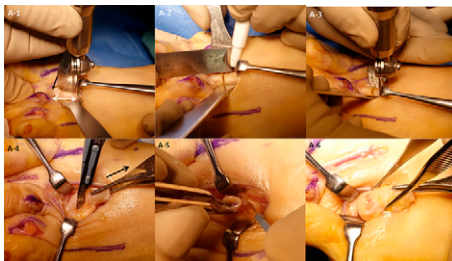


Fig. 5-A

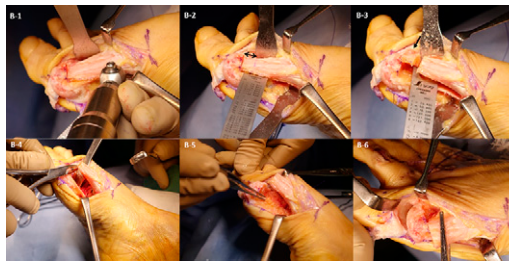


Fig. 5-B

**Figs. 5-A and 5-B** Osteotomy and reduction. **Fig. 5-A** For reduction of a lesser-toe MTP joint subluxation or dislocation, enough length of the metatarsal shaft must be resected. **Fig. 5-A-1** Soft tissue including periosteum was kept retracted medially and laterally to confirm the metatarsal head (black arrow) over the capsule. Then, the first cut was added 1.5 cm (double-headed white arrow) proximal to the metatarsal head. **Fig. 5-A-2** The length to be resected was measured preoperatively (Step 1). **Fig. 5-A-3** The second cut was added at the measured length proximal to the first cut. **Fig. 5-A-4** After resection of bone, the distal fragment (metatarsal head) was pulled proximally (direction of the black arrow), and at the same time the capsule was opened using a scalpel. Inflamed synovial tissue and soft-tissue adhesions in the MTP joint were removed. The insertions of the medial and lateral collateral ligaments were partially released with the scalpel. **Fig. 5-A-5** Adhesions between the capsule and the bottom of the proximal end of the distal fragment should be removed using the scalpel. **Fig. 5-A-6** Adequate reduction of the MTP joint was confirmed.

**Fig. 5-B** For correction of hallux valgus deformity, enough shortening of the first metatarsal shaft is performed as dictated by the preoperative planning (Step 1). Furthermore, sufficient translation after the osteotomy is required. **Fig. 5-B-1** A horizontal osteotomy was performed. To avoid pronation of the first metatarsal head and loss of the longitudinal arch of the foot, the direction of the bone saw during the osteotomy should not be parallel to the transverse axis of the first metatarsal. Rather, an oblique direction (from medial-dorsal to lateral-plantar) is recommended. **Fig. 5-B-2** Enough of the first metatarsal shaft (indicated by the double-headed arrow) was shortened as dictated by preoperative planning (Step 1). **Fig. 5-B-3** The shortening osteotomy was completed. The bone fragment after the shortening osteotomy (arrow) was preserved for bone transplantation. **Fig. 5-B-4** Partial resection of the lateral end of the dorsal (proximal) bone fragment was carried out to make reduction easier. **Fig. 5-B-5** A bone chip from the resected bone (shortening) was transplanted into the medullary canal of the plantar (distal) and dorsal (proximal) fragments. **Fig. 5-B-6** The distal bone fragment was shifted laterally, followed by confirmation that the newly formed metatarsal head was placed on the sesamoid bones.

**Great Toe**

- Through the medial incision, incise and elevate the periosteum and soft tissue from around the dorsal, plantar, and medial aspects of the first metatarsal.
- Remove the medial metatarsal head osteophyte (bunion).
- Draw the preplanned osteotomy cuts on the bone.
- Using an oscillating saw, make the first cut 10 mm proximal to the metatarsal head and perpendicular to the longitudinal axis of the first metatarsal.
- Make the second longitudinal cut parallel to the sole of the foot<sup>1</sup>. To avoid pronation of the first metatarsal head and loss of the longitudinal arch of the foot, the direction of the bone saw during the osteotomy should not be parallel to the transverse axis of the first metatarsal. Rather, an oblique direction (from medial-dorsal to lateral-plantar) is recommended.
- Make the third cut on the plantar cortex and 10 mm distal to the TMT joint.
- Make the fourth cut parallel to the first cut and at the premeasured distance (Step 1) proximal to the first cut.
- Make the fifth cut parallel to the third cut and at the premeasured distance (Step 1) distal to the first cut.
- Partially resect the lateral end of the dorsal (proximal) bone fragment to make reduction easier.
- Confirm release of the insertion of the lateral collateral ligament from the medial approach and remove any proliferated synovial tissue.
- Translate the distal bone fragment laterally, and confirm that the metatarsal head is aligned with the sesamoid bones.

### Step 6: Fixation

Lock the distal fragment (metatarsal head) of the lesser metatarsals into 3-mm-deep grooves in the cortical bone of the proximal fragment and then secure it to the proximal fragment with a 1.2-mm Kirschner wire (Fig. 6-A); shift the distal bone fragment of the first metatarsal laterally and securely fix it with screws (Fig. 6-B).

#### Lesser Metatarsals

- Fashion the cortex of the distal end of the proximal stump into a narrow spike with 2 grooves dorsally using a power burr.
- Ream the medullary canal of the metatarsal head fragment using the burr to create a mortise to receive the proximal fragment spike.
- Insert the spike of the proximal fragment into the medullary canal mortise of the distal fragment.
- First insert a 1.0 or 1.2-mm Kirschner wire antegrade from the proximal end of the distal fragment, through the MTP, PIP, and distal interphalangeal (DIP) joints to exit at the toe apex.
- Then reduce the metatarsal neck osteotomy and drive the Kirschner wire in a retrograde fashion into the medullary canal and across the TMT joint. The dorsal spike of the proximal fragment should sit securely in the medullary canal mortise of the distal fragment, stabilized by the Kirschner wire.
- Place bone chips from the resection around the osteotomy sites to fill any defects.

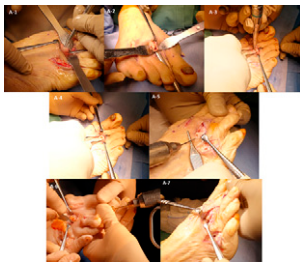


Fig. 6-A

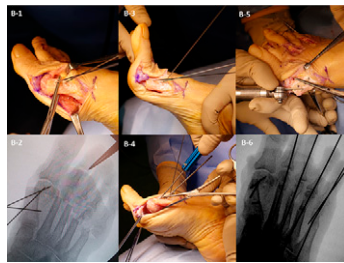


Fig. 6-B

**Figs. 6-A and 6-B** Fixation. **Fig. 6-A** The distal fragment (metatarsal head) was fixed (hooked) into 3-mm-deep grooves in the cortical bone of the proximal fragment. After that, the distal and proximal fragments were fixed with a 1.2-mm Kirschner wire. **Fig. 6-A-1** The cortical bone of the distal end of the proximal stump is chiseled into a narrow spike with 2 grooves using a high-speed burr. **Fig. 6-A-2** Completed small narrow spike with 2 grooves. **Fig. 6-A-3** Cortical bone at the bone marrow side of the proximal end of the distal stump is shaved using a high-speed burr. **Fig. 6-A-4** Completed canal mortise of the distal fragment. **Fig. 6-A-5** A 1.2-mm Kirschner wire was first inserted from the proximal end of the distal fragment, passing the newly formed MTP joint, PIP joint, DIP joint, and toe apex. **Fig. 6-A-6** A switch-backed Kirschner wire was inserted from the distal end of the proximal fragment, passing the site of offset correction and the medullary canal of the proximal fragment, subsequently stopped after passing the TMT joint. **Fig. 6-A-7** The spike with 2 grooves (proximal fragment) was placed into the medullary canal mortise of the distal fragment and fixed (hooked). **Fig. 6-B** The distal bone fragment was shifted laterally and was fixed with screws. **Fig. 6-B-1** Three guidewires (1.1 mm) for AcuTwist screws were inserted. Of the 3 screws, 2 were directed for the metatarsal head and neck and 1 was for the proximal end of the metatarsal shaft of the distal fragment. **Fig. 6-B-2** The directions of the guidewires were checked with fluoroscopy. **Fig. 6-B-3** The range of motion of the first MTP joint was checked. Almost 90° was achieved in the representative case. **Fig. 6-B-4** Internal fixation was completed. The fragments were pinched tightly with Kocher forceps to maintain the corrected position. **Fig. 6-B-5** After fixation, medial overhanging bone of the proximal fragment was resected using a bone saw. **Fig. 6-B-6** Checking with fluoroscopy determined whether the overhanging bone was adequately resected.



## First Metatarsal

- Use 3 AcuTwist screws (Acumed) for the fixation.
- Before fixation, place chips from the resected bone into the medullary canal of both fragments to act as bone graft.
- After manually aligning the osteotomy, insert 3 1.1-mm guidewires for 2 screws to stabilize the metatarsal head and neck and 1 screw to secure the proximal aspect of the osteotomy.
- Confirm proper placement of the guidewires with fluoroscopy.
- Complete the fixation as the fragments are held securely with Kocher forceps.
- After fixation, resect any medially overhanging bone from the proximal fragment with a power saw.
- Use fluoroscopy to confirm that any overhanging bone has been removed.

## Step 7: Medial Capsular Interposition and Closure

*After correction of the hallux valgus deformity using the modified Scarf osteotomy, interpose the 10-mm-wide capsular flap into the first MTP joint (Fig. 7).*

- Grasp the 10-mm-wide capsular flap with Kocher forceps that have been passed from the lateral side through the first MTP joint, and pull it laterally so that it is interposed between the base of the proximal phalanx and the metatarsal head.
- Apply tension to the flap so that the toe assumes a slightly varus position.
- Suture the proximal end of the flap to the stump of the dissected adductor hallucis tendon and the soft tissue surrounding the metatarsal head (Videos 1 and 2).
- Close the skin over drains for all wounds (Fig. 8).

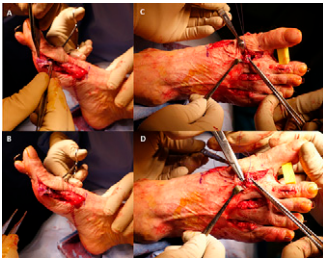


Fig. 7



Fig. 8

**Fig. 7** Medial capsule interposition and capsule closure. **Fig. 7-A** A 10-mm-wide flap was pinched with Kocher forceps from the lateral side of the first MTP joint. **Fig. 7-B** The Kocher forceps were pulled laterally, and the flap was interposed in the newly formed first MTP joint. **Fig. 7-C** The flap was pulled to keep the hallux in a slightly varus position, and the position was maintained by some cushion between the first and second toes. **Fig. 7-D** The proximal end of the interposed flap was sutured to the dissected adductor hallucis tendon and the soft tissue around the lateral aspect of the first metatarsal head.

**Fig. 8** Skin closure. Drainage was done for all of the wounds.

**Video 1** Modified Scarf osteotomy (horizontal osteotomy and medial capsule interposition).

**Video 2** Modified metatarsal shortening offset osteotomy.

## Results

In our series of 76 cases in 60 patients, sufficient reduction of the hallux valgus deformity was achieved consistently even in cases with severe destruction (Larsen grade 4 or 5) of the first MTP joint due to rheumatoid arthritis<sup>2</sup>. Painful callosities plantar to the lesser-toe metatarsal heads routinely disappeared following the metatarsal shortening offset osteotomies<sup>3</sup>. This combined joint-preserving surgery for the great and lesser toes resulted in greater plantar pressure distribution under the first MTP joint and lower plantar pressure distribution under the second and third MTP joints with weight-bearing<sup>4</sup>.

## Pitfalls & Challenges

- To avoid the “troughing” phenomenon, and to obtain stable fixation, abundant bone-chip transplantation into the metatarsal canal after the Scarf osteotomy is required.
- To avoid pronation of the first metatarsal head and loss of the longitudinal arch of the foot, the direction of the bone saw during osteotomy should not be parallel to the transverse axis of the first metatarsal. Rather, an oblique direction (from medial-dorsal to lateral-plantar) is recommended.
- Any residual pronation deformity of the great toe should be corrected at the time of surgery using an Akin osteotomy of the proximal phalanx.
- Persistent valgus hindfoot deformity carries some risk for recurrence of the hallux valgus deformity and often can be managed with shoe inserts.
- Conversely, persistent varus hindfoot deformity poses some risk for the recurrence of subluxation/dislocation of the lesser-toe MTP joints.

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Makoto Hirao, MD, PhD<sup>1</sup>

Kosuke Ebina, MD, PhD<sup>1</sup>

Hideki Tsuboi, MD, PhD<sup>2</sup>

Akihide Nampei, MD, PhD<sup>3</sup>

Shigeyoshi Tsuji, MD, PhD<sup>4</sup>

Takaaki Noguchi, MD, PhD<sup>4</sup>

Hajime Owaki, MD, PhD<sup>5</sup>

Hideki Yoshikawa, MD, PhD<sup>1</sup>

Jun Hashimoto, MD, PhD<sup>4</sup>

<sup>1</sup>Department of Orthopaedics, Osaka University Graduate School of Medicine, Suita, Japan

<sup>2</sup>Department of Orthopaedics, Osaka Rosai Hospital, Sakai, Japan

<sup>3</sup>Nampei Orthopaedics and Rheumatology Clinic, Katsuragi, Japan

<sup>4</sup>Department of Orthopaedics/Rheumatology, National Hospital Organization, Osaka Minami Medical Center, Kawachinagano, Japan

<sup>5</sup>Department of Orthopaedics, Japan Community Health Care Organization (JCHO), Osaka Hospital, Osaka, Japan

E-mail address for M. Hirao: makohira777@gmail.com

ORCID iD for M. Hirao: [0000-0002-1408-7851](https://orcid.org/0000-0002-1408-7851)

ORCID iD for K. Ebina: [0000-0002-2426-1024](https://orcid.org/0000-0002-2426-1024)

ORCID iD for H. Tsuboi: [0000-0001-6705-9355](https://orcid.org/0000-0001-6705-9355)

ORCID iD for H. Owaki: [0000-0001-5485-4405](https://orcid.org/0000-0001-5485-4405)

ORCID iD for H. Yoshikawa: [0000-0002-7697-8035](https://orcid.org/0000-0002-7697-8035)

ORCID iD for J. Hashimoto: [0000-0002-5816-4599](https://orcid.org/0000-0002-5816-4599)

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