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ORIGINAL PAPER

# Bone reconstruction with vascularized free fibula in the treatment of osteomyelitis of the distal radius: a case series

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## Abstract

**Background** Osteomyelitis of the distal radius and wrist with bone defect presents a reconstructive challenge. Free fibula grafts have been successfully used in post tumor resection reconstruction of the wrist. We applied these techniques to the reconstruction of wrist adjacent osteomyelitis associated bone defects and report on the feasibility of the technique in this context.

**Methods** We retrospectively evaluated 4 patients treated from January 2009 to February 2017 with a free fibular osteocutaneous flap for distal radius osteomyelitis. Previous operations, defect size, time of operation, type of fixation, complete bone union, and functional outcomes were assessed.

**Results** The mean age at surgery was 45.8 years (range 37–60 years). The mean operation time was 430 min (range: 350–570 min). The ulnar head was removed in all patients. The average time to complete bony consolidation was 8 months. Three of the patients were pain-free at rest, and one had a remaining pain rated as VAS 2–3. The average grip strength was 23.6 kg.

**Conclusions** The use of vascularized fibular grafts for the reconstruction of the distal radius appears to be a reliable solution with satisfactory clinical results. It has the advantage of restoring the continuity of the forearm and wrist in one step using vital bone tissue, which is more resistant to infection than a non-vascularized graft.

Level of evidence: Level V, Therapeutic.

**Keywords** Distal radius · Fibulo-scapholunate fusion · Wrist arthrodesis · Osteomyelitis · Vascularized free fibula

## Introduction

The reconstruction of large bone defects due to chronic osteomyelitis presents a challenge in reconstructive surgery [1–3]. Accurate (serial) debridement of infected bone and soft tissue followed by a rigid stabilization with external fixation and staged bone reconstruction present the basis of successful limb salvage in these patients [4]. In osteomyelitis of the distal radius, wrist function and potential preservation of a residual range of motion must be considered in the reconstructive process. Reconstruction of bone defects in the upper extremity including the radius diaphysis due to osteomyelitis with a vascularized bone graft has been described before [5]. Free microvascular fibula transfer is an effective procedure for reconstructing large diaphyseal bone defects in the upper extremities [5–8]. Resection of the distal radius and fibulo-scapho-lunate fusion in the treatment of tumors of the distal radius has also been described [9, 10]. Orthopedics prosthetics or arthrodesis material typically are not used in an infectious setting and instead a staged procedure is favored. By combining established techniques from diaphysis bone loss in the upper extremities due to osteomyelitis and free fibula-based reconstructive techniques for tumor resection of the distal radius successful treatment of severe osteomyelitis of the distal radius can be achieved.

Marco Guidi and Viviane Nietlispach have contributed equally to this work and share first authorship.

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**Table 1** General patient characteristics

| Case | Age/gender | Occupation | Previous surgeries | Current smoking habit |
|---|---|---|---|---|
| 1 | 60 M | Truck driver | ORIF*/total wrist fusion | No |
| 2 | 41 M | Salesperson | ORIF | Yes |
| 3 | 45 M | Gardener | ORIF/RE-ORIF | Yes |
| 4 | 37 M | Unemployed | none | Yes |

*ORIF* open reduction and internal fixation

## Methods

This study presents a retrospective clinical and radiological analysis of 4 patients treated from January 2009 to February 2017 with a free fibular osteocutaneous flap for distal radius osteomyelitis. Previous operations, defect size, time of operation, type of fixation, complete bone union, and clinical outcome were assessed.

### Surgical technique

The primary operative step consisted of extensive debridement of the affected bone. Depending on the extent of the osteomyelitis, parts of the carpus and the ulnar head were resected as well. The osteocutaneous fibular flap was harvested from the ipsi- or contralateral leg via a standard lateral approach. When direct skin closure was not possible, a split skin graft from the upper thigh was used to cover the donor site defect.

The fibular graft was connected proximally to the radius and distally to the capitate and/or 3rd metacarpal. Depending on the defect size and type, a 3.5-mm reconstruction plate or 3.5-mm LCP plate was used. In one patient with a 23-cm defect zone, a 3.5-mm LCP plate was used proximally, and a wrist arthrodesis plate was used distally. All fibula flaps were anastomosed in an end-to-end fashion using an 8–0 Nylon suture on the radial artery. In all cases, a single venous anastomosis was performed to the larger concomitant vein of the radial artery. A coupler device was used in 3 cases; in one case, venous anastomosis was performed by hand also using the 8–0 Nylon suture. Arterial and venous anastomoses were performed under microscopic magnification (Table 2).

Postoperatively, perfusion monitoring of the flaps was performed according to standard protocols, and the patients received a splint for immobilization of the wrist. All patients remained on bed rest for 5 days. Prior to discharge, a physical therapist instructed the patients to practice walking, and full weight-bearing of the donor site leg was allowed immediately in all cases. Radiological follow-up was performed after 6, 12, and 24 weeks with either conventional radiographs or CT scans.

Outcomes of interest: free flap survival, bony union, time until weight-bearing.

## Results

Free fibula-based reconstruction of severe osteomyelitis of the distal radius was performed in 4 male patients. The mean age at surgery was 45.8 years (range 37–60 years). Three of the patients developed osteomyelitis after complex extremity trauma and several post-traumatic surgeries, one patient suffered had sustained a distal radius fracture, which was treated conservatively, but was complicated by hematogenous bacterial spreading (Table 1).

The mean operation time was 430 min (range: 350–570 min). In the longest case, the arterial and venous anastomosis had to be done twice due to an initial compression under the bone graft. The ulnar head was removed in all patients (Table 2). One patient was lost to follow-up after 5 months. At that time, the beginning of consolidation had already been documented by x-ray on both the proximal and distal graft. In the other three

**Table 2** Details of the reconstructive surgery received

| | OR time (min) | Defect length (cm) | Type of plate | Plate removal | Microsurgical anastomoses with 8.0 Nylon suture | Complications |
|---|---|---|---|---|---|---|
| 1 | 570 | 9 | LCP 3.5 | Yes | End-to-end to radial artery, one venous anastomosis (2.5 mm Coupler) | Plate loosening, partial lesion of superficial peroneal nerve |
| 2 | 440 | 13 | Reko 3.5 | No | End-to-end to radial artery, one venous anastomosis (by hand) | |
| 3 | 350 | 6 | Reko 3.5 | No | End-to-end to radial artery, one venous anastomosis (2.0 mm Coupler) | Neuromas of dorsal branch of the ulnar nerve and superficial branch of the radial nerve |
| 4 | 360 | 23 | LCP 3.5 | No | End-to-end to radial artery, one venous anastomosis (2.5 mm Coupler) | |

*OR* operation, *LCP* locking compression plate, *Reko* reconstruction plate

**Table 3** Clinical and radiological results

| Case | Proximal consolidation | Distal consolidation | Return to work | Pronation and supination | Jamar grip strength (kg) | VAS at rest |
|---|---|---|---|---|---|---|
| 1 | 8 | 6 | 17 M | 90–0-90° | 22 (32) | pain-free |
| 2 | 5 | 5 | 2 M | 90–0-40° | na | pain-free |
| 3 | 8 | 11 | - | 70–0-45° | 15 (35) | 2–3 |
| 4 | na | na | na | 65–0-25° | 34 (54) | pain-free |

*na* not available, *M* months, *Jamar Grip strengths in brackets* contralateral side, *VAS* visual analogue scale

patients, complete proximal bony consolidation was documented after 7 months, and distal consolidation at 7.3 months, complete consolidation was documented at 8 months. Three of the patients were pain-free at rest, and one had a remaining pain rated as VAS 2–3. Average grip strength was 23.6 kg. The range of motion results are shown in Table 3.

## Cases

### Case 1

A 60-year-old male truck driver sustained a complex fracture of the distal radius with concomitant scapholunate (SL) dissociation. After primary open reduction and internal plate fixation from both palmar and dorsal combined with temporary SL transfixation with *k* wires (Fig. 1A), the patient developed severe osteoarthritis of radiocarpal, ulnocarpal, and radioulnar joints with complete destruction of the radiocarpal articular surface. Plate removal and a total wrist fusion augmented with cancellous bone graft from the iliac crest were performed (Fig. 1B). Postoperatively, the patient developed a wound infection of the dorsal wrist, which ultimately resulted in staphylococcal osteomyelitis. Serial debridements were performed, after an interval of suppressing antibiotic treatment the arthrodesis plate was removed and intravenous antibiotic therapy continued.


**Fig. 1** Case 1. **A** Primary reconstruction with plate and K-wire osteosynthesis. **B** Total wrist arthrodesis. **C** Plate removal. **D/E** Post reconstruction with a free fibular graft, lateral, and posteroanterior projection. **F/G** Monitoring after plate removal, posteroanterior, and lateral projection after plate removal and ulnar head resection with complete proximal and distal consolidation

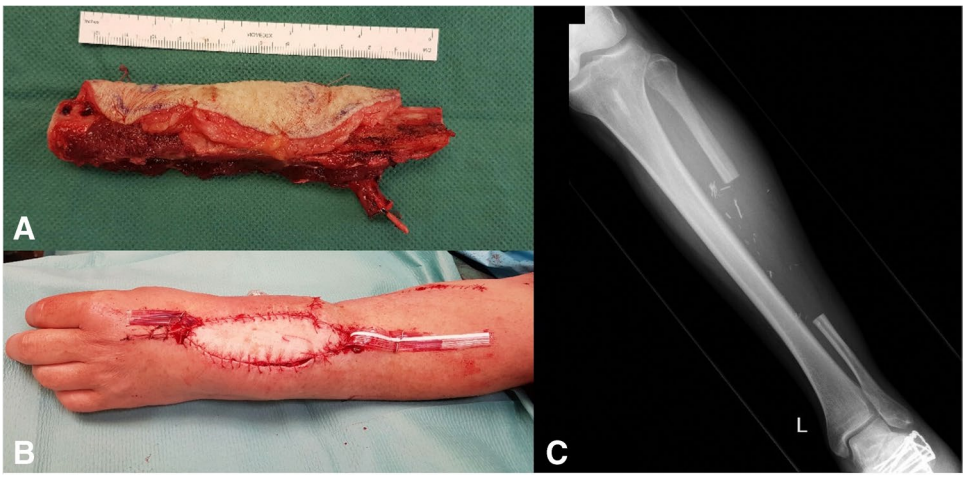


**Fig. 2** Case 1. **A** The fibula was harvested from the ipsilateral leg with a skin island. **B** The free flap was anastomosed to the radial artery in an end-to-end fashion and the skin island was placed on the dorsal forearm. C Stability of the leg was preserved

Nineteen months after the initial trauma, the patient presented with painful pseudoarthrosis and complete destruction of the radiocarpal and mediocarpal joint surfaces, as well as the distal radioulnar joint (Fig. 1C). Surgical resection of avital, sclerotic bone resulted in a defect zone of 9 cm and was reconstructed with a free osteocutaneous fibular flap from the ipsilateral leg (Figs. 1D/E and 2A–C). During fibula harvest, the superficial peroneal nerve was partially injured and repaired directly by epineural coaptation. Complete consolidation of the fibular graft was documented 8 months postoperatively. After 13 months, the dorsal plate led to irritation of the extensor tendons of the fingers. The plate had to be removed, and an ulnar head resection was performed. The patient returned to work as a truck driver 17 months after the fibular based reconstruction (Fig. 3A/B). Light residual hypesthesia of the dorsal foot remained from the iatrogenic nerve injury.

## Case 2

This 41-year-old male patient suffered a complex distal radius fracture with complete destruction of the distal radius and proximal carpal row on the right side in a motorcycle accident. Initially, the fracture was treated with closed reduction and external fixation, followed by open reduction and plate osteosynthesis. Due to a local infection, the plate had to be removed prematurely. One year later, the patient was referred to our department. At this time, he presented with a destruction of the distal radioulnar joint and chronic *Staphylococcus aureus* osteomyelitis (Fig. 4A). A resection of the distal radius the proximal scaphoid pole, the lunate and proximal hamate, and capitate was performed, leaving a 5.5-cm-long defect zone, which was temporarily filled with a gentamicin cement spacer, and an external fixator was placed (Fig. 4B).

Two months later, spacer and external fixator were removed and a further resection of the radius back to healthy bone was performed, resulting in a gap of 13 cm length. This gap was grafted with a free fibular osteocutaneous flap from the ipsilateral leg. The fibula was fixed with a 3.5-mm reconstruction plate proximally to the radius and distally to the capitate (Fig. 4C). The patient tolerated the procedure well without any complications. The patient returned to work as a salesperson 2 months postoperatively. Complete consolidation was reported 5 months postoperatively (Fig. 4D).

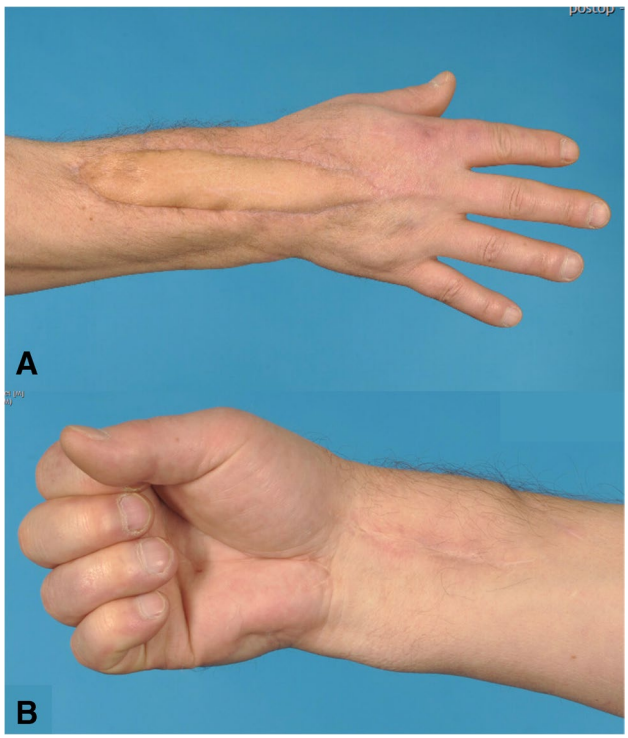


**Fig. 3** The patient returned to work as a truck driver 17 months after the fibular based reconstruction with an acceptable result both from a functional but also from an esthetic perspective

## Case 3

A 45-year-old male suffered a multifragmentary intraarticular distal radius fracture. The patient was treated with an external fixator, which was replaced one week later by dorsal and palmar plate osteosynthesis and defect bridging with cancellous bone chips. Due to an unsatisfactory repositioning of the radial styloid, a re-osteosynthesis was performed 1 week later. In the postoperative course, the radial joint surface secondarily dislocated. Plates had to be removed, the radius styloid was resected, and an RSL arthrodesis with iliac bone graft was performed (Fig. 5A/B). The patient then developed a nonunion of the distal radius with ulnar abutment and DRUJ osteoarthritis. After a non-vascularized iliac bone graft and resection of the ulnar head, the patient developed osteomyelitis of the distal radius with *Enterobacter cloacae*. After sufficient debridement the final bone defect zone measured 6 cm. This was again reconstructed with an osteocutaneous free fibular graft, which was fixed with a 3.5-mm reconstruction plate to the proximally to the radius and distally to the capitate and 3rd metacarpal base (Figs. 5C/D and 6A–C). Complete bony consolidation was documented 11 months postoperatively (Figs. 7A/B). The patient suffered from neuropathic pain associated to the dorsal branch of the ulnar nerve and the superficial branch of the radial nerve. This was managed conservatively.

## Case 4

A 37-year-old male patient was referred to our department with fistulizing osteomyelitis of the right radius, wrist arthritis, and osteonecrosis of the lunate and proximal scaphoid pole. These conditions followed a distal intraarticular radius fracture that had been treated conservatively 2 years prior. An MRI of the wrist showed osteomyelitis of the distal radius. A preoperative CT scan is shown in Fig. 8A. In a one-stage procedure, the distal 3/4 of the radius, proximal carpal row, and parts of the distal carpal row were resected, leaving a 23-cm defect zone. A free fibular osteocutaneous flap was harvested from the contralateral left side and fixed with a 3.5-mm LCP plate proximally and a 3.5/2.7 arthrodesis plate distally to the capitate and third metacarpal shaft. The last X-ray at our clinic was performed 3 months postoperatively, where the beginning of consolidation could be seen proximally and distally (Fig. 8B/C). The patient was then lost to follow-up.


**Fig. 4** Case 2. **A** Complete post-traumatic arthritic destruction of the radiocarpal and radioulnar joint. **B** Post resection of the distal radius and parts of the proximal carpal row and bridging of the defect zone with gentamicin cement. **C** Postoperative image after reconstruction with a free fibular graft. **D** Complete consolidation proximally and distally, 5 months postoperatively


**Fig. 5** Case 3. **A/B** Posteroanterior and lateral projection following radius styloid resection and RSL arthrodesis with pelvic cancellous bone graft. **C/D** Posteroanterior and lateral projection following ulnar head resection and free fibular osteocutaneous graft, showing complete proximal and distal consolidation

## Discussion

Chronic osteomyelitis remains a challenge in reconstructive limb surgery [1–4]. Reconstruction of diaphyseal bone defects in the upper extremity due to osteomyelitis with a vascularized bone graft has been described before [5]. Resection of the distal radius and fibulo-scapho-lunate fusion in the treatment of tumors of the distal radius has

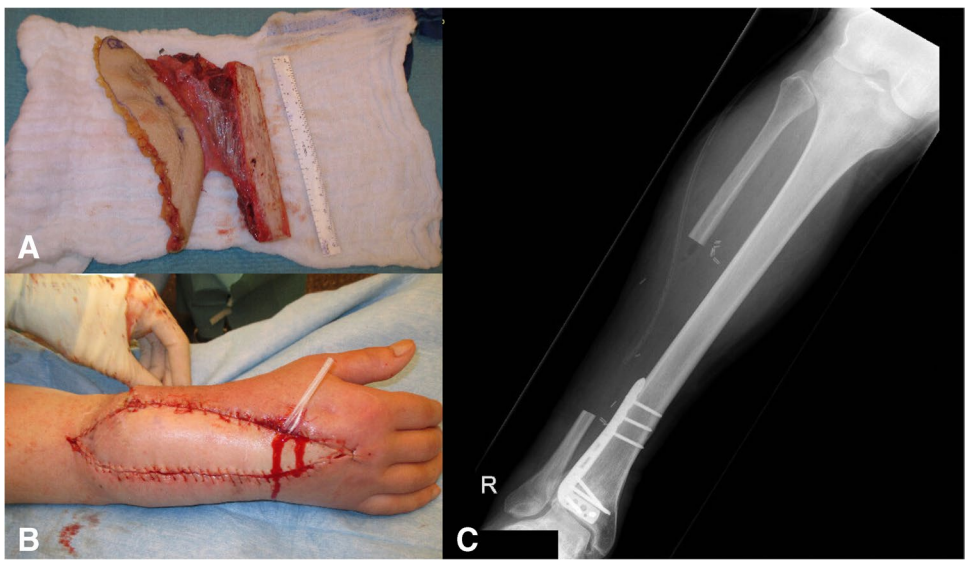


**Fig. 6** Case 3. **A/B** The fibula artery was anastomosed to the radial artery in an end-to-end fashion. The skin island was placed over the dorsal wrist. **C** Stability of the lower leg was maintained

also been described [8–11] Combining, to the best of our knowledge, the combination of established approaches of tumor surgery with those of surgical treatment of bone infection in this difficult setting have not been reported on. To address this lack of knowledge, we are reporting on our approach of merging established techniques from midsubstance bone loss in the upper extremities from osteomyelitis and reconstructive techniques for tumor resection of the distal radius into a new treatment regime for osteomyelitis of the distal radius.

In bone defects, bone autografts are the mainstay of reconstruction. Whether these should be vascularized or not and what defect size warrants a vascularized graft remains a topic of debate [12]. Vascularized bone grafts retain their intrinsic blood supply and therefore enable us to achieve sound bony union irrespective of the length of the bone defect. This intrinsic blood supply also helps against biofilm formation [13]. In our patient cohort, this was of particular relevance as we utilized arthrodesis material and due to the previous surgeries, the soft tissue situation around the resulting bone defect was scarred and therefore not ideally vascularized.

We are convinced that a vascularized bone graft is a better choice in this patient clientele. Of course, a free fibula graft is an invasive surgical procedure with a significant donor site morbidity [14]. The donor site morbidity of the vascularized fibula does in our opinion not outweigh the benefits of this technique. Vail et al. observed only a low prevalence of motor weakness or sensory deficits in the foot after the harvest of fibular flaps [15]. In our cohort, one patient suffered an iatrogenic injury to the superficial branch of the peroneal nerve, which could be directly repaired. No weakness of the extensor hallucis longus was found in the follow-up visits.

In tumor resections of the distal radius, other authors suggested doing a FSL fusion to preserve motion in the midcarpal joint [10]. To reduce the risk of persisting infection, we performed a more radical bone resection and chose total wrist fusion over residual wrist mobility. Generally, one of the indications for total wrist fusion is to relieve the pain after severe trauma to the wrist as a painful wrist causes disability and affects function of the upper extremity [16]. In these patients with affection of different locations of the wrist joint, a wrist fusion can therefore be considered a more predictable approach concerning postoperative symptoms.

All patients reviewed were satisfied with the decrease in pain after surgery and the resolution of their issues after numerous surgeries. Of course, this is a retrospective study and may thus may be prone to observer bias. The conclusions will need to be supported by prospective data for greater impact. Additionally, as we are presenting consecutive cases, patients were operated on by different surgeons. These adhere to department standards concerning the postoperative regime, but minor deviations based on personal preference might have been made. As this type of extensive infection is rather rare, this case series is of course short. To draw general conclusions, larger patient cohorts will have to be operated on and followed up with the described technique. Lastly, we did not specifically assess and describe functional outcomes or document the return to work, which are key factors when evaluating the reconstructive outcome.

## Conclusions

The use of the vascularized fibula is highly suitable for reconstruction of the distal radius because of its similar shape and structure. The management of chronic osteomyelitis of the distal radius with a vascularized fibula has the advantage of

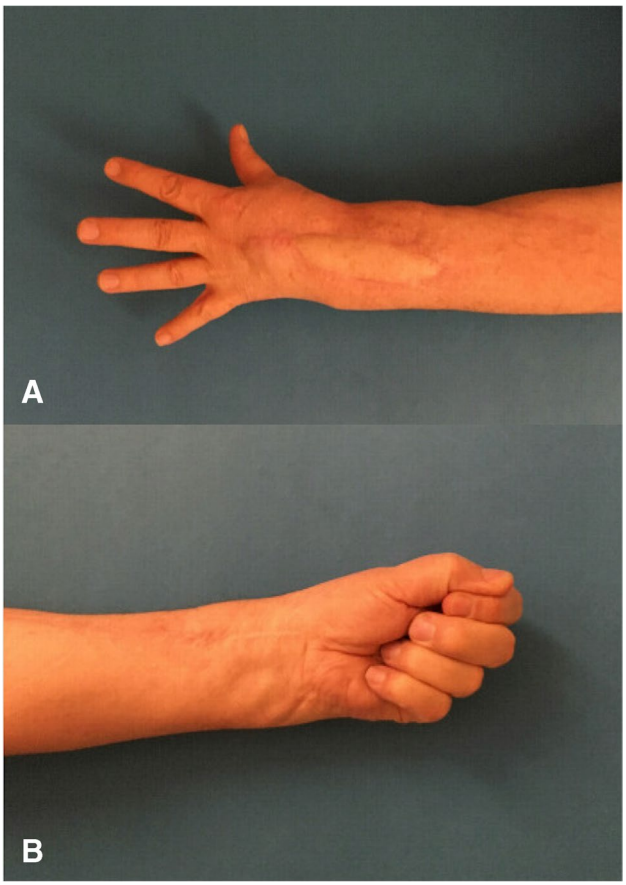


**Fig. 7** Case 3. **A/B** Complete bony consolidation was documented 11 months postoperatively. The patient showed good overall hand function


**Fig. 8** Case 4. **A** Preoperative CT scan showing the osteomyelitic process of the distal radius. **B/C** Lateral and posteroanterior projection 3 months after reconstruction with free fibular ostecutaneous graft showing beginning of consolidation proximally and distally

restoring the continuity of the forearm and wrist in one step using vital bone tissue, which is more resistant to infection than a non-vascularized graft. This method commonly results in good functional results.

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## Declarations

**Ethics approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. According to the local ethics committee, this study did not require specific ethical approval (BASEC-Nr. Req-2021–01128).

**Statement of informed consent** Informed consent was obtained from the patients of the study.

**Conflict of interest** Marco Guidi, Viviane Nietlispach, Florian Samuel Frueh, Bong-Sung Kim, Inga Swantje Besmens, David Jann, Thomas Giesen, Pietro Giovanoli, Maurizio Calcagni declare no competing interests.

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