

# A modified Matti–Russe technique of grafting scaphoid non-unions

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## Abstract

**Introduction** In treatment of scaphoid non-union bone healing requires beside vital tissue and stability, enduring compression and a good interface between the graft and scaphoid fragments. While fixation techniques show a good primary stability, they reduce sintering and thus compression of fragments in the long term. Therefore, a modified technique optimising the cancellous interface between graft and scaphoid but still providing enough stability without fixating implants should be evaluated.

**Materials and methods** A corticocancellous bone graft from iliac crest was shaped ellipsoid and was implanted in a modified Matti–Russe press fit-technique. Thereby the cancellous side contacts the scaphoid fragments. In a retrospective design, we reviewed 52 patients with documented non-unions of the scaphoid. The average length of follow-up was 8.6 months. Range-of-motion, pain and grip-strength was measured and compared with contralateral wrist. Radiological assessment included beside X-rays CT scans. Results were further measured by DASH score and Mayo wrist score.

**Results** The average postoperative pain was 0.9 based on NRS-Score. The mean range-of-motion was satisfactory with a dorsal-palmar arch of 115.3°, radial-ulnar: 48.2°

and pro-supination: 171.3°. Mayo Wrist Score showed with 91.2 out of 100 an excellent result. The analysis of DASH score revealed a mild subjective constriction (9.2/100). Regarding roentgenographic findings complete union was confirmed in 44 of the 52 patients (84.6%). Patients with non-union were significantly older than patients with union ( $p < 0.05$ ). Grip-strength on average was equal to that of the uninjured hand although in failure cases a slightly reduced grip-strength was seen.

**Conclusions** The modified technique of Matti–Russe provided a good contact of the cancellous part of the bone graft to the scaphoid in grafting a scaphoid pseudarthrosis with a high healing rate. However, since age, previous failed surgery and a proximal fracture line are the most important handicaps for bone healing in this study, for patients at risk gadolinium-enhanced MRI scan could be helpful to estimate vascularisation preoperatively. In cases of poor vitality, vascularised bone grafting should be considered.

**Keywords** Matti–Russe · Scaphoid non-union · Grafting · Consolidation

## Introduction

The scaphoid is the most frequently fractured carpal bone. The inappropriate blood supply of the bone decelerates bone healing. The axis of load transmission and the shape of the articular surfaces by the time cause a dispersion of both fragments. This leads to instability of the proximal carpal row. A delayed treatment of a scaphoid fracture thus often results in a non-union which causes pain, a limited range-of-motion and early osteoarthritis.

In the treatment of scaphoid non-union there is a vast consensus in favour of an operative therapy. Several

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techniques have been described. Some authors prefer grafting techniques while others use fixation methods or a combination for enabling an early mobilisation. While fixation techniques show a good primary stability [10], they reduce sintering and thus compression of fragments in the long term. However, bone healing requires beside vital tissue and stability, enduring compression and a good interface between the graft and scaphoid fragments. The most widely used operation techniques are the Herbert screw fixation [8] and the Matti–Russe operation [13, 18]. Matti–Russe technique ensures stability and compression but reduces the cancellous interface between the graft and the transplants.

We report our experience with a modified corticocancellous bone grafting technique optimising the cancellous interface between graft and scaphoid but still providing enough stability without fixating implants in the treatment of non-union of the scaphoid. The aim of this study was the analysis of the functional outcome, the consolidation rate and the subjective life quality of the patients.

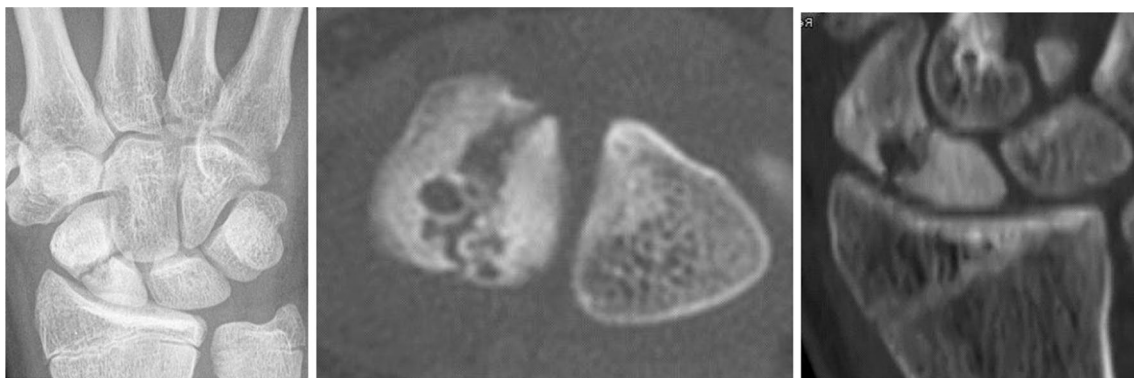
## Patients and methods

We retrospectively reviewed 52 patients with documented non-unions of the scaphoid, defined as missing consolidation for more than 6 months (Fig. 1). The average age of the patients at time of operation was 30.9 (range 18–59) years. The group consisted of 48 male and 4 female patients. The approval of the ethical board was obtained. The time interval between the injury and bone grafting ranged from 6 months to 20 years (average 35 months). 12 patients could not remember the time of injury. Prior surgical treatment before the index operation included a graft-operation in three cases, in one case a Herbert-screw fixation and in three cases a combination of autogenous bone grafting and screw fixation. The informed consent of the patients was obtained prior to surgery. 14 fractures were located in the proximal pole, 1 in the distal pole and 37 in the waist of

the scaphoid. All patients had symptoms like pain, stiffness or weakness before the operation. Mild osteoarthritis in terms of a SNAC-wrist I° (scaphoid non-union advanced collapse) was present in seven wrists. Two patients showed a proceeded arthritis with a SNAC-wrist II°. 19 patients showed a mild sclerosis of the proximal fragment.

Results were measured with objective and subjective scores. Therefore, DASH score [5] and Mayo wrist score [1] were evaluated. Testing was not performed preoperatively. Additionally, range-of-motion was measured for extension/flexion, abduction/adduction and pronation/supination and compared with contralateral wrist, using a handheld goniometer. Grip-strength was measured in percentage of the contralateral side by the JAMAR Dynamometer®. Subjective pain during 1 week before examination was assessed on the Numerical Rating Scale (NRS) ranging from 0 to 10 (0: no pain, 10: intolerable pain). The usage of analgesics was recorded. The average length of follow-up was 8.6 months (range 2–38 months).

In all patients, radiological assessment consisted of standard X-rays in two planes, ulnar deviation view and X-ray with fist closure scrunching a tennis ball. The pre- and postoperative radiographs were assessed for osteoarthritis and the degree thereof, the radiological density and union by the same surgeon. Scapholunate angles were measured pre- and postoperatively. Patients with preoperative non-vital bone and advanced humpback deformity were excluded. According to the house treatment regimen, these patients were instead scheduled either for vascularised bone grafting or salvage procedures. Union was defined as trabecular continuity across the site of the fracture and a disappeared fracture gap. Postoperative X-rays were taken 2 days, 12 weeks after surgery and finally at the time of examination. In 35 patients a proper assessment of consolidation was not possible according to the plain radiographs. In these cases CT scan in thin-film technique was performed. Four patients were lost for follow-up and had been excluded from the study.



**Fig. 1** Scaphoid non-union 11 months following wrist trauma

## Operative technique

A palmar skin incision of about 4 cm is made over the M. flexor carpi radialis tendon in a longitudinal direction. This approach realises an easy access and allows a distraction of the non-union and the use of an oversized autograft. The tendon is luxated and kept ulnar. Dissection is continued through the ground of the tendon. After cutting the palmar wrist ligaments, the scaphoid non-union is perfectly visible. A round hole has to be made in the scaphoid inside the non-cartilage zone of the bone using a chisel. Afterwards all avascular bone is cored-out with a bone curette and a ball-end mill. Both poles are caved as far as vital cancellous bone appears (Fig. 2 left). A corticocancellous bone graft is harvested from the ipsilateral iliac crest using a chisel. It is shaped ellipsoid with an oversize of 1–2 mm in comparison to recipient bed, leaving a cortical layer on one side (Fig. 2 middle). On average the bone graft was 4.44 mm (range 3.5–5.5) in diameter and 10.57 mm (range 7–13) in length. The graft has to be implanted in a press fit-technique. Thereby, the cortical side of the graft closes up the palmar approach to the non-union, while the cancellous side contacts the scaphoid fragments (Figs. 2 right, 6a). Compression was achieved by radial-duction and flexion of the wrist. There were no incidents of graft piece fractures. Finally, the stability of the graft inside the scaphoid fragments was checked by movement of the wrist. In all cases a solid construction could be achieved. Therefore, no additional *k* wire fixation was necessary. A radiological control proves the position of the graft and again the stability during movement. In case of cavities between graft and scaphoid, cancellous bone chips are punched in. Ligaments are sutured, the tendon is set again in place and skin is closed. Mean operation time was 58.3 min (range 49–74).

The after-care consisted of an immobilisation for 12 weeks in a scaphoid-forearm-cast in all cases.

Statistical differences regarding risk factors for non-union were calculated with the Mann–Whitney *U* test.

Where the patient groups were too small descriptive statistics were used.

## Results

### Subjective assessment

The average pain at follow-up was 0.9 on NRS. Several patients reported on remaining stress pain during extraordinary burdens like pushups. None of the patients suffered complaints in the iliac crest in terms of a donor site morbidity. None of the examined patients used pain killers for wrist complaints. The analysis of DASH score revealed a mild subjective constriction (9.2/100).

### Functional outcome

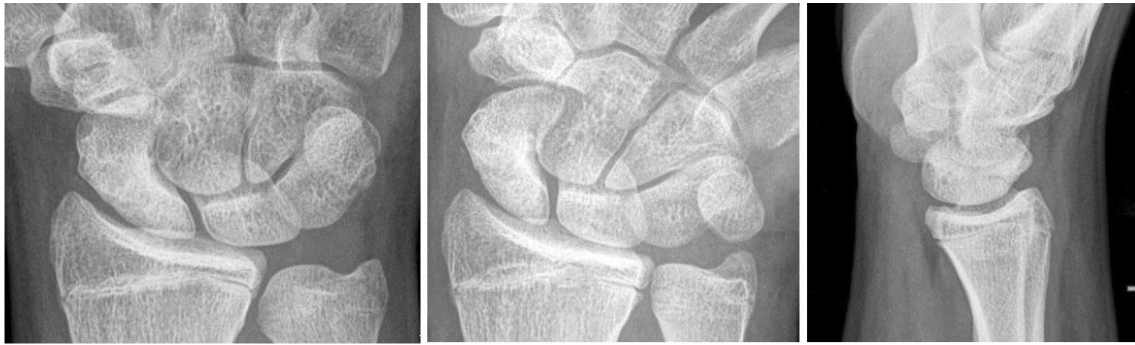
The mean range-of-motion was satisfactory with a dorsal-palmar arch of 115.3°, radial-ulnar: 48.2° and pro-supination: 171.3°. Range-of-motion remained less than on the contralateral side (dorsal-palmar arch of 126.7°, radial-ulnar: 57.2° and pro-supination: 175.6°), thus, not significant. Grip-strength on average (111.7 lb, SD 14.9 lb) was not significantly different from that of the uninjured hand (119.8 lb, SD 17.2 lb) although in failure cases a slightly reduced grip-strength was seen. Mayo wrist score showed with 91.2 out of 100 an excellent result (excellent 16, good 6, fair 3). No complications such as infections or hematomas occurred.

### Radiographic evaluation

Regarding roentgenographic findings complete union was confirmed in 44 of the 52 Patients (84.6%) (Figs. 3, 4, 5). In three cases (4.9%) we observed a partial union 4.7 and 14 months postoperatively. Partial union was defined as a consolidation in some but less than half of the CT layers. All three patients had little complaints, two with good, the third with fair values in DASH- and Mayo wrist scores. Five patients showed non-union at all (9.6%).

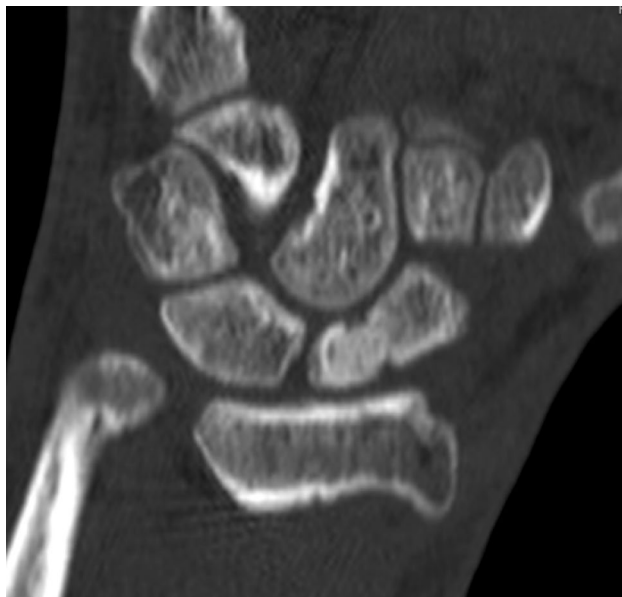
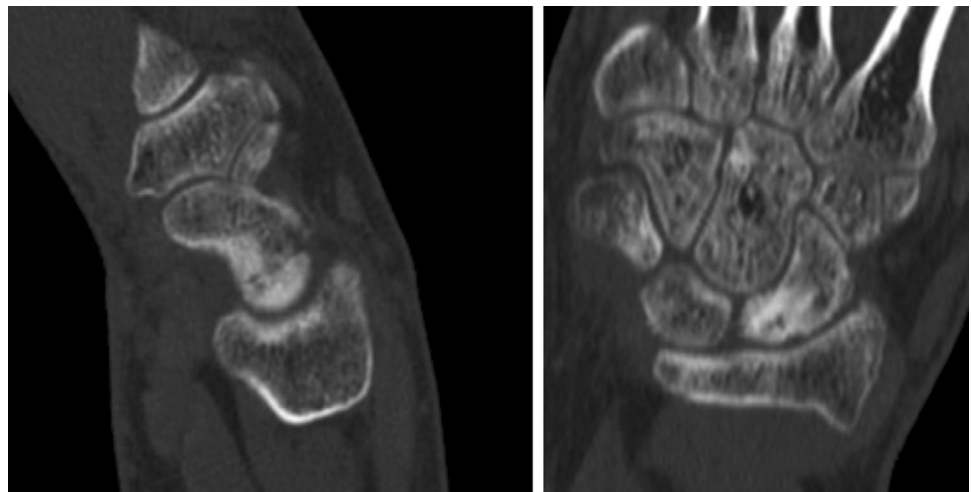


**Fig. 2** Modified Matti–Russe procedure with a corticocancellous bone graft



**Fig. 3** Nine months after modified Matti–Russe operation: complete consolidation, full range-of-motion

**Fig. 4** Two months after modified Matti–Russe operation



**Fig. 5** Four months after modified Matti–Russe operation

Three of the five patients with missing union had been operated before (Table 1). Consolidation rate of revision surgery was poor (4/7, 57%). One of the five patients without radiological union was examined 8 weeks after operation and finally lost to follow-up. Therefore, consolidation might have occurred later without our knowledge.

The rates of bony consolidation at proximal pole (78.6%) was less than at the waist (86.5%) or distal third (100%) (Table 2). Patients with union in the CT scan, respectively, X-ray were significantly younger than patients with non-union (CT scan  $p < 0.036$ , X-ray  $p < 0.029$ ). Regarding X-rays, we could not find any correlations between sclerosis of the fragments and bony consolidation. At patients with non-union a significant longer time period prior to surgery was recorded ( $n = 4$ , average 63.5 months, SD 37.1) compared to patients with union ( $n = 34$ , average 34.2 months, SD 32.9,  $p < 0.033$ ).

On average scapholunate angle improved from  $65.0^\circ$  ( $44.5^\circ$ – $79.0^\circ$ ) preoperatively to  $55.0^\circ$  postoperatively



**Table 1** Failed modified Matti–Russe grafting

	Time from injury to operation (years)	Previous surgery	Localisation	Age at surgery (years)	Sklerosis
Patient 1	3.5	Conventional screw + graft	Middle	27	Yes
Patient 2	5		Proximal	39	Yes
Patient 3	3.7	1. Matti–Russe, 2. Herbert-screw	Middle	34	No
Patient 4	9.8	Herbert-screw	Proximal	37	No
Patient 5	3.3		Proximal	49	Yes

**Table 2** Potential risk factors for non-union

Potential risk factors	Total (mean)	Union	Non-union	Partial union	<i>p</i>
Time prior to surgery (months)	35.0	34.2	63.5		<0.033
Age (years) for non-union determined in CT	34.0	31.5	43.8	32.5	<0.036
Age (years) for non-union determined in X-ray	34.0	36.0	41.1	30.7	<0.029
Potential risk factors	Total ( <i>n</i> )	Union	Non-union	Partial union	Rate of union (%)
Proximal	14	11	3	2	78.6
Middle	37	32	2	1	86.5
Distal	1	1	0		100
Sclerosis	19	16	3		84
Revision surgery	7	4	3		57

Mann–Whitney *U* test (upper part,  $p < 0.05$ ). Descriptive statistics lower part

(43.0°–74.0°). The difference was not statistically significant ( $p < 0.05$ ).

## Discussion

Scaphoid pseudarthrosis often can be seen as a result of delayed diagnosis due to the limited reliability of the diagnostics by plane X-ray [11]. In some cases the pseudarthrosis is a result of failed primary operation [10, 14]. If a non-union has been diagnosed, simple fixation is not suitable any more, in these cases bone grafting for scaphoid pseudarthrosis is a widely accepted procedure with a high percentage of consolidation. Thereby, Matti–Russe technique seems to be the method most widely used. Union rates of at least 70% have been reported indicating reproducibility of results [6, 17–20]. However, differences in outcome reflect varying surgical techniques and dissimilarities in the case mix.

### Graft shape

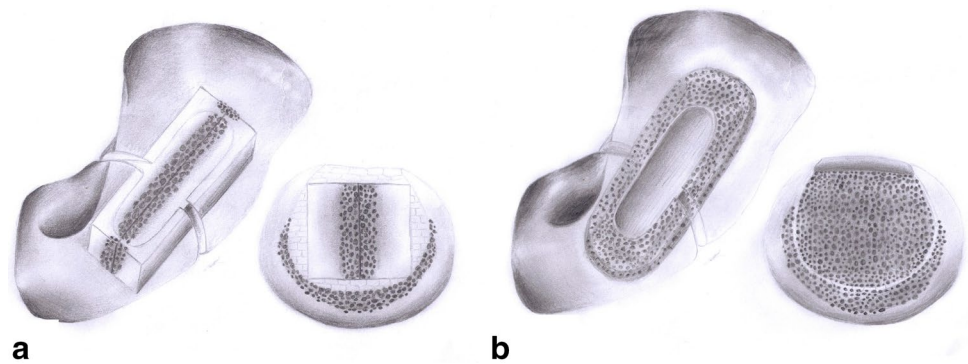
Historically, Matti described a new method for treatment of scaphoid non-union in 1937 using a dorsal approach, an excavation of the fragments and a filling of the cavity with

cancellous autologous bone grafts [13]. In 1960, Russe reported a modification switching the dorsal to a palmar approach and utilising a corticocancellous bone [18]. This was later referred to as Matti–Russe technique. This method enables a sintering of the fragments assuring a good contact to the graft and good stability without hardware application. However, the outwards orientated cortical surface of the Matti–Russe graft is a handicap for bone healing, since contact of cancellous bone of the graft to the fragments is little (Fig. 6).

Therefore, we apply a corticocancellous bone graft, in which cancellous bone surface is facing outwards. The cortical layer closes up the bone-approach to the scaphoid giving stability to the graft. In this way, good mechanical and biological properties are combined. In our series of un-united scaphoid fractures, treated by this modified Matti–Russe procedure consolidation rate was 84.6%.

Previous studies demonstrated success rates of original Matti–Russe operation of 70 to 100% [6, 18, 20]. Russe himself reported a consolidation rate of 95% in 200 cases with a follow-up of 20 years [19]. In comparison to Russe's results union rate in our series was less. However, Russe did not conduct a systematic evaluation of his patients and did not use a CT scan for assessment of bone healing [19]. Nevertheless, computed tomography is an important tool

**Fig. 6** **a** Original Matti–Russe technique, **b** modified grafting with optimised cancellous interface



for assessing bony consolidation [16]. Hannemann et al. [7] reported a relatively low average sensitivity (0.65) and specificity (0.67) of diagnosing scaphoid waist fracture union on standard scaphoid radiographs. Conventional radiographic imaging was considered as accurate and moderately reliable in diagnosing union, and reliable but inaccurate in diagnosing non-union of scaphoid waist fractures at 6 weeks follow-up. This could be confirmed in our study, where a failed bony consolidation was mostly not clearly visible in X-rays, but CT scan finally revealed non-union.

In contrast to Russe, Green reported a union rate of 75% (34 of 45 cases) conducting Matti–Russe operation [6]. He also placed the cortical sides of the grafts facing outwards (Fig. 6a). He recommended an intraoperative scrutinising of bone-vascularity. From our point of view, in doubt this should be checked before by gadolinium-enhanced MRI scan since intraoperative evaluation is difficult and not reliable.

### Fixation techniques

1984 Herbert and Fischer described the use of Herbert screws for treatment of scaphoid pseudarthrosis but showed poor results using a screw fixation without grafting [8]. Herbert himself reported his experience of 234 ununited scaphoids [4]. His overall average union rate including sclerotic pseudarthroses was 70%. Several authors used Herbert screws in combination with bone grafts with better results [2, 8, 9, 12]. Most of them utilised wedge grafts. Barton reported a higher union rate of 78% of wedge grafts in combination with Herbert screw in comparison to original Russe graft [2].

In our view a screw-fixation technique enables initial compression of the fragments and stability. This is provided by a plate fixation technique as well; however, it is discussed controversially due to reported complications in the literature, especially damage of the cartilage of the radius surface requiring the plate removal. In this way early mobilisation is possible which reduces subsequent restriction of motion. On the other hand, sintering of fragments

is avoided in the long term and joints are affected inserting the screw. This might be the reason why reported healing rates are lower than those of original Matti–Russe operation [20]. Wedge grafting technique is a demanding procedure. Shaping of the wedge graft and placing the screw to fixate three bone fragments is difficult. Additionally, further cartilage is sacrificed by placing the screw.

### Risk factors

In our series three of the five patients with missing union had been operated before. Altogether revision surgery in our series showed a consolidation rate of just 57.2%. This corresponds to results of other authors presenting a poorer outcome of corrective scaphoid surgery [3, 17, 21]. Reduced bone stock and bone quality after failed operations, therefore, seem to undermine conditions for corrective surgery. Ramamurthy et al. showed an overall union rate of 71% in 126 cases, using a combination of bone grafting and fixation techniques with *k* wires or screws [15]. Our findings show a tendency that the site of non-union is an important determinant of outcome. In our series in three of the five patients with failed grafting the fracture line was proximal; however, the statistics on that was not significant and the group of the patients with a distal location of the pseudarthrosis was very small (Table 1). In contrast to our findings Reigstad et al. could not confirm correlations between localisation of pseudarthrosis or time interval to surgery and consolidation rate. He reviewed 50 patients 8–18 years following varying operations for scaphoid non-union. They showed a consolidation rate of 90% [16].

Four of our patients without scaphoid union were older than our mean age of 30.9 years and the age in the non-union group in our data was significantly higher than in the union group. However, there is no confirmation on this theory in previous studies, either to the lack of statistical significance [11] or to the fact that the factor age was not included as prognostic factor [12, 13, 16]. In summary, proximal fracture line, age and previous operations

as important prognostic factors in our series are worthwhile being evaluated in further studies.

### Limitations

The retrospective design with a lack of pre-op data is a limitation of our study. There are limitations of comparison of the results with other studies, as more difficult cases as humpback deformities and patients with an avascular proximal pole were excluded. In our opinion for these cases other techniques should be chosen. For the statistics it was taken into consideration that some patient groups were too small for reliable statistical evaluation.

### Conclusion

We find our results of modified Matti–Russe technique encouraging with a high consolidation rate, a good clinical outcome and good function. The operation is not time consuming. However, some restrictions as stress pain and a slightly limited range-of-motion remained. Limitation of the technique is an avascular proximal pole and advanced humpback deformity.

Since age, previous failed surgery and a proximal fracture line are potential handicaps for bone healing according to our data, for patients at risk gadolinium-enhanced MRI scan could be helpful to estimate vascularisation preoperatively. In cases of poor vitality, vascularised bone grafting should be considered as alternative.

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### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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