

# Long-term follow-up of callotasis lengthening of the capitate after resection of the lunate for the treatment of stage III lunate necrosis

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**Abstract** The callotasis lengthening technique was used to gradually lengthen the capitate after resection of the lunate in stage IIIa necrosis in 23 patients. Results of ten patients with a follow-up of at least 5 years showed rapid and sufficient callus formation in every patient regardless of age. The callotasis lengthening modification of the Graner II operation provides all advantages and avoids the major inconvenience of the traditional Graner II operation. There was no increased rate of disturbed fracture healing. Results of the DTPA-gadolinium MRI study did not show any significant impairment of vascularization within the region of the capitate bone. With the “intrinsic bone formation,” contrary to every other intercarpal arthrodesis at the wrist, there is no need for an additional bone graft.

**Keywords** Hand · Wrist · Lunate · Necrosis · Kienböck · Distraction · Osteogenesis · Partial arthrodesis

## Introduction

In spite of the patients' excellent subjective judgments of the postoperative results after Graner II operations in case of grade III lunate necrosis, the good functional results and the equal rate of secondary arthritis when compared to other intercarpal arthrodeses [1–9, 11, 14–16, 18, 21, 22, 24–29, 32–34], this technique nowadays is very rarely used. This is due to its major inconvenience, the risk of disturbed fracture healing leading to pseudarthrosis in about 30% and/or avascular necrosis of the capitate in 20–25% of cases [11, 15, 18, 24, 27]. Disturbed fracture healing is caused by inadequate capitate osteotomy [14, 15] and/or immediate transfer of the proximal pole with disruption of the nutrient blood vessels [9, 17, 23, 31]. In order to reduce the risk of iatrogenic devascularization of the capitate, the callotasis lengthening technique of Ilizarov [13] has been used after capitate osteotomy between the middle and distal third of the capitate.

## Materials and methods

Twenty-three patients presenting stage IIIa lunate necrosis were operated on using the new technique. The results of ten patients with follow-up of at least 5 years are reported. Preoperative examination included history taking, clinical and radiological examinations (X-ray, DTPA-gadolinium MRI). Intraoperative examination evaluated cartilage and bone quality. Postoperative clinical and radiological examinations (X-ray) were carried out. Active range of motion was measured using the neutral-0 method. Power and pinch grips were evaluated with the JAMAR<sup>®</sup> and the Pinch Meter<sup>®</sup>, respectively. The average of three measurements was noted. The Cooney wrist score was

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R. Hierner dedicates this article to his co-author, Professor Klaus Wilhelm, a great teacher in hand surgery, on the occasion of this 75th birthday.

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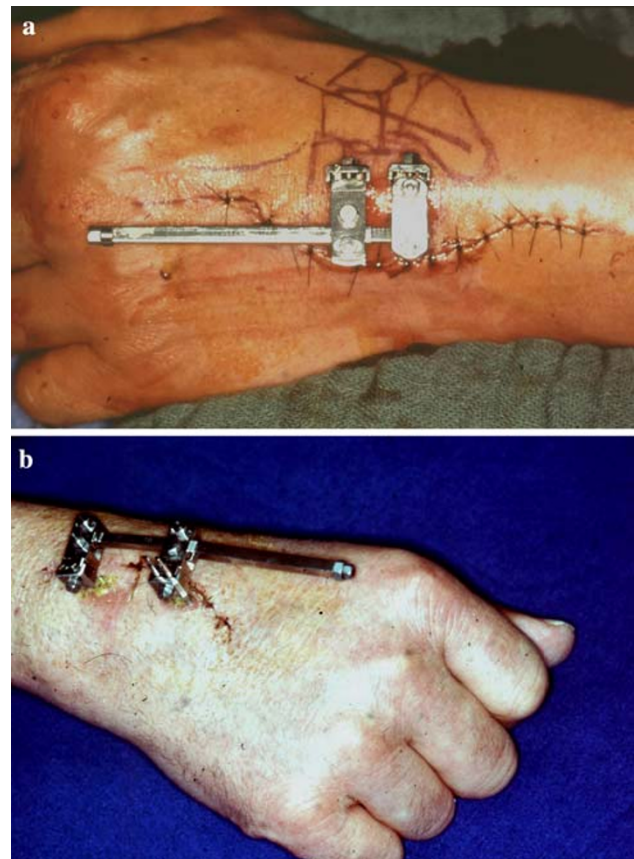
**Table 1** Therapeutic schedule of callotasis lengthening of the capitate

1. Operative phase
Placing of the distraction device
a. Dorsal skin incision
b. Capsular exposure and partial wrist denervation
c. Capsule incision
d. Scaphoid positioning and temporary K-wire fixation
e. Atraumatic lunate resection
f. Cartilage check (capitate, radius)
g. Determination of osteotomy site
h. Predrilling of pin holes
i. Subperiosteal dissection
j. Transverse capitate osteotomy/corticotomy
k. Pin placement
l. Assembly of distraction device
m. Periosteum/capsule closure
n. Skin closure
2. Predistraction period
7–10 days
Onset of active and passive finger motion
3. Distraction period
Distraction speed 1 mm/day
4. Consolidation period
Twice as long as distraction period
Replacement of external distraction device by percutaneous K-wires
Onset of physical therapy to improve range of motion of the wrist
5. Rehabilitation phase
a. Removal of K-wires
b. Onset of physical therapy to improve grip strength

calculated for functional evaluation. The DASH score was used to evaluate the subjective judgment at the 5-year point. Finally, the functional value of the operation for the patients' professional lives was evaluated according to returning to the previous job, returning to the job after professional retraining or not returning to professional life. Additionally, a postoperative DTPA-gadolinium-enhanced MRJ study was carried out 16 weeks after the operation.

#### Indication and contraindication

The callotasis technique for lengthening of the capitate is indicated in cases of stage IIIa lunate necrosis. It is firmly contraindicated in cases where no patient compliance can be expected, like in the case of alcoholics. Because of potential harm to the palmar vessels to the carpal bones, this procedure is contraindicated in cases of a previous injury or extensive operation in this region. Severe arthritis at the head of the capitate and the articular surface of the radius are also contraindications for this technique [2, 12,

**Fig. 1** Clinical aspect during capitate lengthening: **a** postoperative aspect, **b** late distraction period (5 weeks)

21, 35]. In case of a persisting rotatory subluxation of the scaphoid (stage IIIb according to Lichtmann's classification), the new technique is also contraindicated because of lack of definitive fixation of the scaphoid. Impaired soft tissue at the dorsum of the hand is also a contraindication unless reconstructive procedures have preceded the callotasis lengthening. Because of the reduced potential for bone growth in patients over the age of 25 [13], there might be some impaired bone formation using the callotasis lengthening technique in elderly patients.

#### Operative technique and postoperative care (Table 1)

The distraction device was developed in cooperation with and supplied by FIXOMED, Munich (Fig. 1).

#### Results (Table 2, Fig. 2 a–f)

There were eight males and two females. All patients were manual workers. The stage IIIa lunate necrosis was caused by trauma (one case) or by Kienböck's disease (nine cases). The mean age was about 37.9 years (range: 23–55; Table 2).

**Table 2** Five-year results for callotasis lengthening of the capitate

Diagnosis	Age	Sex	Lengthening			Distraction length (mm)			Active ROM		Mean (3×) grip power (kg)			Complications Secondary surgery	DASH (pts)	Return to job
			pd	di	co	tot	Pre-op UA/RA	Ex/Flex	5 years UA/RA	Ex/Flex	Power	Pinch	Pinch			
1 Posttraumatic	51	M	7	27	54	88	12	20–0–20°	20–0–20°	15	25	25	*Wrist pain Pin ex	35	Yes	
2 Kienböck	46	M	10	31	56	97	11	20–0–20°	20–0–20°	12	18	18	*Palmar capitate Malalignment	32	Yes	
3 Kienböck	55	M	7	24	48	79	12	10–0–10°	10–0–10°	7	8	8	*Palmar capitate Malalignment	34	No	
4 Kienböck	37	M	10	26	52	88	10	40–0–50°	40–0–50°	12	18	18	*Palmar capitate Malalignment	42	Yes	
5 Kienböck	36	M	7	27	50	84	10	20–0–30°	20–0–30°	15	18	18	Pseudarthrosis Complete	44	Yes	
6 Kienböck	23	F	8	28	56	92	11	10–0–10°	10–0–10°	7	8	8	*Incomplete Lengthening	29	Yes	
7 Kienböck	23	F	7	26	53	81	10	60–0–60°	60–0–60°	12	17	17	*Palmar capitate Malalignment	31	Yes	
8 Kienböck	34	M	8	27	54	86	10	20–0–25°	20–0–25°	17	23	23	*Palmar capitate Malalignment	36	Yes	
9 Kienböck	29	M	7	29	52	86	11	10–0–20°	10–0–20°	8	8	8	*Palmar capitate Malalignment	33	Yes (after retraining)	
10 Kienböck	42	M	9	30	59	82	10	60–0–60°	60–0–60°	14	19	19	*Palmar capitate Malalignment	29	Yes	
Mean	39.7	8 M 2 F	8	27.5	53.4	86.3	10.6	30–0–30°	30–0–30°	15.4	21.8	21.8	1 Pseudarthrosis 9 Palmar capitate Malalignment	8 Yes 1 Retraining 1 No		

pd predistraction period, di distraction period, co consolidation period, tot total time



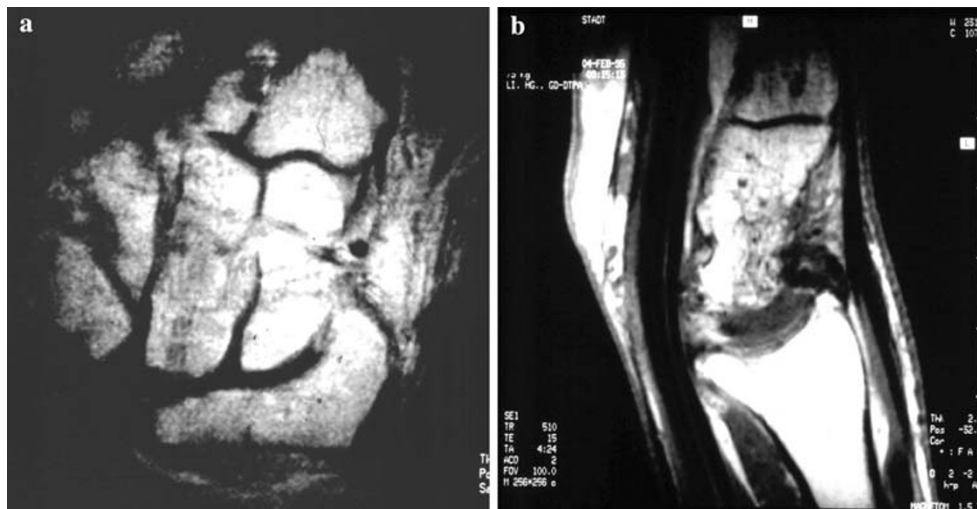
**Fig. 2** Active range of motion after 5 years. **a** Extension, **b** flexion, **c** ulnar abduction, **d** radial abduction, **e** pronation, **f** supination

The mean duration of capitate lengthening (tot) was about 86.3 (range: 79–97) days, with a mean of 8 (range: 7–10) days for the predistracton period (pd), 27.5 (range: 24–31) days for the distraction period (di) and a mean of 53.4 (range: 48–59) days for the consolidation period (co). The mean distraction length was about 10.6 (range: 9–12) mm. The mean range of motion prior to operation was about 33/0/33° (range: 20–60/0/20–60°) for extension/flexion, 11/0/25° (range: 2–20/0/10–40°) for radial/ulna deviation and 72/0/72° (range: 60–80/0/60–80°) for prono-supination. The mean range of motion at the 2-year interval was about 29/0/27° (range: 20–30/0/20–40°) for extension/flexion, 9/0/19° (range: 0–10/0/10–30°) for radial/ulnar deviation and 60/0/62° (range: 40–80/0/50–80°) for prono-supination (Fig. 2 a–f). The mean power grip and pinch grip strength prior to the operation were about 15.4 (range: 12–20) kg and 7.2 (range: 6.5–8) kg, respectively. The mean grip and pinch strength at the 5-year interval was about 21.8 (17–28) kg and 7.2 (6.5–8) kg, respectively.

All patients showed good callus formation. In nine cases uneventful bone healing occurred; in one patient a pseudoarthrosis within the capitate bone after an attempt to manually correct the sagittal capitate malalignment was seen. In nine patients the MRI study showed complete viability of the proximal and distal part of the capitate (Fig. 3a,b). In one patient (with uneventful bone healing), there was a partial necrosis of the distal capitate segment. Evaluation of the DASH scores showed a mean value of 44.5 points (range, 38–54 points). Eight of ten patients could return to their previous work after a mean of 137 days after the operation. One patient returned to his professional life after retraining. Another patient retired.

### Complications

Mild to moderate pain during the distraction period, especially in the evening, was experienced by all of the



**Fig. 3** DTPA- gadolinium-enhanced MRI study of bone viability in the capitate region 16 weeks postoperatively

**Fig. 4** Radiological evolution during capitate lengthening (d.p. and lateral view). **a** Preoperative aspect, **b** early distraction period (2 weeks), **c** late distraction period (4 weeks), **d** early consolidation period (6 weeks), **e** late consolidation period (10 weeks), **f** radiological aspect after 5 years



patients; it responded well to the application of NSAR (Diclofenac 50 mg 1–1–1). Severe pain was experienced by one patient, who responded well to paracetamol (500 mg 1–1–1). There were three superficial pin tract infections that could be treated conservatively. Incomplete lengthening of the capitate was seen in one patient who demonstrated limited compliance. In one patient pseudarthrosis occurred after trying to correct the sagittal malalignment deformity of the capitate manually during the distraction period. This patient finally required a complete

wrist arthrodesis (Table 2). With the ongoing distraction, a sagittal malalignment deformity of the capitate with a mean of 14° [10–21] occurred in nine of ten patients (Fig. 4b–d).

### Discussion

The aim of the new technique was: (1) to achieve the good functional results of the traditional Graner II technique

without creating any donor site morbidity for bone graft harvesting and (2) to avoid the risk of avascular necrosis within the capitate bone leading to disturbed fracture healing [35].

Regarding the results of clinical examination, the subjective judgments of our patients were positive due to the excellent pain relief, good preservation of wrist motion and significant increase in grip power. This was also documented by the results of the DASH score. The slight increase in pinch grip power probably should be interpreted more as a result of the physical therapy than the operation itself.

Disturbed fracture healing and avascular necrosis in the capitate region are caused by the osteotomy trauma and more importantly the single-stage capitate lengthening leading to extreme stretching or ultimately rupture of the supplying palmar blood vessels. According to Kerschbauer et al. [15], the appropriate choice of osteotomy site will minimize the osteotomy trauma. Taking into account the extrinsic and intrinsic vascularity of the capitate, the less invasive localization of the osteotomy site is at the junction of the middle to the distal third of the capitate. During progressive capitate lengthening, the proximal fragment, being a capsular pedicled vascularized bone graft, is smoothly shifted towards the radius. There is no excess in stretching the intact palmar blood vessels. Moreover, by progressive distraction, the blood supply will not be disturbed; in contrast, there even will be an increase in vascularity [15]. Thus, the risk of avascular necrosis is diminished considerably again. Even if the callotaxis lengthening might fail in elderly patients, which never was the case in our series, and therapy must be switched over to the lengthening-interposition technique [12, 19]—the salvage procedure, this advantage will still play a major role.

Regarding the results of the MRI study, there were no significant vascularization defects in the capitate region after callotaxis lengthening. Another indirect argument for better vascularization in the callotaxis lengthening group is the shorter time of immobilization. Comparing immobilization time after a conventional Graner II operation [21] and our technique, there was a significant reduction from 3 months to 6 weeks.

The first application of the callotaxis lengthening technique in the hand was used for posttraumatic cases [19, 20], and these still represent the most common use. Subsequently, the new technique was used to treat congenital hand deformities in children. For treatment of congenital deformities, there are some data in the literature showing that carpal lengthening has been successfully performed [10, 12, 30]. This led to the idea to use this technique in adult patients to lengthen the capitate after lunate resection. Although there are reports in the literature that callus formation might decrease with age, there was sufficient bone

formation in all our cases, even in the age group above 30 years. Moreover, no secondary fracture occurred during the consolidation and rehabilitation period. Thus, no bone grafts were needed in any of our patients.

As bone segment shifting and not lengthening is carried out, many soft tissue-related problems such as nerve and vessel stretching, distal joint contractures and fibrosis of the adjacent muscles do not occur. However, there was one specific complication. With the ongoing distraction, a palmar rotation of the proximal shifted capitate segment (Figs. 4b–d, 3b) occurred in nine out of ten patients. This capitate malalignment might be due to the strong palmar ligaments, which could not be sufficiently stretched by the distraction device used. Especially in the late distraction phase, there was some deformation of the distraction device in the sagittal plane. The palmar rotation must be regarded as a “prearthritic deformity” that could lead to accelerated degenerative arthritis at the radiocarpal joint. This complication can only be overcome by using a stronger distraction device. However, up to now no accelerated degenerative changes between the head of the capitate and the radius have been seen.

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