Intraoperative monitoring of ulnar nerve function during replacement of the rheumatoid elbow via the lateral approach

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Neurography of the ulnar nerve was performed pre-, intra- and postoperatively in 8 arms of 7 patients with rheumatoid arthritis operated on with total elbow replacement via the lateral approach. Ulnar nerve decompression was performed in 4 elbows before implantation. A reduction in the amplitude of compound muscle action potential (CMAP) recorded from the abductor digiti minimi on stimulation of the ulnar nerve in the axilla, was observed during elbow dislocation at surgery in all patients, in 5 cases transiently and in 3 cases until the end of surgery. The ulnar nerve had been decompressed in all patients with lasting amplitude reduction. One of them had a mild sensory ulnar nerve palsy, while the other 2 had normal nerve function at the postoperative clinical examination. All 3 had a reduction in the amplitude of compound sensory nerve action potential (SNAP) and 2 of them also in CMAP amplitude at the postoperative neurographic examination. In patients with transient reduction during surgery, the CMAP amplitude quickly normalized on relocation of the elbow and both the SNAP and the CMAP were preserved at the postoperative neurographic examination. The authors conclude that dislocation of the laterally approached elbow carries a risk of ulnar nerve injury, which is not prevented by decompression of the ulnar nerve, but frequent relocation of the elbow during surgery seems important. It is suggested that the ulnar nerve should not be decompressed routinely, and that the dislocated elbow should be frequently relocated.

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Posterior approaches are most frequently used for prosthetic surgery of the elbow, but the lateral approach (Ewald and Jacobs 1984) offers several advantages. The triceps tendon is not completely detached, the medial collateral ligament is preserved and the incidence of wound healing complications and deep infection is low (Hodgson et al. 1991, Ewald et al. 1993, Ljung et al. 1995). An increased risk of ulnar nerve palsy may, however, be a disadvantage. Hodgson et al. (1991) reported 16 ulnar nerve palsies in 23 patients operated on with the lateral approach. Ewald et al. (1993) reported a lower incidence of ulnar nerve palsy with the lateral approach (18/120) than with a posterior approach (25/82), and suggested that ulnar nerve palsy might be prevented by a release of the fibrous arch at the medial epicondyle and by frequent relocation of the elbow during surgery. The purpose of our study was to identify moments during the operation, critical for the function of the ulnar nerve, and to investigate the preventive effect of ulnar nerve decompression and of relocation of the elbow during surgery.

Patients and methods

During 1994, we implanted 8 capitellocondylar prostheses in 7 women with a median age of 56 (23–73) years. 1 patient was operated on both sides with an interval of 4 months. 5 patients had rheumatoid arthritis and 2 had juvenile chronic arthritis with a median disease duration of 20 (10–40) years. None of the patients had clinical signs of ulnar nerve neuropathy and none had vasculitis. 5 elbows had been previously operated on, in 4 cases with a synovectomy and in 1 case because of an olecranon bursitis. There had been no previous surgery of the ulnar nerve. Clinical examination of ulnar and median nerve function was performed preoperatively as well as 1 day and 6 weeks postoperatively. Paresthesias of the 5th finger were inquired about and recorded as absent or present. Tactile sensibility of the 2nd and 5th fingers and strength of the abductor pollicis brevis and digiti minimi muscles was clinically examined and compared with the contralateral side. Deficit was recorded as absent, sensory, motor or sensory and motor. 2-

point discrimination (2-PD) of the 2nd and 5th fingers was determined bilaterally and recorded at 2 mm intervals.

The operation

The prosthesis was implanted via the lateral approach (Ewald and Jacobs 1984) in all cases. Bloodless field was not used since the tourniquet compression blocks nerve conduction. In 4 elbows, the ulnar nerve was not exposed while, in the other 4 elbows, the fibrous arch of the medial epicondyle and the proximal part of the fascia of the flexor carpi ulnaris, overlying the ulnar nerve, was incised through a separate medial incision. The ulnar nerve of the left elbow of the patient operated on bilaterally was not exposed (Figure 1a), while the ulnar nerve of the right elbow of the same patient was exposed (Figure 2a). All patients were operated on by the same surgeon.

Neurophysiologic examination

Intraoperative motor neurography of the ulnar nerve was performed repeatedly and immediately before and after changes in position of the elbow during surgery. The position of the elbow was continuously recorded as located (during exposure and closure), dislocated (during humeral preparation) or dislocated and fully flexed (during ulnar preparation and cementation). The ulnar nerve was stimulated at the level of the axilla with surface electrodes (flexible lead electrodes, 1 × 6 cm) attached to the skin with an interelectrode distance of 3 cm. Constant current supramaximal stimulation (50 percent above max.) with square pulses of 0.3 ms duration was used. Compound muscle action potentials (CMAP) with a large initial negative component were recorded from the abductor digiti minimi muscle, with a reference electrode at the 5th metacarpophalangeal joint. The ground electrode was placed on the shoulder. The CMAP amplitude was measured peak-to-peak and at reduction, the supramaximal nature of the stimulation was checked by adjusting the stimulus strength. All examinations were performed by the same electrographer, using Viking Nicolet IV equipment. For ethical reasons and to make it possible to test the effect of relocation, the surgeon was informed of the result of the neurography during surgery at a certain level of CMAP amplitude reduction. A threshold level of 50 percent of the initial value was chosen for practical reasons and because it was considered to be a significant but not a total reduction. At this level, the elbow was relocated for a few minutes.

Preoperative neurographic examination of the ipsilateral ulnar and median nerves and the contralateral ulnar nerve was performed on the day before surgery. The ulnar nerve examination included a fractionated motor neurography with determination of motor conduction velocity within the forearm, elbow and upper arm segments and recording of the compound sensory nerve action potential (SNAP) at the wrist on stimulation of the 5th finger. The median nerve was examined with motor neurography of the forearm segment, including the distal latency over the wrist and recording of the SNAP at the wrist on stimulation of the 1st and 3rd fingers. Surface electrodes were used for stimulation and recording. In addition to motor and sensory conduction velocities, CMAP and SNAP amplitudes were measured. Postoperative neurographic examination of the ipsilateral ulnar and median nerves was performed 6 (5–12) weeks after surgery. In cases with lasting reduction of the CMAP amplitude at the end of surgery (Table 1; 2b-d), an additional neurographic examination was performed 2 weeks postoperatively and a needle EMG examination was added at the second postoperative examination.

Results

Ulnar and median nerve functions were normal at preoperative clinical examination in all patients, and remained normal postoperatively in all patients but one, who had a mild sensory ulnar nerve deficit. 2-PD of the 5fth finger had increased from 4 to 12 mm 1 day postoperatively, but was again normal at 6 weeks.

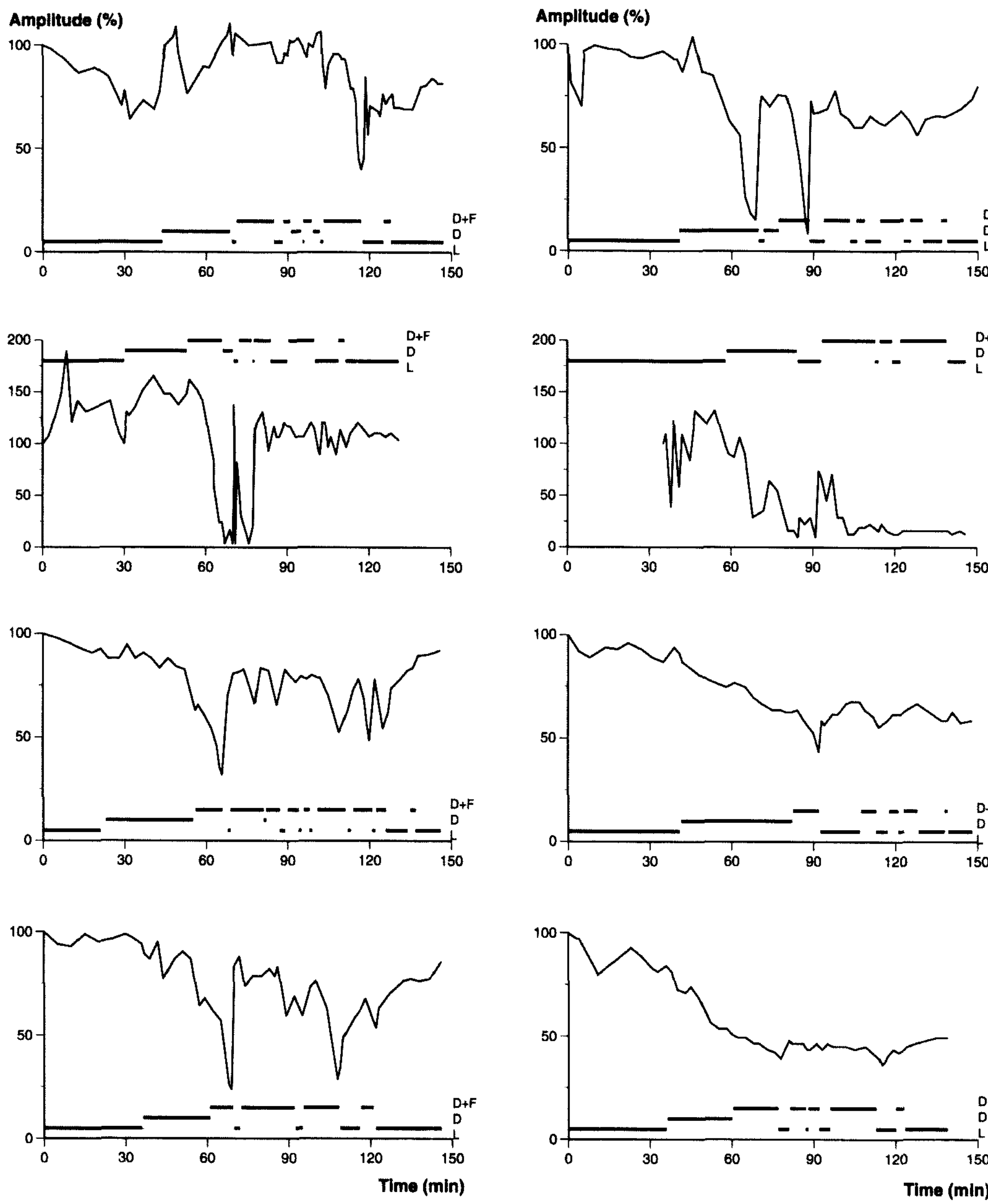
Neurophysiologic examination

The CMAP amplitude was reduced to less than half of the initial value in periods during surgery in all patients. Neurography of the 4 patients, in whom the ulnar nerve was not exposed, followed a similar pattern (Figure 1). During periods of elbow dislocation combined with full flexion, the amplitude was reduced to less than half in about 15 minutes and then normalized again within a few minutes after relocation. In 3 patients, there were two episodes of amplitude reduction and in the 4th only one. During periods of elbow dislocation without full flexion, reduction of amplitude to less than half was not seen. There was no amplitude reduction during cement curing. The amplitude had returned to approximately initial values in all 4 patients at the end of surgery.

Intraoperative neurography of the 4 patients, in whom the ulnar nerve was exposed, were different in some aspects (Figure 2). In 2 patients, the CMAP amplitude was reduced to less than half in about 15 minutes, already during elbow dislocation without full flexion. After relocation, amplitude normaliza-

Figures 1 and 2. Intraoperative neurography of the ulnar nerve in 8 total elbow replacements, without (1a–1d) and with (2a–2d) ulnar nerve decompression. Amplitude of compound muscle action potential (percent of initial value) and different elbow positions (L located, D dislocated, D+F dislocated and fully flexed) vs time. Note the different scale on the Y axis in (1b) and (2b).

Cases 1a–1d without ulnar nerve decompression **Cases 2a–2d with ulnar nerve decompression**



tion followed the same pattern as described above in 1 of the patients, even after repeated dislocation in combination with full flexion, while it was slow and incomplete in the other one, with a lasting, nearly total reduction of amplitude after repeated dislocation in combination with full flexion. This was the only patient with clinical signs of postoperative ulnar nerve palsy. In the other 2 patients, the amplitude decreased slowly, during 30 minutes or more of elbow dislocation, both with and without full flexion, to about half of the initial value. After relocation, the amplitude increased very little, and then remained at about the same level throughout the operation (Figure 2c-d).

Table 1. Patient data, intra-, pre- and postoperative amplitudes of compound muscle action potential (CMAP) and compound sensory nerve action potential (SNAP) of the ulnar nerve in 8 total elbow replacements

Patient data			Amplitude of CMAP				Amplitude of SNAP		
Elbow (nr.)[a]	Age (years)	Dis.dur. (years)	Intraop. (%)[b]	Preop. (mV)	Postop.1 (mV)	Postop.2 (mV)	Preop. (μV)	Postop.1 (μV)	Postop.2 (μV)
1a	23	9	82	10.4	—	10.1	11	—	7
1b	58	40	103	7.0	—	8.0	2	—	3
1c	54	30	92	8.7	—	9.0	2	—	3
1d	63	15	86	5.4	—	5.6	1	—	3
2a	23	9	80	8.9	—	9.5	19	—	21
2b	30	20	13	7.4	0.3	3.4	21	2	14
2c	73	19	59	4.7	5.0	5.6	5	2	3
2d	69	20	49	4.7	2.3	2.4	8	4	6

[a] Ulnar nerve decompression was performed in (2a–2d), but not in (1a–1d)
[b] Final value in % of initial value

The pre- and postoperative CMAP of the ulnar nerve, evoked by stimulation above the elbow, was compared with the final intraoperative CMAP (Table 1). There was a considerable reduction in the final intraoperative amplitude of CMAP in 3 patients (Table 1; 2b–d). One of them (Table 1; 2b) had a marked reduction in both SNAP and CMAP amplitude postoperatively at 2 weeks with some improvement at 6 weeks and, furthermore, needle EMG in the abductor digiti minimi at 6 weeks showed signs of denervation. This patient also had clinical signs of nerve injury. The 2nd patient (Table 1; 2c) had a postoperative reduction of SNAP but not of CMAP amplitude, while the 3rd patient (Table 1; 2d) had a postoperative reduction in both SNAP and CMAP amplitude. Neither of these 2 patients had clinical signs of a nerve lesion or denervation signs in the EMG. No postoperative changes in SNAP or CMAP were observed in the remaining 5 patients (Table 1; 1a–d and 2a). There were no changes in motor conduction velocity at the elbow in any of the patients.

Discussion

All 8 intraoperative ulnar nerve neurographies showed considerable reduction in the CMAP amplitude during elbow dislocation, which in 1 patient resulted in a postoperative ulnar nerve palsy. The direct mechanism of nerve injury during dislocation, however, is not obvious. Factors of importance for the reduction of amplitude may include kinking of the nerve under the fibrous arch or the fascia at the medial epicondyle, heat injury during cement curing, or extensive stretching or compression of the nerve between the medial epicondyle and the olecranon. Kinking of the nerve under the fibrous arch or the fascia is less plausible since its release did not prevent amplitude reduction. Heat injury is not likely, since the amplitude did not decrease during cement curing. Stretching injury to the ulnar nerve due to elbow lengthening after implantation of the prosthesis has been suggested (Blewitt and Pooley 1994) but, in our study, the amplitude did not decrease after relocation of the implanted prosthesis. Extensive stretching of the ulnar nerve during elbow dislocation is also possible. Stretching injury often results in denervation, which was severe in only one of our patients, however. Compression of the ulnar nerve between the medial epicondyle and the olecranon during elbow dislocation, inducing local ischemia, is the most plausible explanation of the reduction in amplitude observed in our study. Experimental nerve compression (Lundborg et al. 1982) resulted in the same type of transient conduction disturbances; these were present in 5 of our patients at surgery (Figures 1 and 2). In the study by Lundborg et al., different degrees of compression at 30, 60 and 90 mmHg resulted in partial or complete conduction block. More severe compression may, however, cause a mechanical deformation of the nerve, with lasting conduction block and axonal degeneration (Pedowitz 1991), which might explain the presence of postoperative reduction of CMAP and/or SNAP in 3 patients (Table 1; 2c–d) and signs of denervation in one of them (Table 1; 2b). Postoperative ulnar nerve palsy in prosthetic surgery of the rheumatoid elbow probably has several causes, including, apart from the above-mentioned, peripheral neuropathy, tourniquet-induced ischemia or mechanical injury and fibrosis or ischemic injury of the ulnar nerve after neurolysis, factors which may increase the susceptibility of the ulnar nerve to local compression.

Release of the fibrous arch and the fascia overlying the ulnar nerve at the medial epicondyle (Ewald et al. 1993) did not prevent the reduction in CMAP amplitude during dislocation of the laterally-approached elbow in our study. There were, however, some neurographic differences between the two groups of patients operated on with or without ulnar nerve decompression. In 2 patients with ulnar nerve decompression, the amplitude decreased quickly, as in the patients without ulnar nerve decompression, but already during elbow dislocation without full flexion. In the other 2 patients with ulnar nerve decompression, the amplitude decreased slowly, however (Figure 2). These differences are probably individual rather than differences between the two groups, as exemplified by the patient who was operated on both elbows, with and without ulnar nerve decompression (Figures 1 and 2). Her right elbow was stable and her left elbow moderately unstable, preoperatively. There was a more pronounced decrease in amplitude on the right side, already during dislocation without full flexion, probably due to greater difficulties in dislocating this elbow, which was tighter. The elbow of the only patient with a postoperative nerve palsy was also very tight and difficult to dislocate at surgery. Furthermore, in 3 patients, operated on with ulnar nerve decompression, the amplitude was not normalized at the end of surgery (Figure 2). In all 3 cases, the amplitude reduction had lasted longer before relocation was performed, in 2 patients due to a slow decrease in amplitude and in 1 patient due to circumstances during surgery.

In our series of 8 total elbow replacements, only 1 patient had a mild, transient postoperative ulnar nerve palsy, which is a low incidence. Of course, no conclusions can be drawn from this limited material. One might speculate, however, over the effect of not using a bloodless field. More important is probably the fact that ulnar nerve function was monitored during surgery and that the surgeon relocated the elbow when the amplitude was reduced to less than half of its initial value. The time factor also seems important. In 5 patients who had a relocation shortly after the onset of amplitude reduction, the amplitude quickly normalized, while it did not normalize at relocation in 3 patients with more longstanding reduction in amplitude. If the degree of compression is high enough, however, the amplitude reduction is hardly reversible, even if the time is short. A drawback with intraoperative electrophysiologic monitoring of ulnar nerve function is that it is impossible to use a bloodless field at the same time. One solution may be to use a bloodless field during the surgically more demanding exposure up to the point of dislocation and then release the tourniquet and start monitoring the ulnar nerve function. In the absence of routine monitoring of ulnar nerve function during surgery, the dislocated, laterally approached elbow should be frequently relocated.

We conclude that dislocation of the laterally approached elbow, especially when combined with full flexion of the joint, carries a risk of ulnar nerve injury. Such an injury is not prevented by release of the fibrous arch and the fascia overlying the ulnar nerve at the medial epicondyle, but frequent relocation of the elbow joint at intervals during surgery seems important for preventing postoperative ulnar nerve palsy. We suggest that the ulnar nerve should not be routinely decompressed and that the dislocated elbow should be frequently relocated.

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