STABILITY OF CHRONIC INTRAFASCICULAR ELECTRODE RECORDINGS

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ABSTRACT

We have implanted intrafascicular electrodes in peripheral nerves of cats and have recorded neural activity from a small population of nerve fibers for as long as six months, suggesting that these electrodes can be used on a chronic basis to acquire information about limb position, muscle force and skin contact.

INTRODUCTION

In order to achieve fine motor control with Functional Neuromuscular Stimulation systems, reliable real-time feedback is needed. Nerves carry a mixture of signals, in the form of action potentials, in a large number of afferent and efferent fibers. To acquire specific information about muscle force and length, and pressure on the skin, it is necessary to record from a small number of afferent fibers. Using intrafascicular electrodes developed in our laboratory, we have been able to record neural activity for as long as six months. In order to evaluate the usefulness of our electrode design, it is important to monitor the stability of the population of nerve fibers from which activity is recorded during this time.

METHODS

We have modified bipolar intrafascicular electrodes previously developed in our laboratory [1] to be used for chronic implantation. Electrodes were inserted into single fascicles of the radial nerves of anesthetized cats. The fascicles were left connected to the rest of the nerve and the epineurium was removed from the fascicle surface to allow for ease of insertion. After implantation the electrodes were secured with sutures.

Using the technique described in Goodall [2] we identified populations of nerve fibers from which activity was recorded for each electrode. Recordings were made at the time of implantation, and at 0.5, 1, 2, 4, and 6 months following implantation. By comparing successive recordings made from the same electrode, the presence of individual units in multi-unit recordings was chronologically monitored.

RESULTS

Data for 6 electrodes are presented in Figure 1. Four of these electrodes have been monitored for six months. The other two electrodes have not yet been observed at six months, but were still functioning at four months. For each recording session an 'x' is used to represent the presence of a single unit in a multi-unit recording. Horizontal lines are used to connect the same units identified in different recordings. This provides a time-line that shows the appearance and fade of each unit in the population.

For most electrodes there was an increase in the number of units in the population after the first month or two. During this time other units disappeared from the original population, some of which reappeared in later recordings. A few events may have occurred which produced this phenomenon. First, the electrode may not be stable within the fascicle until significant connective tissue growth has secured the electrode. Movement

0932--IEEE ENGINEERING IN MEDICINE & BIOLOGY SOCIETY 11TH ANNUAL INTERNATIONAL CONFERENCE
CH2770-6/89/0000-0932 $01.00

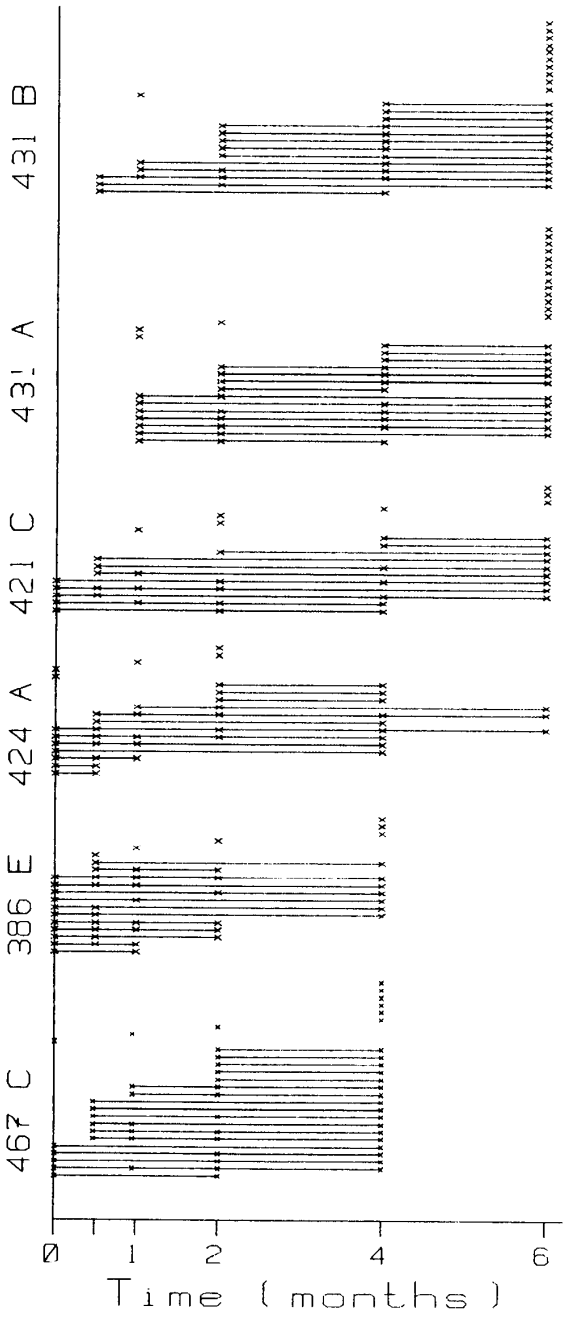

Figure 1. Time-lines of single unit stability recorded from chronically implanted intrafascicular electrodes. Each number represents a different electrode and each line represents a single unit.

of the electrode during this time would alter the population of fibers within the electrode's recording zone. Second, post-implant conduction block may cause a transient "loss" of unit activity during the first two months , which is restored when the fibers recover. A significant increase in the number of single units by six months for two electrodes suggests that the implantation procedure may have damaged some nerve fibers in this manner. The increase in population size would then be due to regeneration of damaged fibers.

CONCLUSIONS

Our preliminary results suggest that the activity of a small population of nerve fibers can be reliably monitored on a long-term basis using intrafascicular electrodes. They appear to cause little or no permanent damage, and so may be suitable for use in an FNS feedback system.

REFERENCES

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[2] E.V. Goodall and K.W. Horch, "Unit Analysis in Composite Neural Recordings," (this volume).

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