The Use of a Resorbable Wrapper for Peripheral-Nerve Repair

Experimental Studies in Chimpanzees*

CAPTAIN DAVID G. KLINE, MC, USAR,† AND COLONEL GEORGE J. HAYES, MC, USA
Department of Experimental Surgery, Walter Reed Army Institute of Research, Washington, D. C.

Protection of the site of a neuorrhaphy from infiltration with fibrous tissue and prevention of neuromatous formation by the use of wrappers, cuffs, or tubes of various materials has been practiced since 1880. At that time Gluck attempted to interpose a drain of decalcified bone between the severed ends of a sciatic nerve. Fibrous union without return of function, however, resulted. Bünstner (1891) enclosed the stumps of a severed nerve within a segment of brachial artery and reported successful regeneration between the stumps. Stookey (1922) and Weiss (1944) have summarized the materials and methods used for nerve wrapping and tubulization. Thus, in addition to decalcified bone and vessels, fascia lata, fat, muscle, parchment, Cargile membrane, gelatin, agar, rubber, fibrin film, and various metals have been used with varying degrees of success. Many materials failed because they incited a foreign-body reaction, produced constricting scar tissue, were technically difficult to apply, or required secondary operation for their removal.

The partial success of tantalum foil, which was used extensively during World War II,† and the more recent successful use of Millipore, a microporous cellulose acetate sheet, by Campbell, Bassett et al. support the concept that a wrapper or cuff around the site of neuorrhaphy restricts the tendency for regenerating axons to escape into extraneural tissue and prevents connective-tissue invasion of the area of repair. Both tantalum and Millipore technically are difficult to handle and with time can fragment, producing fibrosis and calcification. Since cuffs made of these materials are not resorbed, secondary operations for their removal often are necessary. These experiences, and in particular the excellent experimental work of Weiss and Campbell, and Bassett et al., have stimulated a search for an effective wrapping material that might be resorbable. Krippaehehe et al. recently demonstrated that autologous and homologous collagen taken from the submucosa of the small bowel and implanted subeutaneously or used as a vascular graft underwent progressive resorption. Cellular reaction to the subcutaneous implants subsided with resorption of the implant. The vascular collagen grafts were replaced subsequently with host connective tissue. Since commercially processed and purified Collagen* is presently available for research purposes in the form of thin, transparent membranes which have been irradiated, it was elected to give this a trial as a nerve wrapper. The collagen is extracted from bovine deep-flexor tendons, reconstituted, and tanned by a process promoting cross linkage of the collagen fibers which delays absorption. The purpose of this report is to describe a series of experiments using various types of processed collagen as a wrapper around both intact and repaired nerves of the chimpanzee. Chimpanzees were used since previous experimental work in our laboratory indicated that response of species to various types of peripheral-nerve injury differed. The chimpanzee responded to trauma with more connective tissue and axonal disorganization and slower

Received for publication November 1, 1963.

* Presented at the 35th annual meeting of the American Academy of Neurological Surgery, Palm Springs, California, October 25, 1963.

† Present address: Dept. of Neurosurgery, University of Michigan Medical Center, Ann Arbor, Michigan.

* Kindly supplied by Ralph Lyng, Director of Field Research, Ethicon, Inc., Sommerville, N. J.
return of function than the other species studied suggesting that it might be a more reliable animal for testing new methods of repair.

**Methods**

The principles of laboratory animal care as promulgated by the National Society for Medical Research were observed. A colony of 12 chimpanzees 6–10 years of age and 35 to 65 pounds in weight were used for these studies.

**Nerve Repairs.** The chimpanzees were anesthetized by intramuscular phencyclidine* 2–3 mg./kg. and then intravenous Nembutal 2–6 mg./kg. Intramuscular phencyclidine rendered the animal catatonic and permitted handling with a minimum of danger. Under aseptic conditions, the peroneal nerves of both lower limbs were exposed from their sciatic-nerve origins to the head of the fibula. A Grass stimulator was used to determine the functional threshold of stimulation. The electrical stimuli were delivered at a rate of 5 per sec. with a duration of 1 msec. The lowest voltage necessary to produce dorsiflexion of the foot was termed the functional threshold of stimulation. The threshold of stimulation in the intact nerve ranged from 1 to 2 V.

Lateral epineurial sutures were placed so that the nerve could be divided sharply between them. After severance of the nerve, the lateral sutures were tied. Several epineurial sutures were then placed anteriorly and posteriorly. Preplacement of the lateral sutures minimized handling the nerve, helped gain optimal fascicular alignment, and aided standardization of the repair (Fig. 1). The same technique was used on both peroneal nerves but one was wrapped over a distance of 2.5–3.0 cm. with a transparent collagen membrane 1 mil. in thickness. The collagen membrane was flexible and when moistened in saline could be wrapped readily around the repaired nerve. As shown in Fig. 1, the wrapper had to be secured by circular ties of either Mersilene or collagen suture.

After observation for periods of 24 hours, 2, 6, 8, 14, 24, and 32 weeks, the chimpanzees were anesthetized and the sites of repair were exposed by sharp dissection. Thresholds of stimulation were determined by increasing the voltage (from 0 V.) by increments of 0.5 V. until dorsiflexion was observed or 10 V. were reached. A 4 to 6 cm. segment of nerve includ-

---

* Supplied as Sernylan by F. E. Eads, D. V. M., Parke-Davis Co., Detroit, Mich.

---

**Fig. 1.** Method of severance and suture. Nerve was placed on wooden tongue blade and lateral epineurial sutures were preplaced (a). The nerve was severed with a razor blade and the preplaced lateral sutures were tied (b). Anterior and posterior epineurial sutures were then placed (c). The nerve was then wrapped with a transparent collagen film held in place by Mersilene or resorbable collagen suture ties (d).