Development of an artificial prosthesis using nerve signals

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Abstract

In this study, we tried to directly measure the nerve potential of motor nerves in amputated limbs. For motor nerve branches that control a single muscle in an animal limb, the optimum configuration and burial method of the electrode were examined. Deduced nerve potential was compared with the movement of the animal's limb and the correlation between motion and the nerve potential of the animal was confirmed. We cut off the nerve that deduced the nerve potential on the peripheral side of the electrode and that disconnected the dominant muscle from neural control. After this amputation of the nerve, we confirmed that locomotive stimulation to the controlled muscle continues to be deduced as nerve potential. We observed the changes in nerve potential and we tried to deduce the individual locomotor stimulation to the muscle by attaching an electrode array that arranged the electrodes of the mounting in the animal's limb.

1. Introduction

A myoelectric prosthesis uses EMG signals or potentials from voluntarily contracted muscles within a person's residual limb on the surface of the skin to control the movements of the prosthesis, such as elbow flexion/ extension, wrist rotation and opening/closing of the hand or fingers. Prostheses of this type utilize the residual neuro-muscular system of the human body to control the functions of an electric powered prosthetic hand, wrist or elbow. This is as opposed to an electric switched prosthesis, which requires straps and/or cables actuated by body movements to actuate or operate switches that control the movements of the prosthesis or one that is totally mechanical. The myoelectric regulation of prostheses still has some problems, however. The volitional muscle contraction in the proximal site of the amputated edge has been expressed as only one part of patient motion intention. Several papers have been published on myoelectric prostheses. [1-8]

In higher site amputation cases, the

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muscle of the limb does not remain, making it impossible to derive myoelectricity. Malfunctions are caused by changes in the contact conditions with the electrodes and poor contacting with the connector area as a result of sweat, bad electrodes and signal detection failures resulting from the contraction of other muscles with the contraction of the muscle in the mounting area, etc.

In this study, we tried to directly measure the nerve potential of a rabbitÅfs hind leg. If we could deduce the nerve potential of motor nerves in the amputated limb, it would lead to the development of a prosthesis using the patientÅfs natural motor function.

2. Experimental

We used a Japanese white rabbit (body weight: 2.7kg) in this experiment as shown in Fig.1. We administered 0.1mg/kg of medetomidine hydrochloric acid as a general anesthetic and isoflurane mask anesthesia to the rabbit. We made the rabbit lie on its side and shaved and disinfected the area around the femur. We removed the skin from the inner femur proximal region along the thighbone, as well as the subcutaneous tissue and fascia lata. We then verified the thigh artery, vein and nerve. The femoral nervus were carefully exposed where the femoral nerve imports to the quadriceps femoris.

An electrode insulated with silicon was attached to the femoral nervus as shown in Fig.2. We fixed the electrode to the nerve bundle using nylon strings and the silicon was sutured and fixed so that it would not to slip and fall afterwards. The electrode was grounded near fat tissue. Electric wire was exposed from the dorsal cervix via femur and buttocks subcutaneous tissue and was fixed by ligation. The incision layer of the skin was finally sutured using the common procedure.

The nerve potential of the rabbit's hind leg was measured in a shield room. The signal was amplified to 1000 times using a bio-amplifier as shown in Fig.3. The nerve potential was

Fig.1 Japanese white rabbit used in this experiment

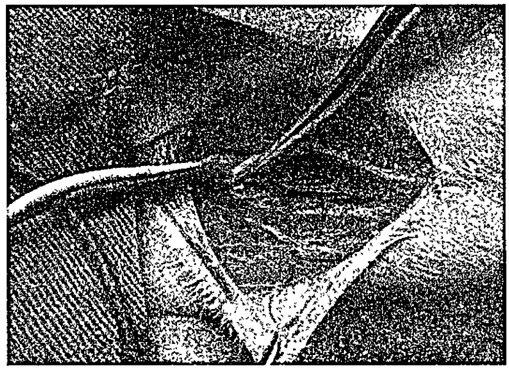

Fig.2 Electrode was attached to nerve bundles

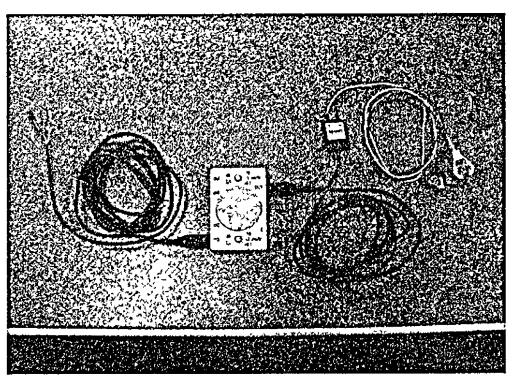

Fig.3 Bio-amplifier

also measured using an oscilloscope and a Galvanometer.

The physiology of the nerve was examined to confirm whether there was an influence on the nerve on the tip side from the electrode installation after three weeks at the Tokai University School of Medicine.

3. Results and discussion

The nerve signals were measured by oscilloscope when the rabbit was not moving. The wave pattern measured using an oscilloscope was relatively weak and remained constant as shown in Fig.4.

The nerve signals were measured at 2Vp-p when the rabbit moved by touch as shown in Fig.5. The wave pattern measured using an oscilloscope was greatly changed by the movement. Fig.6. shows the changes in nerve potential using a Galvanometer for 30 seconds. The rabbit did not move until the first seven seconds and then started moving. The electric potential markedly changed through the rabbit's movements after seven seconds.

We prepared an actuator device (a solenoid) that can convert the electric potential generated by the nerve potential into linear motion. The solenoid could be moved by the nerve potential.

The physiology of the nerve was examined to confirm whether there was an influence on the nerve on the tip side from the electrode installation after three weeks as shown in Fig.7. As a result, the nerve tissue in the trivial part was observed to be normal. Accordingly,

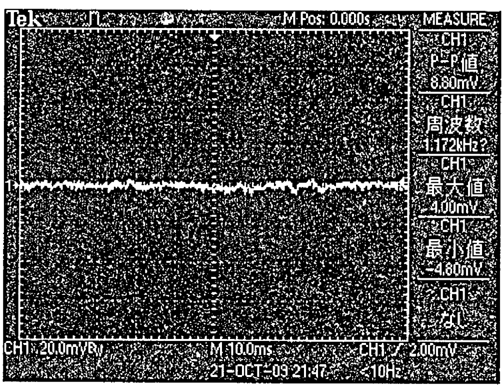

Fig.4 Nerve signals when the rabbit does not move

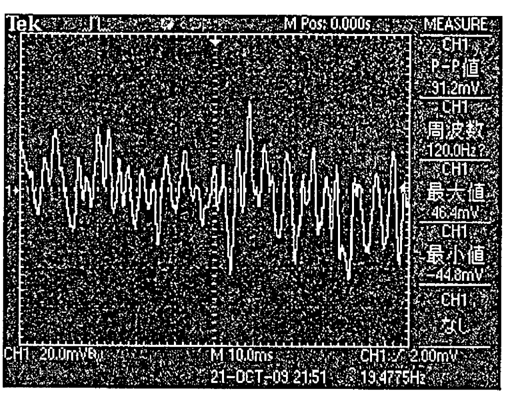

Fig.5 Nerve signals when the rabbit moved

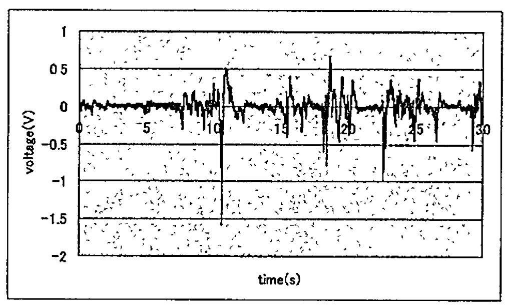

Fig.6 Changes in nerve potential using a Galvanometer for 30 seconds

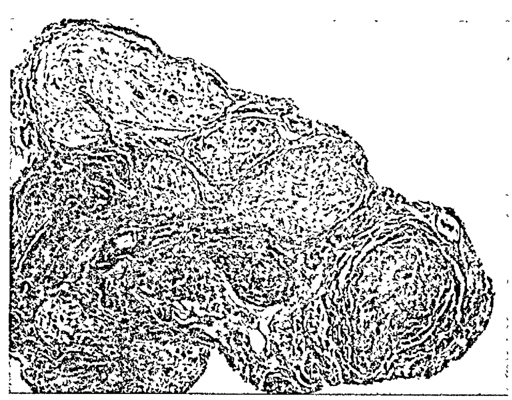

Fig.7 Physiology of the nerve

the attachment of the electrode on the nerve bundle did not affect the nerve tissue in the trivial part.

In this study, we were able to directly measure the nerve potential of a rabbit's hind leg, leading to the development of a prosthesis using the patient's natural motor function.

This study was approved by the Institutional Animal Care and Use Committee of Toin University of Yokohama.

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