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Comparison of reinnervation for preservation of denervated muscle volume with motor and sensory nerve: An experimental study

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Summary Prevention of the atrophy of denervated muscles is essential for a good outcome in facial contouring and oral reconstruction. In this study, we compared the effectiveness of end-to-end and end-to-side neurorrhaphy of the motor nerve, and end-to-end neurorrhaphy of the sensory nerve, all of which are frequently used in such reconstruction for the prevention of muscle atrophy.

Wistar rats were divided into four groups: group 1, motor nerve division of semi-membranosus without repair; group 2, motor nerve division and end-to-end coaptation to the saphenous nerve; group 3, motor nerve division and end-to-side coaptation to the sciatic nerve; and group 4, motor nerve division and end-to-end repair.

Measurement of semi-membranosus volume, histological evaluation and staining of neuromuscular junctions that were carried out 3 months postoperatively revealed that muscle volume preservation was larger in groups 3 and 4 than in the other two groups ($p < 0.05$), but slightly superior in group 4 ($p < 0.05$). There was no statistical difference between groups 2 and 1; histologically, muscle architecture was better preserved in group 2 than in group 1; reactivation of the neuromuscular junctions was observed in all except group 1.

End-to-side repair of motor nerves is one of the better options for the preservation of muscle volume when end-to-end nerve repair is not indicated. Sensory protection may also provide some advantages in the preservation of muscle volume.

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Denervation of the muscle causes loss of contracture and muscle atrophy. In tongue reconstruction, atrophy of the transplanted muscle causes dysfunctional swallowing.[1,2] Therefore, control of the volume of transplanted muscle is crucial for a good outcome from not only the cosmetic but also the functional aspect.

Various trials have been conducted for the control of muscle atrophy by reinnervation.[3–9] Two known forms of the reinnervation of muscle flap transfers are (1) motor-to-motor reinnervation and (2) sensory-to-motor reinnervation. The first is classified into end-to-end and end-to-side nerve repair, the former of which is considered most effective, although it involves sacrifice of the donor motor nerve; therefore, indications for this method are limited. Recently, collateral sprouting of motor axons in end-to-side nerve repair has been demonstrated and is considered less invasive for motor nerve reinnervation than end-to-end nerve repair.[4,5,10–14] Furthermore, during the last decade, experimental studies have proven that sensory nerve reinnervation also preserves muscle volume (sensory protection).[3,6,9]

Clinically, the three types of neurorrhaphy are the most practical choices for nerve repair. Studies on each pattern have been carried out; however, no comparison of the three forms has been made. Here, we compared the effectiveness of end-to-end neurorrhaphy of the motor nerve, end-to-side neurorrhaphy of the motor nerve and sensory protection, with the use of a rat model.

Materials and methods

Animals

Wistar rats (adult female rat) used in this study were, in groups, housed in a temperature-controlled colony room with a 12/12-h light/dark (L/D) cycle, in acrylic cages with woodchip bedding and given unlimited access to normal laboratory chow and water. All experiments were carried out with the approval of the Committee on Animal Care and Welfare, Kobe University School of Medicine. The animals were randomly divided into four groups: (1) division of motor branch of sciatic nerve without repair (denervation (DN)) ($n = 9$); (2) end-to-end coaptation of the motor branch of the sciatic nerve and the saphenous nerve (sensory protection (SP)) ($n = 10$); (3) end-to-side coaptation of the motor branch of the sciatic nerve and the main trunk of the sciatic nerve (end-to-side motor protection (MPes)) ($n = 11$); and (4) division of the motor branch of the sciatic nerve and its immediate repair (end-to-end motor protection (MPee)) ($n = 9$). Some animals died during the experimental period; the remaining 39 rats were included in the study. The contralateral limb of each animal was left unoperated on and served as the control (Figure 1).

Surgical procedure

The animals were anaesthetised with intra-peritoneally administered sodium pentobarbital (47 mg/kg). Through a transverse skin incision on the medial thigh, the intermuscular septum between the gracilis and the semimembranosus was dissected, and the semi-membranosus and motor branches of the sciatic nerve were identified.

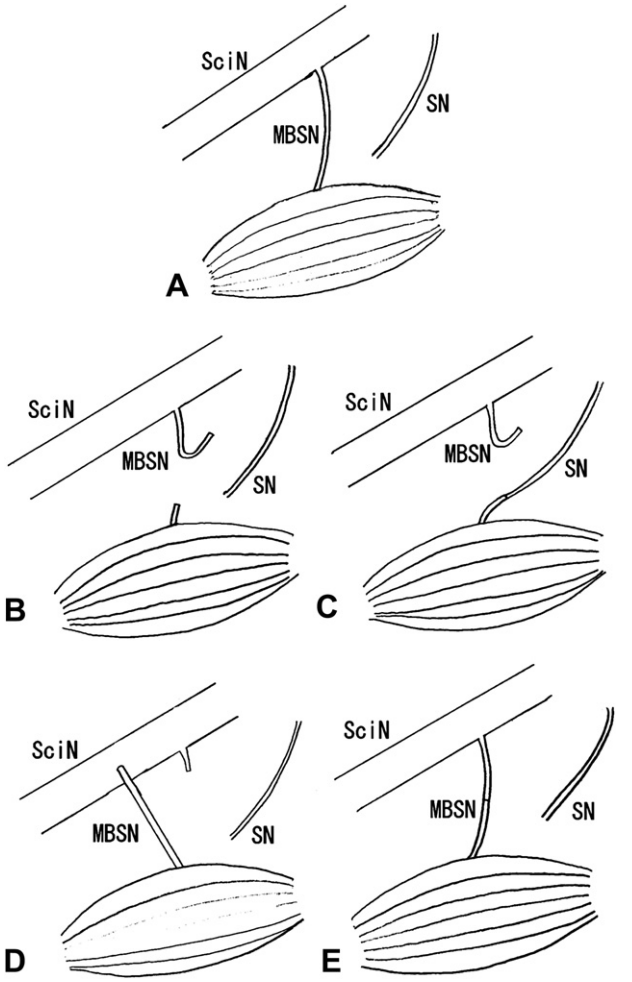

Figure 1 Schema of surgical procedure. (A) Control. (B) Group 1, denervation (DN). (C) Group 2, sensory protection (SP). (D) Group 3, end-to-side motor protection (MPes). (E) Group 4, end-to-end motor protection (MPee). SciN, sciatic nerve; SN, saphenous nerve (sensory); MBSN, motor branch of sciatic nerve.

The nerve was stimulated before its division so as to confirm that it was the motor nerve of the semimembranosus. In group 1 (DN), the motor branch of the sciatic nerve was sharply transected under microscopical vision. The distal nerve stump was removed from the muscle, and the proximal nerve stump was removed from the main trunk of the sciatic nerve, leaving a gap of over 10 mm to avoid spontaneous reinnervation. In group 2 (SP), the saphenous nerve and the motor branch of the sciatic nerve were sharply transected, and the proximal saphenous nerve and the distal motor branch of the sciatic nerve were coapted with 10/0 nylon under microscopical vision. The proximal motor branch of the sciatic nerve was removed from the main trunk, leaving a gap of over 10 mm to avoid spontaneous reinnervation. In group 3 (MPes), the main trunk of the sciatic nerve was exposed and an epineural window was created. The motor branch of the sciatic nerve was sharply transected and the distal nerve trunk was coapted end to side to the main trunk of the sciatic nerve with 10/0 nylon under microscopical vision. The proximal