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End-to-side "loop" graft for total facial nerve reconstruction: Over 10 years experience☆

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Summary *Background:* Multiple-branch reconstruction is required in order to attain facial reanimation for extensive facial nerve defects. We previously reported that end-to-side nerve grafting, with the use of a single nerve graft for defect reconstruction, was easy to perform. We have also demonstrated the efficacy of end-to-side nerve suture of the recipient nerve to the donor graft nerve, in experimental rat models and clinical cases. The regenerating axons, which extended into the nerve graft, were "distributed" to multiple recipient nerves via end-to-side nerve-suture sites.
Methods: Thirty-two patients who underwent facial nerve reconstruction (five to 10 branches) had a single sural nerve graft coapted to the proximal stump of the facial nerve in an end-to-end manner, followed by end-to-side nerve suture of the recipient nerve stumps to the side of the nerve graft. In 19 patients who were expected to undergo postoperative radiotherapy and/or chemotherapy, the distal end of the graft was connected to the side of the hypoglossal nerve for "axonal supercharging," to enhance the recovery of the facial muscles.
Results: Initial facial movements were noted at 5—12 months postoperatively, and good recovery (House—Brackmann grade III/IV) was observed during long-term follow-up in most patients.
Conclusion: End-to-side nerve suture of the recipient nerve stumps to the nerve graft requires less graft nerve material and less technical mastery to reconstruct multiple branches of the facial nerve. We also described the concept of "axonal supercharging," namely the connection

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of double-donor neural sources to the graft, and "axonal distribution," namely the reinnervation of multiple recipient nerve stumps connected to the graft in an end-to-side manner. This combination of axonal supercharging and distribution can be a useful option in facial nerve reconstruction.

Introduction

Extensive facial nerve defects after ablative surgery of the parotid gland should be reconstructed to avoid permanent postoperative facial palsy. The use of multiple cable grafts to reconstruct the defect is technically demanding, and it requires a large amount of nerve graft. We reported a new technique that uses a single nerve graft with end-to-side nerve suture to recipient branches.[1] In this end-to-side nerve-suture technique, microscissors are used to make small cuts to the donor graft nerve, and the recipient nerve is connected to these "windows" by suturing the epineurium in an end-to-side manner. The efficacy of this technique was confirmed in a rat sciatic nerve model with a two-branch reconstruction[2] and a rat facial nerve model with a four-branch reconstruction.[3] The unique approach of this technique, as compared with other end-to-side neurorrhaphy techniques, is that it inflicts an injury to the donor graft nerve by partially lacerating it, and then it coapts the recipient nerve stump to the window in the graft nerve with a significant discontinuity of nerve fibers (neurotmesis). Terminal sprouting of the regenerating fibers in the severed graft is more important for re-regenerating fibers into the recipient nerve than for those from collateral sprouting.[2,3] Thus, the regeneration process in our method seems to differ from that of the "conventional" end-to-side neurorrhaphy through an epineurial window to the mostly intact donor nerve. In our technique, the graft used looks like part of a loop configuration after nerve suture to both ends and sides. We therefore refer to it as "loop-graft" technique. End-to-side nerve suture to the nerve graft allows various types of multiple-branch reconstruction of the facial nerve. In addition, the connection of the ipsilateral hypoglossal nerve as an additional donor nerve to the other end of the graft may facilitate reanimation supercharging of the regenerating nerve fibers into the recipient nerve (Figure 1). This supercharging may be more effective for severe facial nerve palsy in patients with preoperative palsy and those undergoing postoperative chemotherapy/radiotherapy.

Patients and methods

Between 2001 and 2013, 32 patients (19 men and 13 women) underwent facial nerve defect reconstruction using this method (Table 1). The patient at surgery was 25–79 years (average, 57.3 ± 2.6 years). A single nerve graft harvested from the sural nerve was used in all cases. Parotid carcinoma was the most common ($n = 24$) reason for ablative surgery, followed by benign recurrent pleomorphic adenoma ($n = 4$), squamous cell carcinoma of the cheek or the external ear ($n = 3$), and facial nerve schwannoma ($n = 1$). Preoperative facial palsy was observed in 11 patients. In 27 patients, four areas (T: temporal, Z: zygomatic, B: buccal, and M: marginal mandibular branch of the facial nerve) were reconstructed. The number of reconstructed branches was 3–10 (average, 5.7 ± 0.26 branches). In 13 patients, the ipsilateral proximal facial nerve was used as the only neural source. The other 18 patients underwent additional axonal supercharging using the hypoglossal nerve. We performed crossover coaptation to the masseteric nerve in cases where a proximal facial nerve stump was not available.

Simultaneous soft-tissue reconstruction was performed in 19 patients; the predominant flap was the pectoralis major flap in eight cases and the free anterolateral thigh flap in five cases. The areas of soft-tissue defect in these cases were limited within the parotid region or the preauricular cheek, which do not result in extensive facial muscle defect. The patients with extensive facial muscle/skin defect with the reconstruction using large flap(s) resulting in poor muscle function and poor skin pliability were excluded from this study. Duration of follow-up was 6–135 months (average, 29.0 ± 4.4 months). Disease-free patients with four-area reconstruction (TZMB) data and >18 months postoperative follow-up were evaluated based on examinations or videos at the latest visit by three plastic surgeons with at least 15 years' experience with facial nerve disorders using the Sunnybrook facial grading system[4] to assess voluntary movement, facial symmetry, and synkinesis, and the House–Brackmann (H–B) grading system[5] for a gross overview of the facial function. The most frequent or mean score in the three observers was adopted as each patient's data.

Statistical analysis

The chi-squared test was used to determine the statistical significance of differences in the postoperative H–B scores, with or without hypoglossal supercharging. The Mann–Whitney test was used to analyze differences between the groups in other variables. All differences were considered to be significant when p was <0.05.