DIRECT COAPTATION OF EXTENSIVE FACIAL NERVE DEFECTS AFTER REMOVAL OF THE SUPERFICIAL PART OF THE PAROTID GLAND: AN ANATOMIC STUDY

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Abstract: *Background.* In the surgical repair of facial nerve paralysis, a tension-free end-to-end coaptation of the trunk or its branches with or without rerouting is functionally superior to grafting. Assuming that a lengthening of all branches of the parotid plexus can be attained by removal of the superficial part of the parotid gland and mobilization of the branches, we performed an anatomic study.

Methods. The parotid regions of 10 cadavers were dissected to investigate the length gained for the branches of the parotid plexus by this technique. Every branch at the upper and ventral border of the gland was marked by a surgical suture. After removing the superficial part of the parotid gland, the branches were cut at the suture, and the proximal stump was drawn toward the distal stump. The distance of the overlapping stumps was measured by means of an electronic gliding caliper. In addition, in five specimens only the trunk of the facial nerve was dissected by the same method, and the distance of the overlapping stumps was measured.

Results and Conclusions. The results demonstrate that removing the superficial part of the parotid gland may be sufficient to enable direct coaptation without nerve grafting. Cut temporal or zygomatic branches with a gap of up to 15 mm and cut buccal or marginal mandibular branches with a gap of up to 23 mm can be bridged by mobilization of just the proximal stumps. This technique may also be used to bridge a 17-mm gap of the trunk of the facial nerve. © 2002 Wiley Periodicals, Inc. *Head Neck* **24:** 1047–1053, 2002

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Facial nerve injury results in facial paralysis and loss of mimetic movement.[1,2] Unfortunately, the facial nerve is the most frequently injured of all cranial nerves.[3] Recent evidence suggests that end-to-end surgical repair of the facial nerve with or without rerouting is functionally and cosmetically superior to grafting. It is most important to gain a tension-free coaptation[4–6] to avoid distraction, which is a major reason for failure of repair.[7]

Facial nerve rerouting techniques were first described by Bunnel[8] and Martin[9] in their attempts to attain end-to-end repair. Since these initial reports, estimates regarding the maximal length of nerve defect that is amenable to primary repair has ranged from 2 to 16 mm.[8,10] According to Johns and Crumley,[11] a gap greater than 1 cm cannot be overcome by any method, including rerouting of the facial nerve in its mastoid segment. Most authors have concluded that defects of greater than 10 mm should be repaired by interpositional grafting.[12–17] Nevertheless Yarbrough et al[18] described in their anatomic study a method of direct coaptation of the trunk of the facial nerve, including mobilization, retroposition of the parotid gland, and dissection of the tympanic portion of the temporal bone. This extensive rerouting technique allows tension-free closure of neural defects of 17.5 mm.

The aim of our study was to investigate the maximal length of nerve defect for the trunk of the facial nerve and for all branches of the parotid plexus that can be repaired with a tension-free end-to-end coaptation when the superficial part of the parotid gland is removed and the parotid plexus is mobilized. The idea for this approach came from an observation made during a surgical repair of branches of the facial nerve in this region, which warrants the clinical feasibility of this technique in patients as well.

ANATOMY

After emerging through the stylomastoid foramen, the trunk of the facial nerve passes through the parotid gland, where it branches to form the parotid plexus. The most common branching pattern is a bifurcation of the trunk.[19] The upper branch gives rise to the temporal and zygomatic branches; the buccal, marginal mandibular, and cervical branches originate from the lower branch. Beyond this point, diversity is considerable because of the formation of interconnections between the branches. The most frequent interconnections are between the zygomatic and buccal branches.

After leaving the parotid gland, the branches lie deep to the superficial musculoaponeurotic system (SMAS)–platysma plane in the face. In the upper face, the temporal branches cross the zygomatic arch to reach the frontalis muscle; the zygomatic branches lead to the orbicular oculi muscle. In the midface, the nerve branches are initially deep to the masseteric fascia and then become more superficial as they reach the muscles of the upper lip.[20] Along the mandible, the marginal mandibular branch is deep to the platysma and just below the mandibular border until it innervates the depressors of the lower lip.[21]

The presence of the facial nerve within the parotid gland gives rise to the so-called superficial and deep parts of the gland. The superficial part lies lateral to the facial nerve, extending anteriorly to the border of the masseter muscle. The deep portion, which makes up about 20% of the gland, lies medial to the facial nerve and in the retromandibular fossa.[22] However, others believe that the gland is bilobar, with an isthmus connecting the deep and superficial lobes.[23] The isthmus lies between the two main branches of the facial nerve. The deep part gives rise to the parotid duct, which crosses the masseteric muscle and pierces the buccinator muscle to enter the oral vestibule.

METHODS AND MATERIAL

To perform this study we dissected the parotid regions of 10 fresh cadavers (5 women, 5 men; $n = 20$) ranging in age from 74 to 84 years. The skin was cut longitudinally ventral to the auricle from the zygomatic arch to the mandibular angle and folded medially. The surface of the parotid gland and 5 mm of the branches of the parotid plexus at the upper and ventral border of the gland were exposed. Every branch, usually two temporal, two zygomatic, two buccal and one marginal mandibular, was marked with a surgical suture at the site of leaving the gland (Figure 1). Then the entire superficial part of the parotid gland was removed, and the parotid plexus was mobilized up to the stylomastoid foramen, so that the nerves were dissected in a 360-degree fashion to free them from the surrounding tissue and the deep parotid (Figure 2). Before going on with the examination, the course of the parotid plexus was drawn on a sketch sheet to note varieties and to enable a final evaluation. One by one each branch was cut at the suture, and the proximal stump was drawn as much as possible toward the distal stump. The distance of the overlapping stumps was measured by means of an electronic gliding caliper, which allows measuring distances down to 0.01 mm (Figure 3).

In addition, in five specimens (three women, two men; ages ranging from 68 to 78 years), only the trunk of the facial nerve was cut after removal

FIGURE 1. Right parotid region after removal of the skin and subcutaneous tissue. The branches of the parotid plexus are marked with surgical suture. 1, temporal branches; 2, zygomatic branch; 3, buccal branches; 4, marginal mandibular branch; 5, masseter muscle; 6, superficial part of the parotid gland.

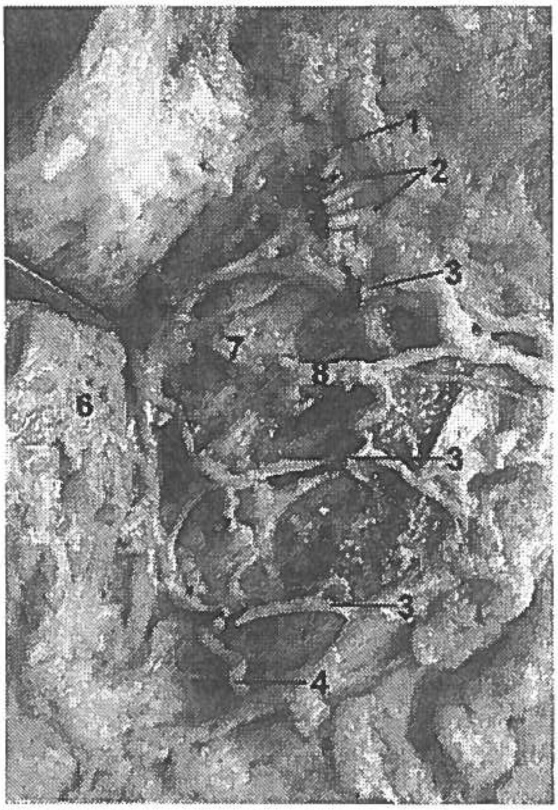

FIGURE 2. Right parotid region after removal of the skin, subcutaneous tissue, and superficial part of the parotid gland. 1, temporal branch; 2, zygomatic branches; 3, buccal branches; 4, marginal mandibular branch; 5, masseter muscle; 6, superficial part of the parotid gland; 7, deep part of the parotid gland; 8, parotid duct.

of the superficial part of the parotid gland and mobilization of the parotid plexus from the deep parotid. The distal stump was drawn toward the proximal one, and the distance of the overlapping stumps was measured (Figure 4).

We used SPSS 10.0 for statistical analysis and determined statistical significance with the paired t test. Probability values (p) less than .05 were considered statistically significant ($\alpha = .05$).

RESULTS

All branches evaluated in the 20 specimens are listed in Table 1. In 50% of all cases, two temporal and two zygomatic branches were found. In 95% two or more buccal branches were found, and in 90% only one marginal mandibular branch was exposed.

After removal of the superficial part of the parotid gland, the range and the mean distances of the overlapping branches were measured as shown in Table 2. The mean measurements were greater on the left side for the temporal, zygomatic, and buccal branches but lower for the marginal mandibular branches. These measurements

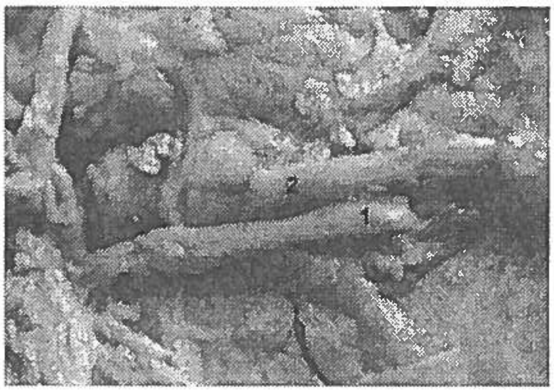

FIGURE 3. Overlapping of the stumps of a cut branch. 1, proximal stump; 2, distal stump.

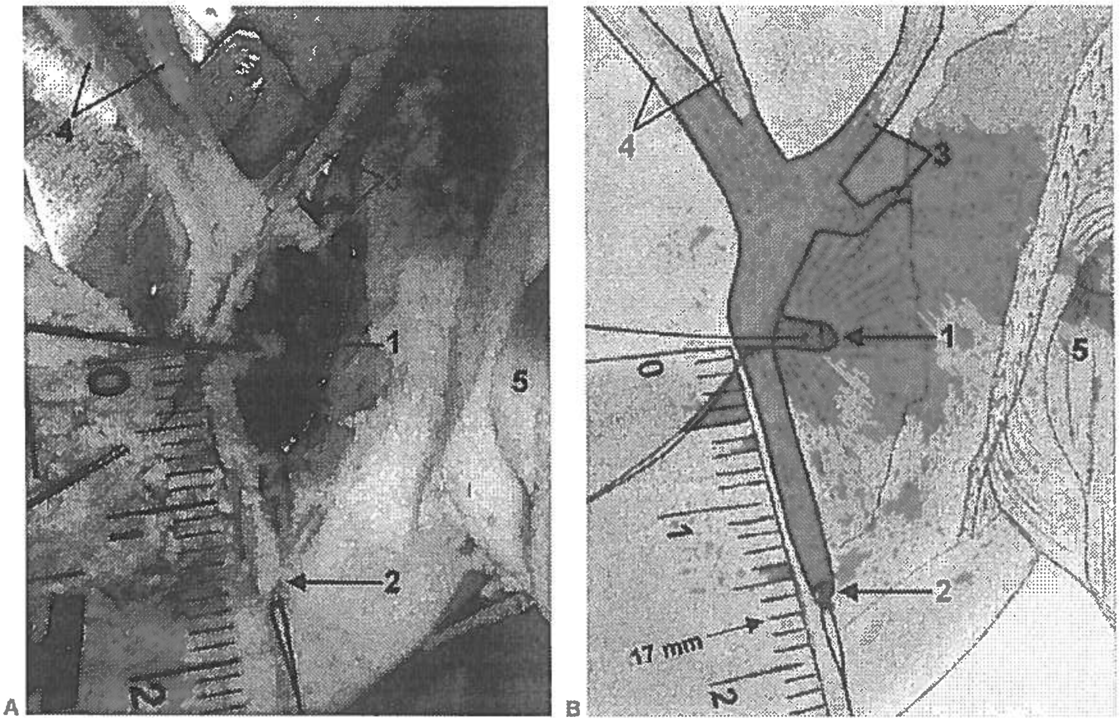

FIGURE 4. **(A)** Photograph and **(B)** schematic drawing after the trunk of the facial nerve has been cut. The cut stumps were snared with surgical suture. The temporal and zygomatic branches have been mobilized, and the distal stump has been drawn caudally to gain a lengthening of 17 mm. 1, snared proximal stump of the trunk; 2, snared distal stump of the trunk; 3, temporal branches; 4, zygomatic branches; 5, left auricle.

showed neither a direct nor an indirect correlation and no statistically significant side differences ($p > .087$).

In five additional specimens ($n = 10$), the stumps of the cut trunks were overlapped with a mean distance of 16.3 mm. For further details see Table 2.

DISCUSSION

The patient with facial palsy presents one of the most difficult challenges seen by the reconstructive surgeon.[24] The basic principles of facial nerve repair have changed little since Bunnell[8] and Martin[9] performed the first successful infratemporal coaptation in the late 1920s. Since then, various techniques of surgical repair were described. The use of either loupe magnification or the operating microscope facilitates identification and repair of the injured nerve branches.[25] Fine suture has expanded clinical applicability, and atraumatic techniques have optimized surgical conditions.[7]

A controversy still exists about how to do the surgical repair of injured branches of the facial nerve when a large defect is present and direct repair is difficult. In these cases, an interposition

Table 1. Number of branches of the parotid plexus at the border of the parotid gland.

	Left				Right				Total			
	Number of branches				Number of branches				Number of branches			
Branches	1	2	3	4	1	2	3	4	1	2	3	4
Temporal	5	5	—	—	6	4	—	—	11	9	—	—
Zygomatic	5	5	—	—	5	5	—	—	10	10	—	—
Buccal	1	7	1	1	—	9	1	—	1	16	2	1
Marginal mandibular	9	1	—	—	9	1	—	—	18	2	—	—

Table 2. Distance of the overlapping stumps.

Nerves	*n*	Mean ± SD (mm)	Min (mm)	Max (mm)
Temporal branch	29	6.9 ± 1.7	4.2	11.7
Zygomatic branch	30	8.2 ± 2.2	5.2	15.2
Buccal branch	43	13.8 ± 3.1	8.1	24.0
Marginal mandibular branch	22	13.0 ± 2.9	8.3	20.0
Main truck	10	16.3 ± 0.8	15.2	17.2

nerve graft can be used. Options include the sural nerve, the greater auricular nerve, and the lateral cutaneous nerve of the thigh. The graft should be longer than the damaged segment to avoid excessive tension on the graft.[26] Grafts obtained from the sural nerve require a separate operative site in the posterior calf.[24] The object of a bridging nerve graft is to provide a scaffolding that will assist regenerating fibers in finding their way to the distal part to thus restore the original pattern of innervation. However, there are many obstacles that a regeneration axon has to overcome on its way to the proper terminal.[6] Axons may be wasted at both the proximal and distal suture line by growing into the perifascicular and epineural connective tissue.[27] Furthermore, in crossing the nerve graft, regenerating fibers risk entering unrelated Schwann cell tubules in the distal stump and terminating in foreign end organs.[6] The loss of axons results in mass motion, synkinesis, and only partial reinnervation.[28]

The risks of the mentioned failures can be reduced, and no second operative site for harvesting the graft is needed when the stumps are coapted directly. Yarbrough et al[18] described in their anatomic study that decompression and mobilization of the facial nerve allows tension-free closure of 8-mm defects of the trunk. Dissection of the tympanic portion of the temporal bone in addition to decompression and mobilization increases the repairable defect size to 14 mm. Retroposition of the parotid gland adds roughly 3.5 mm to the length of facial nerve gained with either of the preceding

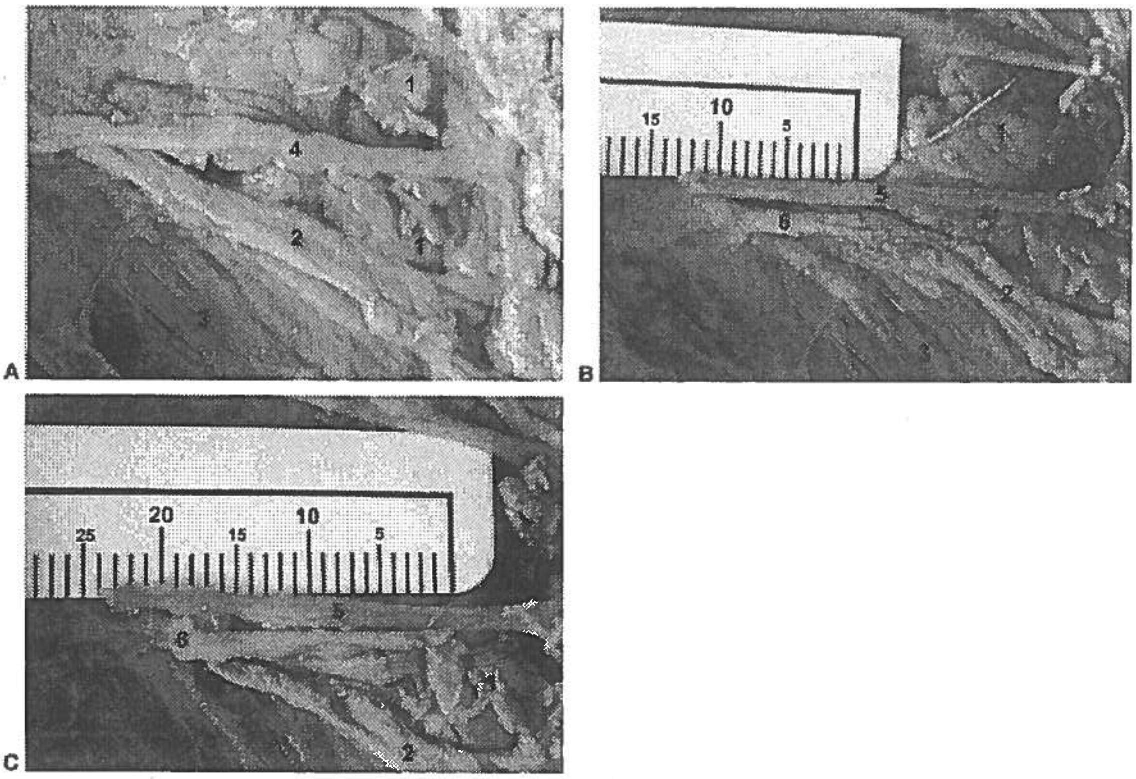

FIGURE 5. **(A)** Depiction of a buccal branch after removal of the superficial part of the parotid gland and mobilization of the parotid plexus. **(B)** Only the proximal stump of the same cut buccal branch is drawn toward the distal one, leading to an overlapping distance of 13 mm. **(C)** Additional mobilization of the distal stump increases the overlapping distance to 24 mm. 1, deep part of the parotid gland; 2, parotid duct; 3, masseter muscle; 4, buccal branch; 5, proximal stump; 6, distal stump.

procedures. The most extensive mastoid-extratemporal rerouting procedure with retroposition of the parotid gland allows closure of neural defects of 17.5 mm.

We are of the same opinion as Spector,[29] who ranked the mentioned techniques according to functional and cosmetic results as follows: first, direct end-to-end anastomosis; second, end-to-end anastomosis after rerouting the nerve; and third, interpositional nerve grafting. Therefore, we tried to find a technique that allows lengthening of the branches of the facial nerve without extensive rerouting and grafting.

After removal of the superficial part of the parotid gland, the parotid plexus can be mobilized and freed from the deep parotid. During this procedure, the deep part of the gland and the parotid duct should be taken care of (Figure 2). The greatest amount of lengthening was attained in the buccal and marginal mandibular branches, which can be used to bridge a mean gap of 13.5 mm and a maximal gap of 23 mm. This can be explained by the long and meandering course of these branches within the parotid gland. The variations of the gained lengths are a result of the various number of branches (Table 1) and several patterns of forming interconnections. The temporal and zygomatic branches can only be lengthened for a mean distance of 7.5 mm and a maximal distance of 15 mm. This is due to their almost straight course within the parotid gland. The high variability of the length of nerve defect that could be repaired can be explained by a varying number of branches in each patient. Compared with the elasticity of a spider web, the higher the number of branches and interconnections, the higher is the length that could be attained by mobilization of these branches. Our mean results are to be considered guidelines.

Mobilization of the distal stumps will add up to 10 mm, depending on the branch and the site of the cut (Figure 5). So, even gaps of a greater amount can be repaired directly.

The various sites of traumatic and iatrogenic lesions of the facial nerve require a simple surgical technique, which can be used by surgeons in repairing defects of both the branches and the trunk. Our results obtained on five additional specimens show that gaps of the trunk of 17 mm can be coapted directly when the branches are mobilized in their intraparotid and extraparotid course and drawn toward the proximal stump of the trunk (Figure 4). The temporal and zygomatic branches will especially limit the lengthening if their extraparotid course is not mobilized sufficiently. The reason for the higher distance of overlapping of the main trunk compared with the branches (mean distance of overlapping of the trunk: 16.3 mm vs 13.8 mm of the buccal branch) might be that the degree of elasticity of the parotid plexus seems to be dependent on the direction of tension. The parotid plexus, again compared with a spider web, seems to have a higher degree of elasticity when it is drawn from distal to proximal (in repair of a trunk defect) compared with a direction from proximal to distal (in repair of a branch defect).

Nevertheless, we agree with the results of Bunnell[8] and Yarbrough et al,[18] who considered defects of greater than 15 mm to be amenable to direct coaptation. In contrast to the extensive temporofacial rerouting including the osteotomy of Yarbrough et al,[18] our technique involves less risks for the patient, is easier to perform, and provides similar results. But the fact that the circumferential dissection of the VII nerve branch, particularly the temporal, does incur risk of devascularization and long term loss of function has to be kept in mind.

CONCLUSIONS

We conclude that removing the superficial part of the parotid gland should be used to enable direct coaptation of cut branches of the facial nerve with a gap of 15 mm. Even higher amounts can be managed when not only the proximal stumps but also the distal stumps are mobilized (Figure 5). This technique may also be used to bridge a cut trunk of the facial nerve. Our results should assist surgeons in determining whether extensive facial nerve defects are amenable to end-to-end repair and should encourage direct coaptation rather than grafting. This article represents an anatomic study showing that this surgical technique is feasible. We performed this technique of extensive facial nerve repair, which requires great caution, in three patients without damage to the mobilized branches. The clinical use and the follow-up period of the patient outcomes will be presented in detail in a later study.

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