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Feasibility of a cross-face reconstruction of the mental nerve—A cadaveric simulation study with histomorphometric analysis

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Summary *Introduction:* The inevitable sacrifice of the inferior alveolar nerve during oncologic resections results in substantial sensory impairment, impacting crucial functions such as speech, saliva retention, and mastication. This study investigated the feasibility of sensory restoration through cross-face reconstruction of the mental nerve via a contralateral mental nerve branch.
Methods: The cross-face reconstruction procedure was simulated in five formalin-fixed cadavers in both sides to evaluate the anatomic fundamentals and the nerve gap between the mental nerve main trunk and transferred contralateral mental nerve branch. Furthermore, a histomorphometric analysis was performed to assess the cross-sectional area and axon counts.
Results: The mean gap distance between the main mental nerve trunk and transferred contralateral branch was 15.3 mm. End-to-end coaptation was achieved in nine out of ten simulations. The mean cross-sectional area was 0.996 mm^2 at the main mental nerve trunk and 0.253 mm^2 at the coaptation site of the nerve branch. The mean donor-to-recipient axon ratio was found to be 0.3:1.
Conclusion: The cadaveric simulation demonstrates the feasibility of a cross-face reconstruction of the mental nerve with only minimal gapping. Advantages of the proposed technique include the use of shorter nerve grafts, to minimize donor site morbidity and enable fast re-

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innervation. This technique may offer a promising method to enhance the quality of life in patients by increasing survival rates and life expectancy.

During major oncologic resections involving the mandibular body, it is inevitable to sacrifice the inferior alveolar nerve (IAN). (Figure 1) The resulting sensory impairment of the lower lip vermillion, lower lip skin, buccal mucosa, and teeth affects basic functions such as speech, saliva retention, and mastication. Despite the considerable impact of these sequelae on the quality of life, reconstruction of IAN is rarely performed during ablative surgery of the mandible.[1,2] This is especially relevant as survival rates and life expectancy of patients with head and neck cancer has been increasing over the last decades.[3] Although high rates of spontaneous regeneration and good results for direct microsurgical repair are described for minor injuries to the IAN, considerably long segmental nerve resections as they occur during oncologic resections preclude minor solutions such as direct nerve repair or nerve conduits and demand more complex reconstructions.[4] Surgical options for extended defects of the IAN draw on the full repertoire of nerve reconstructions including non-vascularized or vascularized autografts and nerve transfers with all their strength and drawbacks. Nerve grafts enable reconstructions of long nerve gaps, but at the expense of delayed reinnervation, donor site morbidity, and an additional microvascular procedure when using vascularized grafts, thereby prolonging total operative time. Nerve transfers, besides donor site morbidity, have the major drawback of requiring cortical integration to relocate sensation to the lip.[5-9] Although cross-face nerve grafting is an established and well-described technique for reanimation of the paralyzed face, reconstruction of the sensory function in the face through cross-face nerve grafting by end-to-side coaptation to the corresponding contralateral nerve was only mentioned through case reports so far.[10,11] To further evaluate the feasibility and exact anatomical specifications of a cross-face reconstruction of the mental nerve, we conducted a cadaveric simulation study with histomorphometric analyses of the donor and recipient nerves.

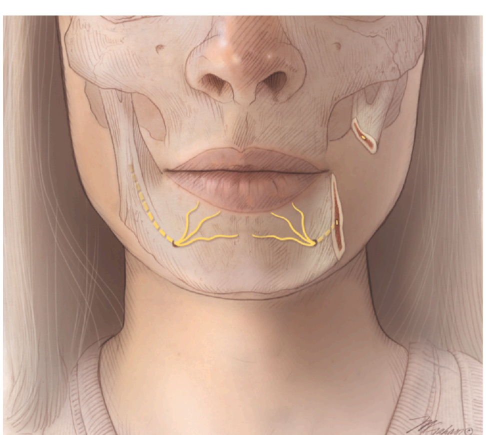

Figure 1 Illustration of a segmental resection of the left mandibular body with the involvement of the inferior alveolar nerve.

Materials and methods

The surgical technique was modified by coaptating the main branch of the mental nerve to the most medial branch of the contralateral mental nerve in an end-to-end manner via short nerve graft. (Figure 2).

The study was performed in accordance with the local rules and regulations and was approved by the ethical institutional committee. Five formalin-fixed cadavers (three females and two males) were dissected. The age of the cadavers ranged from 68 to 96 years (mean 84.8 years; SD 12.6 years). All cadavers were of Caucasian race. All donors gave informed consent for their bodies to be used in medical education and medical scientific research. The mental nerve branches were dissected from their exit at the mental foramen in an antegrade fashion via an intraoral incision on both sides. (Figure 3) Subsequently, the cross-face reconstruction of the mental nerve was simulated. Therefore, the mental nerve trunk was cut at the mental foramen on one side (the simulated affected side) and the most medial branch of the contralateral nerve (the simulated donor side) was cut distally after marking the position with a pin. The nerves were aligned to each other free of tension and the distance between the main nerve trunk and contralateral branch was measured. (Figure 4) The nerves were then repositioned with pins at their original locations to simulate the transfer in the same manner for the contralateral side.

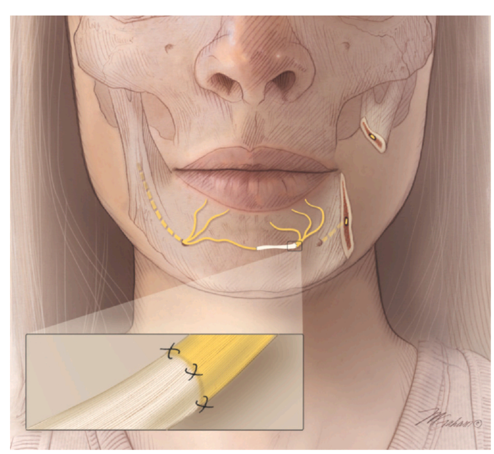

Figure 2 Illustration of a cross-face reconstruction of the mental nerve. The medial branch of the unaffected right side is cut distally and coaptated to the main branch of the affected nerve with an interposition nerve graft. (b).

Figure 3 Dissection of the mental nerve on both sides was performed by an intraoral incision in an anterograde fashion from the exit at the mental foramen.

Figure 4 Simulation of a cross-face reconstruction of the mental nerve of the right inferior alveolar nerve. Left medial mental nerve branch (blue arrow) is aligned with the right main mental nerve branch (red arrow).

For histomorphometric analysis of cross-sectional areas and axon counts, 1-cm nerve segments of the main mental nerve trunk at the mental foramen and distal portion of the medial nerve branch were harvested, resulting in a total of 20 nerve samples. The samples were then embedded in paraffin and sectioned into 3-μm slices. Subsequently, staining with hematoxylin and eosin was performed. The stained samples were photographed under a microscope (*Olympus BX53, Tokio, Japan*) at 4x and 20x magnification. Axon counts and nerve diameter measurements were performed using the "CellSens" software *(EVIDENT Europe GmbH, Hamburg, Germany)*. (Figure 5).

Results

The anatomic specifications of the mental nerves are outlined in Table 1. In all simulations, there was a gap between the main mental nerve trunk and transferred contralateral branch. The gap measured a mean distance of 15.3 mm (range 4-25 mm, SD: 8 mm). In one specimen the medial nerve branch

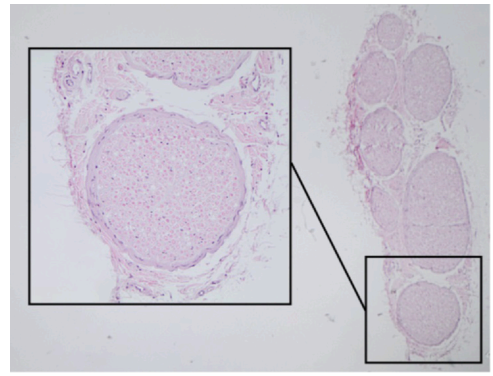

Figure 5 Histological section of a distal mental nerve segment with hematoxylin and eosin staining in x4 magnification and a detailed subsection in x20 magnification.

Table 1 Anatomic specifications of the dissected mental nerves.

Specimen	Side	Total number of nerve branches	Total length of the medial branch (mm)
1	Right	3	40
1	Left	3	23
2	Right	3	42
2	Left	3	29
3	Right	3	42
3	Left	4	42
4	Right	4	40
4	Left	4	26
5	Right	2	40
5	Left	3	39
∅		3.2	36.3

was not suitable for an end-to-end nerve coaptation due to limited distal diameter and the cross-nerve transfer was simulated for an end-to-side coaptation. The mean cross-sectional area was 0.996 mm^2 (range 1.885-0.523 mm^2; SD: 0.465 mm^2) at the main mental nerve trunk and 0.253 mm^2 (range 0.012-0.572 mm^2; SD: 0.180 mm^2) at the medial nerve branch distally. The mean total number of axons was 4489 (1872-7388, SD: 2072) in the main mental nerve trunk and 1370 (range: 708-2338, SD: 661) in the medial nerve branch distally. The mean donor-to-recipient axon ratio was 0.3:1.

Discussion

Cross-face reconstruction of the mental nerve adds on to the armamentarium of reconstructive options for IAN. For cases with no adequate proximal nerve stump, it represents the only way of restoring direct sensation to the lip. However, in cases where a proximal nerve stump available, we see potential advantages: the anatomic simulations showed the feasibility of an end-to-end coaptation with a minimal nerve gap in nine of ten cases. This allows the use of shorter nerve grafts compared to the previously described techniques. This is especially relevant in oncologic reconstructions with perioperative irradiation therapy, which is known to negatively affect the nerve graft vasculature and nerve regeneration.[12,13] Shorter nerve grafts increase the probability of an effective reinnervation. Furthermore, short nerve grafts enable fast reinnervation and minimize donor site morbidity at the harvesting site.[14-16] Technically, it is a simple procedure that can be performed along with bone and soft tissue reconstructions without significantly prolonging the total operating time. In cases of IAN damage without concomitant mandibular defect as they occur after dentoalveolar procedures, cross mentalis nerve reconstruction avoids opening the inferior alveolar canal in the mandibular body and allows repair through an intraoral incision as opposed to an extended external incision. Consistent with the anatomical study of Toure,[17] we found an average of three branches per mental nerve. These findings limit the potential donor site morbidity at the contralateral labiomental area. Toure[17] further reported interconnections between the right and left mental nerve of varying degrees in 73% of the cases, providing the anatomical basis for spontaneous recovery after IAN damage. However, there is no definitive clinical evidence linking these connections to clinical recovery following IAN injuries. Based on the senior authors' clinical experience, sensory recovery of the labiomental area in completely transected IAN injuries is improbable, although some sensory recovery is often observed in partial injuries. Consequently, our recommendation for the proposed technique is as follows: for minor nerve damages (such as those occurring during dental procedures), we suggest monitoring for spontaneous recovery for up to six months, depending on the extent of the deficiency and impairment of oral function. For complete unilateral nerve damages (such as those occurring during oncological resection), sufficient spontaneous regeneration from the contralateral side is highly unlikely, and thus, "supercharging" the ipsilateral nerve stump as proposed should be considered a primary intervention.

The primary limitation of the proposed technique is the mismatch between the donor and recipient nerves in terms of axon numbers and cross-sectional area. Although full recovery of sensation may not be possible due to the reduced axon count, there is a likelihood of regaining basic sensation and two-point discrimination, as the number of axons should suffice for this level of recovery. However, this hypothesis warrants validation in future clinical studies. Another drawback of the technique is the prerequisite of an intact contralateral mental nerve.

Conclusion

Cross-face reconstruction of the mental nerve might be a valuable addition to a comprehensive approach in post oncological mandibular reconstructions. Although sensate reconstruction has been widely neglected in head and neck reconstructions until now, the proposed technique might improve the quality of life in this patient group. This is particularly relevant as survival rates and life expectancy in patients with head and neck cancer continue to increase.

Ethical approval

The study was approved by ethical institutional committee of the University of Uppsala, Sweden.

Funding

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Conflict of interest

None.

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