Cranial Nerve Reconstruction
Review & Own Experience

Thomas Kretschmer, MD, PhD; Christian Heinen, MD; Thomas Schmidt, MD
Department of Neurosurgery, CvO University Oldenburg, GER

Introduction

Cranial nerves (CN) differ in several aspects from peripheral nerves. They are routinely encountered during skull base and cerebrovascular surgery. Not infrequently they suffer from approach related trauma and are lesioned iatrogenically. Repair methods are available and reported since long, however information on results is sparce. There are no common recommendations. We review current knowledge, and available literature on the basis of own experience.

Background

Cranial nerves differ from peripheral nerves in anatomic architecture and histomorphology. This can be readily appreciated at the Obersteiner-Redlich zone: the segment of abrupt transition of covering sheath from pale staining oligodendroglia (central) to darker Schwann-cells (peripheral). They also differ in response to reconstruction and capability for functional reconstitution in dependence on number of functions supplied by nerve (single vs multiple), axon number, nerve fiber type (mixed vs unmixed), and target muscle size. Yet same principles as for PN repair are applied. Surgical technique for intracranial nerve repair however differs in detail from extracranial repair mainly due to difference in tissue handling and nerve tissue structure (endoneuroium, fascicular structure, stability, CSF vs nerve bed). Some cranial nerves (e.g. supplying single motor function) will have excellent results after instant intracranial repair. Different coaptation techniques are available (suture, fibrin glue, combinations). Reconstruction in a confined space and nerve coaptation within CSF necessitate an efficient time and tissue sparing approach.
Experience with fast, local, or distant donor nerve harvest, graft alignment techniques and glue coaptation is necessary.
Differences between cranial nerves

- I & II evagination of the brain
- III multiple target muscles, most precise coordination
- IV & VI single muscle
- V mixed, different nuclei, pain, corneal supply
- VII mixed
- VIII mixed
- IX mixed (5 fibre types), tiny calibre, no reconstruction results
- X no reconstruction results (5 fibre types)
- XI essentially PN, around 1400 axons,
- XII intracranial reconstruction results?

Surgical Methods

Repair techniques

- Decompression (Fig.1)
- End-to-end coaptation, if enough slack
- Graft repair with sural or cervical cutaneous nerve (e.g. major aurical nerve) (Fig. 2)
- Split graft repair (Fig.3)

Coaptation material

- Coaptation with glue if enough tensile strength or 10-0 suture
- If graft weigth pulls at coaptation site and risks dehiscence we use autologous fat as a disburdening bolster

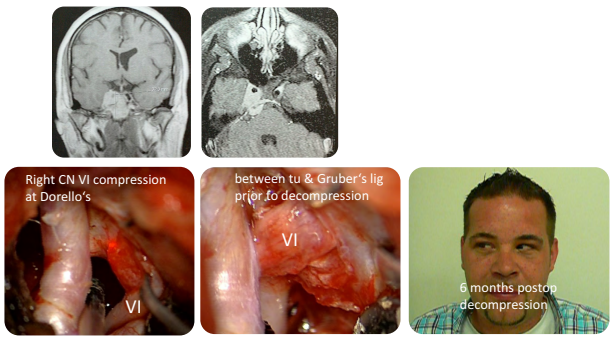

Figure 1. Reinnervation of CN VI palsy 6 months post decompression of nerve within Dorello's canal by tu reduction and transection of Gruber's ligament.

Results for intracranial CN repair

First reinnervation signs can usually be demonstrated within 6 months. If there are no signs at all, patients need to be counseled for secondary procedures (e.g. lid closure, squint surgery). Good results can be expected for trochlear and abducent nerve, mediocre results for facial, and mediocre to bad results for oculomotor nerve. Partial lacerations of CN III seem to have a far better prognosis[9], and repair seems worthwhile. There is lack of reported experience and results with olfactory and lower cranial nerves, and especially so with glossopharyngeal nerve.
This in contrast to an abundance of literature regarding reconstruction of facial nerve (intra < than extracranial), nerve transfers for facial reanimation and facial reanimation in general by direct and indirect means. Also well documented are favorable result of extracranial reconstruction of spinal/extracranial accessory nerve, which in essence is not a real CN at this level.
Although CN XII is frequently a donor for CN VII in facial reanimation, there are no results available for its intracranial repair.

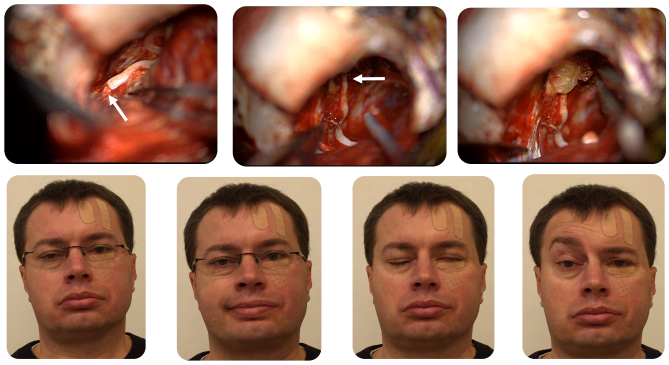

Figure 2. Intracranial CN Reconstruction from brainstem to internal acoustic meatus (IAM) due to removal of 4.5 cm VS. Upper left-prox glue coaptation of CN VII stump (arrow) with sural graft, upper-middle graft inlet into IAM (arrow), upper right-meatus bolstered with fat plug.
Lower row – reinnervation status 10 months postop.

Figure 3. Split repair of CN VII due to cavernoma at facial nerve knee[10]; patient presented with severe VII palsy. Left- drilling of petrous bone via right subtemporal approach, middle-exposure of cavernoma (cav/blue) and part of CN VII, right-sural nerve graft (sg) for partial nerve reconstruction.

Figure 4. From[9]: Menovsky, T., et al. (2013). **Perforated oculomotor nerve after endovascular coiling: complete regeneration after microsurgical repair-** case report.

CN III partially lacerated by coils, reapposition secured with fibrin glue, complete rstoration of functin after 6 months.

Journal of Neurological Surgery. Part A, Central European Neurosurgery, 74 Suppl 1(S 01).

Conclusion

Literature findings and own experience strengthened us to always attempt instant repair in acute situations. Patients thus should be counseled prior to surgery for potential cutaneous nerve graft harvest.
We prefer glue coaptation, as suture is not always practical and necessary for reinforcement, and if applicable we make use of autologous fat graft as mikro-bolster to reduce tension and pull.

Contact

Thomas Kretschmer, MD, PhD, IFAANS
Department of Neurosurgery
Evangelisches Krankenhaus – CvO University Oldenburg
26122 Oldenburg, Germany
Email: thomas.kretschmer@uol.de

References

1. Bender MB, Fulton JF (1938). Functional recovery in ocular muscles of chimpanzee after section of oculomotor nerve. J Neurophysiol 1:144-151.
2. Bacciu, A., Falcioni, M., Pasanisi, E., Di Lella, F., Lauda, L., Flanagan, S., & Sanna, M. (2009). Intracranial facial nerve grafting after removal of vestibular schwannoma. American Journal of Otolaryngology, 30(2), 83–88.
3. Dott, N. M. (1958). Facial paralysis; restitution by extra-petrous nerve graft. Proceedings of the Royal Society of Medicine, 51(11), 900–902.
4. Dott NM (1963). Facial nerve reconstruction by graft bypassing the petrous bone. Arch Otolaryngol 78:426-428.
5. Drake CG (1963). Intracranial facial nerve reconstruction. Arch Otolaryngol 78:456-460.
6. Korte W (1903). Ein Fall von Nervenpropfung: des N. facialis auf den N. hypoglossus. Deutsche Med Wochenschr 17: 293-295.
7. Menovsky, T., & van Overbeeke, J. J. (1996). Intracranial nerve repair: a review of experimental and clinical studies. Neurosurgical Focus, 1(2), e2.
8. Menovsky, T., van der Bergh Weerman, M., Kubista, O. L., Bartels, R. H., & van Overbeeke, J. J. (1999). End-to-end versus peripheral nerve graft repair of the oculomotor nerve in rats: A comparative histological and morphometric study. Microsurgery, 19(8), 392–400.
9. Menovsky, T., van der Zijden, T., Voormolen, M., Van Os, L., Helsen, G., Maas, A., & Parizel, P. M. (2013). Perforated oculomotor nerve after endovascular coiling: complete regeneration after microsurgical repair. case report. Journal of Neurological Surgery. Part a, Central European Neurosurgery, 74 Suppl 1(S 01), e248–54.
10. Reimers, C., Wolf, M., Kretschmer, T., & Röther, J. (2016). Schwieriger magnetresonanztomografischer Nachweis eines Hämangioms des N. facialis – Ein Fallbericht. RöFo - Fortschritte Auf Dem Gebiet Der Röntgenstrahlen Und Der Bildgebenden Verfahren, 188(10), 967–969.
11. Sekhar, L. N., Sen, C. N., Lanzino, G., & Pomonis, S. (1991). Carotid and cranial nerve reconstruction after removal of cavernous sinus lesions. The Keio Journal of Medicine, 40(4), 187–193
12. van Overbeeke, J. J., Cruysberg, J. R., & Menovsky, T. (1998). Intracranial repair of a divided trochlear nerve. Case report. Journal of Neurosurgery, 88(2), 336–339.