# Lateral spread response

In patients with hemifacial spasm (HFS), a lateral spread response (or abnormal muscle response) is recorded from facial muscles after facial nerve stimulation. The origin of this response is not completely understood.

During microvascular decompression for hemifacial spasm monitoring of the abnormal lateral spread response (LSR), an evoked response to facial nerve stimulation, has been traditionally used to monitor the adequacy of cranial nerve (CN) VII decompression.

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Yamashita et al., studied the lateral spread responses elicited by double stimulation in 12 patients with HFS during microvascular decompression. The response was recorded from the mentalis muscle by Electrostimulation of the temporal branch of the facial nerve or from the orbicularis oculi muscles by stimulation of the marginal mandibular branch. The interstimulus intervals (ISIs) of double stimulation ranged from 0.5 to 7.0 ms. R1 was defined as the response elicited by the first stimulus, and R2 as the response elicited by the second stimulus. R1 had a constant latency and amplitude regardless of the ISI, whereas R2 appeared after a fixed refractory period without facilitation or depression in a recovery curve of latency and amplitude. From these findings, they considered that the lateral spread response is due to cross-transmission of facial nerve fibers at the site of vascular compression rather than arising from facial nerve motor neurons [1)].

## Systematic Review and Meta-Analysis

Intraoperative LSR monitoring has high specificity but modest sensitivity in predicting the spasm-free status following MVD. The persistence of LSR carries a high risk for immediate and long-term facial spasm persistence. Therefore, the adequacy of decompression should be thoroughly investigated before closing in cases where intraoperative LSR persists. [2)].

## Case report

Chen et al., report a 34-year-old female with hemifacial spasm who was identified as a candidate for microvascular decompression. Lateral spread response (LSR) was not recorded at first because of anatomical shift of neurovascular relationship after drainage of cerebrospinal fluid, but they reappeared only after a piece of shredded gelatin sponge was placed near the posterior inferior cerebellar artery to expand surgical field. As they removed the gelatin sponge, the LSRs disappeared instantly. Subsequently, the authors put some soft shredded Teflon between the offending vessel and brainstem. Since then the authors did not find LSRs anymore. Clinical follow-up had been carried out with a questionnaire from 1 week to 3 months postoperatively, and the patient was cured with no complications. This report presented that the gelatin sponge placed in an inappropriate position resulting in compression potentially leading to the opposite effect of treatment. Such kind of excessive operation could be avoided by electrophysiological monitoring [3)].

# Unclassified

1: Chen Y, Wang J, Wang X. A Rare Potential Compression Can Be Avoided by Lateral Spread Response Recordings During Microvascular Decompression for Hemifacial Spasm. J Craniofac Surg. 2019 Mar 9. doi: 10.1097/SCS.0000000000005400. [Epub ahead of print] PubMed PMID: 30921064.

2: Son BC, Ko HC, Choi JG. Hemifacial Spasm Caused by Vascular Compression in the Cisternal Portion of the Facial Nerve: Report of Two Cases with Review of the Literature. Case Rep Neurol Med. 2019 Jan 1;2019:8526157. doi: 10.1155/2019/8526157. eCollection 2019. PubMed PMID: 30713778; PubMed Central PMCID: PMC6333014.

3: Czubowicz K, Jęśko H, Wencel P, Lukiw WJ, Strosznajder RP. The Role of Ceramide and Sphingosine-1-Phosphate in Alzheimer's Disease and Other Neurodegenerative Disorders. Mol Neurobiol. 2019 Jan 5. doi: 10.1007/s12035-018-1448-3. [Epub ahead of print] Review. PubMed PMID: 30612333.

4: Park JS, Lee S, Park SK, Lee JA, Park K. Facial motor evoked potential with paired transcranial magnetic stimulation: prognostic value following microvascular decompression for hemifacial spasm. J Neurosurg. 2018 Dec 21:1-8. doi: 10.3171/2018.8.JNS18708. [Epub ahead of print] PubMed PMID: 30579277.

5: Flanders TM, Blue R, Roberts S, McShane BJ, Wilent B, Tambi V, Petrov D, Lee JYK. Fully endoscopic microvascular decompression for hemifacial spasm. J Neurosurg. 2018 Oct 1:1-7. doi: 10.3171/2018.4.JNS172631. [Epub ahead of print] PubMed PMID: 30497190.

6: Eun J, Choi JG, Son BC. Hemifacial Spasm Caused by a Vein: A Case Report. Asian J Neurosurg. 2018 Jul-Sep;13(3):786-788. doi: 10.4103/1793-5482.238005. PubMed PMID: 30283547; PubMed Central PMCID: PMC6159036.

7: Huttunen JK, Airaksinen AM, Barba C, Colicchio G, Niskanen JP, Shatillo A, Sierra Lopez A, Ndode-Ekane XE, Pitkänen A, Gröhn OH. Detection of Hyperexcitability by Functional Magnetic Resonance Imaging after Experimental Traumatic Brain Injury. J Neurotrauma. 2018 Nov 15;35(22):2708-2717. doi: 10.1089/neu.2017.5308. Epub 2018 Sep 27. PubMed PMID: 30019618.

8: Lefaucheur JP. New insights into the pathophysiology of primary hemifacial spasm. Neurochirurgie. 2018 May;64(2):87-93. doi: 10.1016/j.neuchi.2017.12.004. Epub 2018 Apr 16. PubMed PMID: 29673579.

9: Cheng CY, Shetty R, Martinez V, Sekhar LN. Microvascular Decompression of Facial Nerve and Pexy of the Left Vertebral Artery for Left Hemifacial Spasm: 3-Dimensional Operative Video. Oper Neurosurg (Hagerstown). 2019 Jan 1;16(1):E2-E3. doi: 10.1093/ons/opy058. PubMed PMID: 29617905.

10: Lee JM, Park HR, Choi YD, Kim SM, Jeon B, Kim HJ, Kim DG, Paek SH. Delayed facial palsy after microvascular decompression for hemifacial spasm: friend or foe? J Neurosurg. 2018 Aug;129(2):299-307. doi: 10.3171/2017.3.JNS162869. Epub 2017 Sep 1. PubMed PMID: 28862543.

11: Wroe AJ, McAuley G, Teran AV, Wong J, Petasecca M, Lerch M, Slater JM, Rozenfeld AB. Initial testing of a pixelated silicon detector prototype in proton therapy. J Appl Clin Med Phys. 2017 Sep;18(5):315-324. doi: 10.1002/acm2.12120. Epub 2017 Jul 18. PubMed PMID: 28719019; PubMed Central PMCID: PMC5874964.

12: Wei Y, Yang W, Zhao W, Pu C, Li N, Cai Y, Shang H. Microvascular decompression for hemifacial spasm: can intraoperative lateral spread response monitoring improve surgical efficacy? J Neurosurg. 2018 Mar;128(3):885-890. doi: 10.3171/2016.11.JNS162148. Epub 2017 May 12. PubMed PMID: 28498061.

13: van den Pol AN, Mao G, Yang Y, Ornaghi S, Davis JN. Zika Virus Targeting in the Developing Brain. J Neurosci. 2017 Feb 22;37(8):2161-2175. doi: 10.1523/JNEUROSCI.3124-16.2017. Epub 2017 Jan 25. PubMed PMID: 28123079; PubMed Central PMCID: PMC5338758.

14: Shah A, Horowitz M. Persistent hemifacial spasm after microvascular decompression: a risk assessment model. Br J Neurosurg. 2017 Jun;31(3):327-335. doi: 10.1080/02688697.2016.1257110. Epub 2016 Dec 1. PubMed PMID: 27906546.

15: Jia G, Zhang L, Ren H, Xu J, Xu X, Yu Y. What range of stimulus intensities should we apply to elicit abnormal muscle response in microvascular decompression for hemifacial spasm? Acta Neurochir (Wien). 2017 Feb;159(2):251-257. doi: 10.1007/s00701-016-2999-6. Epub 2016 Oct 25. PubMed PMID: 27783168.

16: Li S, Feng B, Xie C, You C, Wei X, Zheng X. Good Surgical Outcomes of Hemifacial Spasm Patients with Obvious Facial Nerve Indentation and Color Change. World Neurosurg. 2016 Aug;92:218-222. doi: 10.1016/j.wneu.2016.05.012. Epub 2016 May 13. PubMed PMID: 27184901.

17: Wilkinson MF, Chowdhury T, Mutch WA, Kaufmann AM. Analysis of facial motor evoked potentials for assessing a central mechanism in hemifacial spasm. J Neurosurg. 2017 Feb;126(2):379-385. doi: 10.3171/2016.2.JNS151384. Epub 2016 May 13. PubMed PMID: 27177175.

18: Lee SH, Park BJ, Shin HS, Park CK, Rhee BA, Lim YJ. Prognostic ability of intraoperative electromyographic monitoring during microvascular decompression for hemifacial spasm to predict lateral spread response outcome. J Neurosurg. 2017 Feb;126(2):391-396. doi: 10.3171/2016.1.JNS151782. Epub 2016 Apr 22. PubMed PMID: 27104851.

19: Kameyama S, Masuda H, Shirozu H, Ito Y, Sonoda M, Kimura J. Ephaptic transmission is the origin of the abnormal muscle response seen in hemifacial spasm. Clin Neurophysiol. 2016 May;127(5):2240-5. doi: 10.1016/j.clinph.2016.02.004. Epub 2016 Feb 11. PubMed PMID: 27072096.

20: El Damaty A, Rosenstengel C, Matthes M, Baldauf J, Schroeder HW. The value of lateral spread response monitoring in predicting the clinical outcome after microvascular decompression in hemifacial spasm: a prospective study on 100 patients. Neurosurg Rev. 2016 Jul;39(3):455-66. doi: 10.1007/s10143-016-0708-9. Epub 2016 Apr 6. PubMed PMID: 27053220.

21: McDowell MM, Zhu X, Hughes MA, Sekula RF Jr. Facial spasms, but not hemifacial spasm: a case report and review of literature. Childs Nerv Syst. 2016 Sep;32(9):1735-9. doi: 10.1007/s00381-016-3057-7. Epub 2016 Mar 16. Review. PubMed PMID: 26984806.

22: Siman R, Cocca R, Dong Y. The mTOR Inhibitor Rapamycin Mitigates Perforant Pathway Neurodegeneration and Synapse Loss in a Mouse Model of Early-Stage Alzheimer-Type Tauopathy. PLoS One. 2015 Nov 5;10(11):e0142340. doi: 10.1371/journal.pone.0142340. eCollection 2015. PubMed PMID: 26540269; PubMed Central PMCID: PMC4634963.

23: Liu J, Yuan Y, Fang Y, Zhang L, Xu XL, Liu HJ, Zhang Z, Yu YB. Microvascular decompression for atypical hemifacial spasm: lessons learned from a retrospective study of 12 cases. J Neurosurg. 2016 Feb;124(2):397-402. doi: 10.3171/2015.3.JNS142501. Epub 2015 Sep 4. PubMed PMID: 26339846.

24: Lee SH, Choi SK, Kim J. Real-time Monitoring of the Lateral Spread Response Resulting from Serial Decompression for Hemifacial Spasm Caused by a Fusiform Aneurysm. J Neurol Surg A Cent Eur Neurosurg. 2015 Jul;76(4):332-6. doi: 10.1055/s-0035-1547361. Epub 2015 May 8. PubMed PMID: 26140340.

25: Thirumala PD, Wang X, Shah A, Habeych M, Crammond D, Balzer JR, Sekula R. Clinical impact of residual lateral spread response after adequate microvascular decompression for hemifacial spasm: A retrospective analysis. Br J Neurosurg. 2015;29(6):818-22. doi: 10.3109/02688697.2015.1054351. Epub 2015 Jun 22. PubMed PMID: 26098605.

26: Hale T, Hoffman SN, Dehdashti AR. Intra-operative monitoring of two facial muscles in hemifacial spasm surgery. Neurochirurgie. 2015 Aug;61(4):266-70. doi: 10.1016/j.neuchi.2015.04.001. PubMed PMID: 26073921.

27: Jones AR, Troakes C, King A, Sahni V, De Jong S, Bossers K, Papouli E, Mirza M, Al-Sarraj S, Shaw CE, Shaw PJ, Kirby J, Veldink JH, Macklis JD, Powell JF, Al-Chalabi A. Stratified gene expression analysis identifies major amyotrophic lateral sclerosis genes. Neurobiol Aging. 2015 May;36(5):2006.e1-9. doi: 10.1016/j.neurobiolaging.2015.02.017. Epub 2015 Feb 19. PubMed PMID: 25801576.

28: Cui Z, Ling Z. Advances in microvascular decompression for hemifacial spasm. J Otol. 2015 Mar;10(1):1-6. doi: 10.1016/j.joto.2015.06.002. Epub 2015 Jul 26. PubMed PMID: 29937774; PubMed Central PMCID: PMC6002561.

29: Chung YH, Kim WH, Chung IS, Park K, Lim SH, Seo DW, Lee JJ, Yang SI. Effects of partial neuromuscular blockade on lateral spread response monitoring during microvascular decompression surgery. Clin Neurophysiol. 2015 Nov;126(11):2233-40. doi: 10.1016/j.clinph.2014.12.030. Epub 2015 Jan 29. PubMed PMID: 25716546.

30: Wilkinson MF, Chowdhury T, Mutch WA, Kaufmann AM. Is hemifacial spasm a phenomenon of the central nervous system? –The role of desflurane on the lateral spread response. Clin Neurophysiol. 2015 Jul;126(7):1354-9. doi: 10.1016/j.clinph.2014.09.030. Epub 2014 Oct 12. PubMed PMID: 25454282.

31: Chung YH, Kim WH, Lee JJ, Yang SI, Lim SH, Seo DW, Park K, Chung IS. Lateral spread response monitoring during microvascular decompression for hemifacial spasm. Comparison of two targets of partial neuromuscular blockade. Anaesthesist. 2014 Feb;63(2):122-8. doi: 10.1007/s00101-013-2286-3. Epub 2014 Feb 7. PubMed PMID: 24499959.

32: Choi SI, Kim MW, Park DY, Huh R, Jang DH. Electrophysiologic investigation during facial motor neuron suppression in patients with hemifacial spasm: possible pathophysiology of hemifacial spasm: a pilot study. Ann Rehabil Med. 2013 Dec;37(6):839-47. doi: 10.5535/arm.2013.37.6.839. Epub 2013 Dec 23. PubMed PMID: 24466519; PubMed Central PMCID: PMC3895524.

33: Fanara B, Christophe JL, Boillot A, Tatu L, Jochum D, Henri Y, Berthier F, Samain E. Ultrasound guidance of needle tip position for femoral nerve blockade: an observational study. Eur J Anaesthesiol. 2014 Jan;31(1):23-9. doi: 10.1097/01.EJA.0000435016.83813.aa. PubMed PMID: 24145804.

34: Wang X, Thirumala PD, Shah A, Gardner P, Habeych M, Crammond D, Balzer J, Burkhart L, Horowitz M. Microvascular decompression for hemifacial spasm: focus on late reoperation. Neurosurg Rev. 2013 Oct;36(4):637-43; discussion 643-4. doi: 10.1007/s10143-013-0480-z. Epub 2013 Jun 10. PubMed PMID: 23749049.

35: Mueller O, Hagel V, Wrede K, Schlamann M, Hohn HP, Sure U, Gaul C. Stimulation of the greater

occipital nerve: anatomical considerations and clinical implications. Pain Physician. 2013 May-Jun;16(3):E181-9. PubMed PMID: 23703417.

36: Wang X, Thirumala PD, Shah A, Gardner P, Habeych M, Crammond D, Balzer J, Burkhart L, Horowitz M. The role of vein in microvascular decompression for hemifacial spasm: a clinical analysis of 15 cases. Neurol Res. 2013 May;35(4):389-94. doi: 10.1179/1743132812Y.0000000153. PubMed PMID: 23540407.

37: Wang X, Thirumala PD, Shah A, Gardner P, Habeych M, Crammond DJ, Balzer J, Horowitz M. Effect of previous botulinum neurotoxin treatment on microvascular decompression for hemifacial spasm. Neurosurg Focus. 2013 Mar;34(3):E3. doi: 10.3171/2012.11.FOCUS12373. PubMed PMID: 23452316.

38: Kang MC, Choi YS, Choi HK, Lee SH, Ghang CG, Kim CH. Efficacy of the Disappearance of Lateral Spread Response before and after Microvascular Decompression for Predicting the Long-Term Results of Hemifacial Spasm Over Two Years. J Korean Neurosurg Soc. 2012 Oct;52(4):372-6. doi: 10.3340/jkns.2012.52.4.372. Epub 2012 Oct 22. PubMed PMID: 23133727; PubMed Central PMCID: PMC3488647.

39: Fang Y, Zhang H, Liu W, Li Y. A comparison of three induction regimens using succinylcholine, vecuronium, or no muscle relaxant: impact on the intraoperative monitoring of the lateral spread response in hemifacial spasm surgery: study protocol for a randomised controlled trial. Trials. 2012 Sep 8;13:160. doi: 10.1186/1745-6215-13-160. PubMed PMID: 22958580; PubMed Central PMCID: PMC3502586.

40: Jo KW, Kong DS, Park K. Microvascular decompression for hemifacial spasm: long-term outcome and prognostic factors, with emphasis on delayed cure. Neurosurg Rev. 2013 Apr;36(2):297-301; discussion 301-2. doi: 10.1007/s10143-012-0420-3. Epub 2012 Sep 2. PubMed PMID: 22940822.

41: Portela DA, Otero PE, Briganti A, Romano M, Corletto F, Breghi G. Femoral nerve block: a novel psoas compartment lateral pre-iliac approach in dogs. Vet Anaesth Analg. 2013 Mar;40(2):194-204. doi: 10.1111/j.1467-2995.2012.00765.x. Epub 2012 Jul 6. PubMed PMID: 22765834.

42: Snowden JN, Beaver M, Smeltzer MS, Kielian T. Biofilm-infected intracerebroventricular shunts elicit inflammation within the central nervous system. Infect Immun. 2012 Sep;80(9):3206-14. doi: 10.1128/IAI.00645-12. Epub 2012 Jul 2. PubMed PMID: 22753376; PubMed Central PMCID: PMC3418739.

43: Misaki K, Nakada M, Mohri M, Hayashi Y, Hamada J. MGMT promoter methylation and temozolomide response in choroid plexus carcinoma. Brain Tumor Pathol. 2011 Jul;28(3):259-63. doi: 10.1007/s10014-011-0033-5. Epub 2011 Mar 26. PubMed PMID: 21442238.

44: Thirumala PD, Shah AC, Nikonow TN, Habeych ME, Balzer JR, Crammond DJ, Burkhart L, Chang YF, Gardner P, Kassam AB, Horowitz MB. Microvascular decompression for hemifacial spasm: evaluating outcome prognosticators including the value of intraoperative lateral spread response monitoring and clinical characteristics in 293 patients. J Clin Neurophysiol. 2011 Feb;28(1):56-66. doi: 10.1097/WNP.0b013e3182051300. PubMed PMID: 21221005.

45: Anns JP, Chen EW, Nirkavan N, McCartney CJ, Awad IT. A comparison of sartorius versus quadriceps stimulation for femoral nerve block: a prospective randomized double-blind controlled trial. Anesth Analg. 2011 Mar;112(3):725-31. doi: 10.1213/ANE.0b013e3182052213. Epub 2010 Dec 2. PubMed PMID: 21127273.

46: Kim CH, Kong DS, Lee JA, Park K. The Potential Value of the Disappearance of the Lateral Spread

Response During Microvascular Decompression for Predicting the Clinical Outcome of Hemifacial Spasms: A Prospective Study. Neurosurgery. 2010 Dec;67(6):1581-1588. PubMed PMID: 27759660.

47: Kim CH, Kong DS, Lee JA, Kwan-Park. The potential value of the disappearance of the lateral spread response during microvascular decompression for predicting the clinical outcome of hemifacial spasms: a prospective study. Neurosurgery. 2010 Dec;67(6):1581-7; discussion 1587-8. doi: 10.1227/NEU.0b013e3181f74120. PubMed PMID: 21107188.

48: Cohen SP, Strassels SA, Kurihara C, Forsythe A, Buckenmaier CC 3rd, McLean B, Riedy G, Seltzer S. Randomized study assessing the accuracy of cervical facet joint nerve (medial branch) blocks using different injectate volumes. Anesthesiology. 2010 Jan;112(1):144-52. doi: 10.1097/ALN.0b013e3181c38a82. PubMed PMID: 19996954.

49: Sekula RF Jr, Bhatia S, Frederickson AM, Jannetta PJ, Quigley MR, Small GA, Breisinger R. Utility of intraoperative electromyography in microvascular decompression for hemifacial spasm: a meta-analysis. Neurosurg Focus. 2009 Oct;27(4):E10. doi: 10.3171/2009.8.FOCUS09142. Review. PubMed PMID: 19795949.

50: Xu F, Cao X, Zhao ZY, Zhang P, Xu SG, Xu L. [Application of intraoperative electrophysiological monitoring in lumbosacral selective posterior rhizotomy for spastic cerebral palsy]. Zhonghua Wai Ke Za Zhi. 2009 Jul 15;47(14):1088-91. Chinese. PubMed PMID: 19781276.

51: Joo WI, Lee KJ, Park HK, Chough CK, Rha HK. Prognostic value of intra-operative lateral spread response monitoring during microvascular decompression in patients with hemifacial spasm. J Clin Neurosci. 2008 Dec;15(12):1335-9. doi: 10.1016/j.jocn.2007.08.008. Epub 2008 Jul 9. PubMed PMID: 18617405.

52: Kong DS, Park K, Shin BG, Lee JA, Eum DO. Prognostic value of the lateral spread response for intraoperative electromyography monitoring of the facial musculature during microvascular decompression for hemifacial spasm. J Neurosurg. 2007 Mar;106(3):384-7. PubMed PMID: 17367059.

53: Li F, Zhu S, Liu Y, Chen G, Chi L, Qu F. Hyperdense intracranial epidermoid cysts: a study of 15 cases. Acta Neurochir (Wien). 2007 Jan;149(1):31-9; discussion 39. Epub 2006 Dec 11. PubMed PMID: 17151831.

54: Feigl G, Fuchs A, Gries M, Hogan QH, Weninger B, Rosmarin W. A supraomohyoidal plexus block designed to avoid complications. Surg Radiol Anat. 2006 Aug;28(4):403-8. Epub 2006 May 6. PubMed PMID: 16680393.

55: Gotman J, Grova C, Bagshaw A, Kobayashi E, Aghakhani Y, Dubeau F. Generalized epileptic discharges show thalamocortical activation and suspension of the default state of the brain. Proc Natl Acad Sci U S A. 2005 Oct 18;102(42):15236-40. Epub 2005 Oct 10. PubMed PMID: 16217042; PubMed Central PMCID: PMC1257704.

56: Wilkinson MF, Kaufmann AM. Monitoring of facial muscle motor evoked potentials during microvascular decompression for hemifacial spasm: evidence of changes in motor neuron excitability. J Neurosurg. 2005 Jul;103(1):64-9. PubMed PMID: 16121975.

57: Murakami H, Kawaguchi T, Fukuda M, Ito Y, Hasegawa H, Tanaka R. Monitoring of the lateral spread response in the endovascular treatment of a hemifacial spasm caused by an unruptured vertebral artery aneurysm. Case report. J Neurosurg. 2004 Nov;101(5):861-3. PubMed PMID: 15540928.

58: Yamashita S, Kawaguchi T, Fukuda M, Suzuki K, Watanabe M, Tanaka R, Kameyama S. Lateral spread response elicited by double stimulation in patients with hemifacial spasm. Muscle Nerve. 2002 Jun;25(6):845-9. PubMed PMID: 12115973.

59: D'Arcangelo G, Tancredi V, Avoli M. Intrinsic optical signals and electrographic seizures in the rat limbic system. Neurobiol Dis. 2001 Dec;8(6):993-1005. PubMed PMID: 11741395.

60: Kiya N, Bannur U, Yamauchi A, Yoshida K, Kato Y, Kanno T. Monitoring of facial evoked EMG for hemifacial spasm: a critical analysis of its prognostic value. Acta Neurochir (Wien). 2001;143(4):365-8. PubMed PMID: 11437290.

61: Kang HS, Wang KC, Kim YM, Kim IO, Kim SK, Chi JG, Cho BK. Choroid plexus carcinoma in an infant. J Korean Med Sci. 1997 Apr;12(2):162-7. PubMed PMID: 9170025; PubMed Central PMCID: PMC3054246.

62: Ishikawa M, Namiki J, Takase M, Ohira T, Nakamura A, Toya S. Effect of repetitive stimulation on lateral spreads and F-waves in hemifacial spasm. J Neurol Sci. 1996 Oct;142(1-2):99-106. PubMed PMID: 8902727.

63: McLoon LK, Wirtschafter JD. Doxorubicin chemomyectomy in orbicularis oculi: increasing drug infiltration at the injection site. Curr Eye Res. 1996 Aug;15(8):883-9. PubMed PMID: 8921232.

64: Ishikawa M, Ohira T, Namiki J, Ajimi Y, Takase M, Toya S. Abnormal muscle response (lateral spread) and F-wave in patients with hemifacial spasm. J Neurol Sci. 1996 May;137(2):109-16. PubMed PMID: 8782163.

65: Ishikawa M, Ohira T, Namiki J, Gotoh K, Takase M, Toya S. Electrophysiological investigation of hemifacial spasm: F-waves of the facial muscles. Acta Neurochir (Wien). 1996;138(1):24-32. PubMed PMID: 8686521.

66: Isu T, Kamada K, Mabuchi S, Kitaoka A, Ito T, Koiwa M, Abe H. Intra-operative monitoring by facial electromyographic responses during microvascular decompressive surgery for hemifacial spasm. Acta Neurochir (Wien). 1996;138(1):19-23; discussion 23. PubMed PMID: 8686520.

67: van den Pol AN. Presynaptic metabotropic glutamate receptors in adult and developing neurons: autoexcitation in the olfactory bulb. J Comp Neurol. 1995 Aug 21;359(2):253-71. PubMed PMID: 7499528.

68: Grinvald A, Lieke EE, Frostig RD, Hildesheim R. Cortical point-spread function and long-range lateral interactions revealed by real-time optical imaging of macaque monkey primary visual cortex. J Neurosci. 1994 May;14(5 Pt 1):2545-68. PubMed PMID: 8182427.

69: Ishikawa M, Ohira T, Namiki J, Takase M, Toya S. [Neurophysiological study of hemifacial spasm–F wave of the facial muscles]. No To Shinkei. 1994 Apr;46(4):360-5. Japanese. PubMed PMID: 8024835.

70: Wellis DP, Kauer JS. GABAA and glutamate receptor involvement in dendrodendritic synaptic interactions from salamander olfactory bulb. J Physiol. 1993 Sep;469:315-39. PubMed PMID: 7903696; PubMed Central PMCID: PMC1143873.

71: Coirini H, Schumacher M, Flanagan LM, McEwen BS. Transport of estrogen-induced oxytocin receptors in the ventromedial hypothalamus. J Neurosci. 1991 Nov;11(11):3317-24. PubMed PMID: 1658249.

72: Sakuma Y, Akaishi T. Cell size, projection path, and localization of estrogen-sensitive neurons in the rat ventromedial hypothalamus. J Neurophysiol. 1987 Apr;57(4):1148-59. PubMed PMID: 3295136.

73: Fujita Y, Rosenberg J, Segundo JP. Activity of cells in the lateral vestibular nucleus as a function of head position. J Physiol. 1968 May;196(1):1-18. PubMed PMID: 4871351; PubMed Central PMCID: PMC1351730.

1)
Yamashita S, Kawaguchi T, Fukuda M, Suzuki K, Watanabe M, Tanaka R, Kameyama S. Lateral spread response elicited by double stimulation in patients with hemifacial spasm. Muscle Nerve. 2002 Jun;25(6):845-9. PubMed PMID: 12115973.
2)
Thirumala PD, Altibi AM, Chang R, Saca EE, Iyengar P, Reddy R, Anetakis K, Crammond DJ, Balzer JR, Sekula RF. The Utility of Intraoperative Lateral Spread Recording in Microvascular Decompression for Hemifacial Spasm: A Systematic Review and Meta-Analysis. Neurosurgery. 2020 Sep 15;87(4):E473-E484. doi: 10.1093/neuros/nyaa069. PMID: 32297629.
3)
Chen Y, Wang J, Wang X. A Rare Potential Compression Can Be Avoided by Lateral Spread Response Recordings During Microvascular Decompression for Hemifacial Spasm. J Craniofac Surg. 2019 Mar 9. doi: 10.1097/SCS.0000000000005400. [Epub ahead of print] PubMed PMID: 30921064.