Surgery for symptoms of lumbar radiculopathy

Clinical Expert

Christoph P. Hofstetter

Assistant Professor, Department of Neurological Surgery,
University of Washington

Director of Spine Surgery, University of Washington Medical Center

Neurosurgeon, Harborview Medical Center

Applicant Name	Christoph Hofstetter
Address	Campus Box 356470, Room RR744A
	1959 NE Pacific Street
	University of Washington, Seattle 98195-6470

1. Business Activities

(a) If you or a member of your household was ***an officer or director of a business*** during the immediately preceding calendar year and the current year to date, provide the following:

Title	Business Name & Address	Business Type
N/A	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.

(b) If you or a member of your household ***did business under an assumed business name*** during the immediately preceding calendar year or the current year to date, provide the following information:

Business Name	Business Address	Business Type
N/A	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.

2. Honorarium

If you ***received an honorarium of more than $100*** during the immediately preceding calendar year and the current year to date, list all such honoraria:

Received From	Organization Address	Service Performed
J&J	Raynham, MA	Teaching, Consulting
Joimax	Irvine, CA	Teaching
Click here to enter text.	Click here to enter text.	Click here to enter text.

3. Sources of Income

(a) Identify ***income source(s) that contributed 10% or more of the combined total gross household income*** received by you or a member of your household during the immediately preceding calendar year and the current year to date.

Source Name & Address	Received By	Source Type
UW	Hofstetter	salary
Click here to enter text.	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.

(b) Does any income source listed above relate to, or could it reasonably be expected to relate to, business that has, or may, come before the Committee?

☐ Yes ☒ No

If "yes", describe: Click here to enter text.
Click here to enter text.
Click here to enter text.

(c) Does an income source listed above have a legislative or administrative interest in the business of the Committee?

☐ Yes ☒ No

If "yes", describe: Click here to enter text.
Click here to enter text.
Click here to enter text.

4. Business Shared With a Lobbyist

If you or a member of your household ***shared a partnership, joint venture, or similar substantial economic relationship with a paid lobbyist***, were employed by, or employed, a paid lobbyist during please list the following:

(Owning stock in a publicly traded company in which the lobbyist also owns stock is not a relationship which requires disclosure.)

Lobbyist Name	Business Name	Type Business Shared
N/A	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.

Provide the information requested in items 5, 6, and 7 below only if:
(a) Your response involves an individual or business if you or a member of your household did business with, or reasonably could be expected to relate to business that has or may come before the Health Technology Clinical Committee.
(b) The information requested involves an individual or business with a legislative or administrative interest in the Committee.

5. Income of More Than $1,000

List each source (***not amounts***) of income over $1,000, other than a source listed under question 3 above, which you or a member of your household received during the immediately preceding calendar year and the current year to date:

Income Source	Address	Description of Income Source
Click here to enter text.	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.

Click here to enter text.	Click here to enter text.	Click here to enter text.

6. Business Investments of More Than $1,000

(Do not list the amount of the investment or include individual items held in a mutual fund or blind trust, a time or demand deposit in a financial institution, shares in a credit union, or the cash surrender value of life insurance.)

If you or a member of your household had a personal, beneficial interest or investment in a business during the immediate preceding calendar year of more than $1,000, list the following:

Business Name	Business Address	Description of Business
N/A	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.	Click here to enter text.

7. Service Fee of More Than $1,000

(Do not list fees if you are prohibited from doing so by law or professional ethics.)

List each ***person for whom you performed a service for a fee of more than $1,000*** in the immediate preceding calendar year or the current year to date.

Name	Description of Service
J&J	Teaching, Consulting
Joimax	Teaching
Click here to enter text.	Click here to enter text.

I certify that I have read and understand this Conflict of Interest Form and the information I have provided is true and correct as of this date.

Print Name Christoph Hofstetter

Check One: ☒ Committee Member ☐ Subgroup Member ☐ Contractor

[redacted]

5/7/2018

Date

CURRICULUM VITAE
Christoph, P Hofstetter, M.D., Ph.D.

PERSONAL DATA

Place of Birth:	St. Pölten, Austria
Citizenship:	Austrian
Date of Birth:	02/27/1977

EDUCATION

09/95 to 01/05	M.D., University of Vienna, Vienna, Austria
09/00 to 05/05	Ph.D., Karolinska Institute, Stockholm, Sweden

POSTGRADUATE TRAINING

07/05 to 06/06	Pre-Residency Fellowship, Mayo Clinic, Rochster, MN
07/05 to 06/06	Internship, Weill Cornell Medical College, New York, NY
07/06 to 06/13	Neurosurgery Residency, Weill Cornell Medical College, New York, NY
07/13 to 06/14	Complex spine fellowship, University of Miami, Miami, FL

FACULTY POSITIONS

09/14-present	Assistant Professor, Department of Neurological Surgery, University of Washington, Seattle WA

HOSPITAL APPOINTMENTS

06/14 to 08/14	Locum tenant, San Juan Regional Medical Center, Farmington, NM
06/14-present	Director of Spine surgery, University of Washington Medical Center, Department of Neurological Surgery, Seattle, WA
06/14-present	Neurosurgeon, Harborview Medical Center, Department of Neurological Surgery Seattle, WA

HONORS

2012	Distinguished Housestaff Award, NewYork-Presbyterian Hospital, NY
2010	Research Fellowship, Neurosurgical Research Educational Fund
2010	Andlinger Residency Exchange Fellowship, Austrian-American Foundation
2006	Chorafas Prize for Best Doctoral Thesis, Karolinska Institute, Sweden
2002	Karolinska Institute Travel Grant, Stockholm, Sweden
2002	Golges Grant, Stockholm, Sweden
2000	Siegfried Ludwig Educational Grant, St. Pölten, Austria
1999	Erasmus Grant, University of Vienna, Vienna, Austria

1995	First Place, Eighth Annual Russian Olympiad, Moscow, Russia

BOARD CERTIFICATION

2017-present	American Board of Neurological Surgery

MEDICAL LICENSURE

2014-present	Washington (MD60464459)
2014 to 2017	New Mexico (MD2014-0310)
2013 to 2015	Florida (ME116257)
2009 to 2015	New York State (255163)

PROFESSIONAL ORGANIZATIONS

2014– present	AANS/CNS Section on Disorders of the Spine and Peripheral Nerves, Member
2014– present	North America Spine Society (NASS), Member
2007– present	International Society for the Advancement of Spine Surgery (ISASS), Member
2007– present	Congress of Neurological Surgeons, Member
2001– present	American Association of Neurological Surgeons, Member
2001– present	Society for Neuroscience, Member

TEACHING RESPONSIBILITIES

2014-present	Teaching residents surgical and medical management of patients with neurosurgical ailments.

Recent CME Courses taught:

04/2018	Instructor: Endoscopic spinal Surgery, Global spine congress, Singapore
04/2018	Course Co-chair: Advanced endoscopic course, Irvin, CA
01/2018	Course Co-chair: Advanced endoscopic course, Irvin, CA
12/2018	Instructor: Surgeon's Cockpit: Training of MISS AO spine, Davos, Switzerland
12/2018	Instructor: Endoscopic spinal Surgery, 11th New York City Minimally Invasive Spine, Spinal Endoscopy, Robotics & Navigation Symposium, Weill Cornell Medical Center, New York, NY
10/2017	Endoscopic TLIF Lab course, Boston, MA
10/2017	Endoscopic TLIF Lab course, Boston, MA
09/2017	Advanced Endoscopic spine surgery course, Salzburg, Austria
07/2017	Mazor and O-arm course, California

07/2017	Course Co-chair: Advanced endoscopic course, Irvin, CA
07/2017	Course Co-chair: Advanced endoscopic course, Irvin CA
06/2017	Course Co-chair: Advanced endoscopic spinal Surgery Axis Research, Irvine, CA
05/2017	Instructor: Endoscopic spinal Surgery, NeuroSpine Symposium, Houston Methodist Hospital, Houston, TX
06/2017	Instructor: Advanced MIS Techniques Seattle Science Foundation, Seattle, WA
05/2017	Instructor: Endoscopic spinal Surgery NeuroSpine Symposium, Houston Methodist Hospital, Houston, TX
03/2017	Instructor: Endoscopic spinal Surgery Surgical Innovations Lab, Weill Cornell Medical Center, New York, NY
2014–present	Course chairman and Instructor, Minimally Invasive Spine Surgery Hands-on Course 29th and 30th annual NASS meeting.
07/2016	Instructor: Endoscopic interlaminar spinal Surgery Surgical Innovations Lab, Las Vegas, NV
05/2016	Instructor: Endoscopic Lumbar spinal Surgery 85th annual AANS meeting, Chicago, IL
2012 – 2013	Instructor, Endoscopic Spine Workshops Surgical Innovations Lab, Weill Cornell Medical Center, New York, NY
09/2011	Lecturer, Neurosurgery, Spine, and Neurotrauma Open Medical Institute, Salzburg, Austria
2000 – 2005	Head Teaching Assistant Department of Anatomy, Karolinska Institute, Stockholm, Sweden
1997 – 1999	Head Teaching Assistant Department of Anatomy, University of Vienna, Vienna, Austria

List trainees taught during last five years,

Zin Khaing, Ph.D., Rachel Bakemore, Thank Tuong, Selena Muong, Brian Kim, Michael Cruz, Jeffrey Hyde, Dane DeWees, Fatma Inanici, M.D., Zeinab Birjandian, M.D., Anna Marie Yanny, Lynn McGrath, M.D., Ashley Gaing, Kayla Shade, Brian Kim, Aubrey Sonnenfeld, Anna-Sophie Hofer, M.D.

EDITORIAL RESPONSIBILITIES

2015-present World Neurosurgery, Reviewer

2016-present International Journal of Spine Surgery, Reviewer

SPECIAL NATIONAL RESPONSIBILITIES

2015-present NASS, Member of the scientific committee

2016-present AANS/CNS Section on Disorders of the Spine and Peripheral Nerves, Member of the scientific committee

RESEARCH FUNDING, PAST AND CURRENT

Craig Neilsen Foundation (PI: Hofstetter) 07/31/18 – 07/30/20
Ultrafast contrast-enhanced ultrasound to measure local blood flow after SCI
The primary goal of this project is to develop ultrafast contrast-enhanced ultrasound to identify tissue in vicinity of a spinal cord lesion at risk for secondary-injury

WACIC, Washington State Spinal Cord Injury Consortium (PI: Hofstetter) 11/01/17-06/30/19
Contrast enhanced-ultrasound to identify potentially viable tissue within the penumbra of human spinal cord injury
The primary aim of this project was to collect contrast enhanced-ultrasound data characterizing the potentially salvageable penumbra of traumatic spinal cord injuries.

WACIC, Washington Spinal Cord Injury Consortium (PI: Moritz) 11/13/17-06/30/19
Transcutaneous spinal stimulation to improve hand & arm function for people with chronic cervical spinal cord injury
We perform a clinical trial of transcutaneous electrical stimulation in patients with chronic cervical spinal cord injury aiming to improve upper extremity function.
Role: Co-Investigator

WACIC, Washington Spinal Cord Injury Consortium (PI: Perlmutter) 11/13/17-06/30/19
Therapeutic Transcutaneous Spinal Stimulation for Improved Recovery after Cervical Spinal Cord Injury in the Rat
Development of translational rodent model for transcutaneous to reproduce the extremely favorable results we have seen in our clinical trial with cervical spinal cord stimulation.
Role: Co-Investigator

University of Washington Royalty Research Fund (PI: Hofstetter) 6/1/2016 – 5/31/2017
Ultrasound-based assessment of spinal perfusion following traumatic spinal cord injury
The primary aim of this project is to determine the contribution of elevated intraspinal pressure towards hypoperfusion of the acutely injured spinal cord

University of Washington Royalty Research Fund (PI: Hofstetter) 6/1/2016 – 5/31/2017
Ultrasound-based assessment of spinal perfusion following traumatic spinal cord injury
The primary aim of this project is to determine the contribution of elevated intraspinal pressure towards hypoperfusion of the acutely injured spinal cord.

University of Washington Institute of Translational Health Sciences (PI: Hofstetter) 6/1/2016 – 5/31/2017
Immunomodulatory 3D scaffold to promote neuronal regeneration after spinal cord injury
The primary aim of this project is to develop novel scaffolds alter the phenotypes of local macrophages and herby reduce local scar formation and promote tissue regeneration.

University of Washington Institute of Translational Health Sciences (PI: Perlmutter) 6/1/2015 - 5/31/2016
Role: Co-investigator
An NHP Model for Cervical Myelopathy and Therapeutic Use of Electrical Stimulation.
The primary aim of this project is to establish a primate model of cervical myelopathy using a chronic compression device.

BIBLIOGRAPHY

PEER REVIEWED JOURNAL ARTICLES

1. Birjandian Z, Emerson S, Telfeian AE, **Hofstetter CP**. *Interlaminar endoscopic lateral recess decompression – surgical technique and early clinical results.* Journal of Spine Surgery. 2017; 3 (2): 123-132.
2. Telfeian AE, Punsoni ME, Klinge PE, Gokaslan ZE, **Hofstetter CP**. *Minimally-Invasive Endoscopic Spinal Cord Untethering: Case Report.* Journal of Spine Surgery. 2017; 3 (2): 278-282.
3. Krok G, Telfeian AE, Wagner R, **Hofstetter CP**, Iprenburg M. *Contralateral facet-sparing sublaminar endoscopic foraminotomy for the treatment of lumbar lateral recess stenosis: technical note.* Journal of Spine Surgery. 2017; 3 (2): 260-266.
4. Ruzevick JJ, Wagner T, Chen E, **Hofstetter CP**. *Periprostetic Osteolysis After 2 Level Cervical Disc Arthroplasty Featuring Artificial Nucleus.* Jacobs Journal of Spine. 2017; 1 (1).
5. Alimi M, Navarro-Ramirez R, Perrech M, Berlin C, **Hofstetter CP**, Moriguchi Y, Elowitz E, Hartl R. *The impact of Cage Dimensions, Positioning, and Side of Approach in Extreme Lateral Interbody Fusion.* Clin Spine Surgery. 2017; E2380.
6. Khaing ZZ, Cates LN, Fischedick AE, McClintic AM, Mourad PD, **Hofstetter CP.** *Temporal and Spatial Evolution of Raised Intraspinal Pressure after Traumatic Spinal Cord Injury*. J Neurotrauma. 2017; 34 (2): 645-651.
7. Khaing ZZ, Ehsanipour A, **Hofstetter CP**, Seidlits SK. *Injectable Hydrogels for Spinal Cord Repair: A Focus on Swelling and Intraspinal Pressure.* Cells Tissues Organs. 2016; 202 (1-2): 67 - 84.

8. Alimi M, Navarro-Ramirez R, Parikh K, Njoku I, **Hofstetter CP**, Tsiouris AJ, Hartl R. *Radiographic and Clinical Outcome of Silicate-substituted Calcium Phophate (Si-CaP) Ceramic Bone Graft in Spinal Fusion Procedures.* Clin Spine Surgery. 2017; 30 (6): E845-E852.
9. Alimi M, **Hofstetter CP**, Torres-Campa JM, Navarro-Ramirez R, Cong GT, Njoku I, Hartl R. *Unilateral tubular approach for bilateral lamintomy: Effect on ipsilateral and contralateral buttock and leg pain.* Eur Spine. 2017; 26 (2): 289-396.
10. Alimi M, , Njoku I, **Hofstetter CP**, Tsiouris AJ, Kesavabhotla K, Bookvar J, Navarro-Ramirez R, Hartl R. *Anterior Cervical Discectomy and Fusion (ACDF): Comparison Between Zero Profile Implants and Anterior Cervical Plate and Spacer.* Cureus. 2016; 8 (4): e573.
11. Madhavan K, Chieng LO, McGrath L, **Hofstetter CP,** Wang MY. *Early Experience with endoscopic foraminotomy in patients with moderate degenerative Deformity.* Neurosurgical focus. 2016; 40 (2): E6.
12. Madhavan K, Chieng LO, Wang MY, **Hofstetter CP,** Wang MY Transforaminal Endoscopic Discectomy to relieve sciatica and delay fusion in a 31 year-old with pars defects and low grade spondylolisthesis. Neurosurgical focus. 2016; 40 (2): E4.
13. McGrath L, Madhavan K, Chieng LO, Wang MY, **Hofstetter CP.** *Early experience with endoscopic revision of lumbar spinal fusions,* Neurosurgical focus. 2016; 40 (2): E2.
14. **Hofstetter CP**, Hofer A, Levi AD. *Explorative meta-analysis on dose-related efficacy and morbidity of bone morphogenetic protein in spinal arthrodesis surgery*. Journal o*f* Neurosurgery Spine. 2016; 24(3): 457-475.
15. **Hofstetter CP**, Alimi M, Tsiouris AJ, Elowitz E, Hartl R. *Extreme lateral interbody fusion for unilateral symptomatic vertical foraminal stenosis.* European Spine Journal. 2015; Suppl 3:346-52.
16. Alimi M, Shin BJ**,** Macielak **M, Hofstetter CP**, Njoku I, Hartl R. *Expandable Polyaryl-Ether-Ketone Spacers for Interbody Distraction in the Lumbar Spine.* Global Spine Journal. 2015; 5(3):169-67.
17. Evins AI, Banu M, Njoku I, Elowitz EH, Härtl R, **Hofstetter CP**. *Endoscopic Lumbar Foraminoplasty: A Cadaveric Study.* Journal of Clinical Neuroscience. 2015; 22(4): 730-734.
18. Alimi M, **Hofstetter CP**, Pyo SY, Paulo D, Hartl R. *Minimally invasive laminectomy for lumbar spinal stenosis in patients with and without preoperative spondylolisthesis: clinical outcome and reoperation rates. Journal of* Neurosurgery Spine. 2015; 22(4); 339-352.
19. **Hofstetter CP**, Hofer A, Wang MY. *The economic impact of minimally invasive lumbar surgery*. World Journal of Orthopedics, 2015; 6(2): 190-201.
20. Alimi M, **Hofstetter CP**, Cong GT, Tsiouris J, James AR, Paulo D, Elowitz E, Hartl R. *Radiological and clinical outcomes following extreme lateral interbody fusion.* Journal of Neurosurgery Spine. 2014; 20(6): 623-635.
21. Alimi M, Njoku I, Cong GT, Pyo SY, **Hofstetter CP**, Grunert P, Hartl R. *Minimally Invasive Foraminotomy Through Tubular Retractors Via a Contralateral Approach in Patients with Unilateral Radiculopathy.* Neurosurgery. 2014; 10 Suppl 3: 436 – 447.
22. **Hofstetter CP**, Shin BJ, Tsiouris AJ, Elowitz E, Hartl R. R*adiographic and clinical outcome after 1- and 2-level transsacral axial interbody fusion.* Journal of Neurosurgery Spine 2013; 19(4): 454-463.

23. Jakimovski D, Bonci G, Attia M, Shao H, **Hofstetter CP,** Tsiouris A, Anand V, Schwartz TH. *Incidence and significance of intraoperative CSF leak in endoscopic pituitary surgery using intrathecal fluorescein.* World Neurosurgery. 2014; 82(3-4): e513-523.

24. **Hofstetter CP**, Kesavabhotla K, Boockvar. *Zero-profile Anchored Spacer Reduces Rate of Dysphagia, Compared to ACDF With Anterior Plating.* J Spinal Disord Tech. 2015; 28(5): E284-290.

25. Mascarenhas L, Moshel YA, Bayad F, Szentirmai O, Salek A, Leng LZ, **Hofstetter CP**, Placantonakis DG, Tsiouris AJ, Anand VK, Schwartz TH. *The transplanum transtuberculum approaches for suprasellar and sellar-suprasellar lesions: Avoidance of Cererospinal fluid leak and lessons learned.* World Neurosurgery. 2014; 82(1-2):186-195.

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27. Burkhardt J, Santillan A, **Hofstetter CP,** Christos P, Berry N, Shin BJ, Foley CP, Ballon DJ, Gobin PY, Boockvar JA. *Intra-arterial Bevacizumab with blood brain barrier disruption in a glioblastoma xenograft model.* J Exp Ther Oncol. 2012; 10 (1): 31 – 7.

28. Burkhardt J, Riina H, Shin BJ, Christos P, Kesavabhotla K, **Hofstetter CP,** Tsiouris J, Boockvar JA. *Intra-Arterial Delivery of Bevacizumab after Blood Brain Barrier Disruption for the Treatment of Recurrent Glioblastoma: Progression Free Survival and Overall Survival.* World Neurosurgery. 2012; 77 (1): 130 - 4.

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33. **Hofstetter CP,** Anand VK, Schwartz TH. *Endoscopic transsphenoidal pituitary surgery*. Operative techniques in Otolaryngology-Head and Neck Surgery. 2011; 22(3): 206 – 214.

34. **Hofstetter CP**, James AR, Hartl R. *Revision strategies for AxiaLIF.* Neurosurgical Focus. 2011; October; 31(4): E17.

35. **Hofstetter CP**, Nanaszko M, Mubita L, Tsiouris J, Anand VK, Schwartz TH. *Volumetric classification of pituitary macroadenomas predicts outcome and morbidity following endoscopic endonasal transsphenoidal surgery*. Pituitary. 2012; 15(3): 450-463.

36. Burkhardt J, Riina H, Shin BJ, Moliterno JA, **Hofstetter CP,** Boockvar JA. *Intra-arterial chemotherapy for malignant gliomas: a critical analysis*. Interventional Neuroradiology 2011; 17(3): 286-295.

37. **Hofstetter CP**, Shin BJ, Mubita L, Anand VK, Boockvar JA, Schwartz TH. *Endoscopic endonasal transsphenoidal surgery for functional pituitary adenomas.* Neurosurgical focus 2011; 30 (4): E10.
38. Gürsel DB, Beyene RT, **Hofstetter CP**, Greenfield JP, Souweidane MM, Kaplitt M, Arango-Lievano M, Howard B, Boockvar JA, *Optimization of glioblastoma multiforme stem cell isolation, transfection and transduction*. Journal of Neuro-Oncology 2011; 104(2): 509-522.
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42. **Hofstetter CP**, Singh A, Anand VK, Kacker A, Schwartz TH. *The endoscopic, endonasal, transmaxillary transpterygoid approach to the pterygopalatine fossa, infratemporal fossa, petrous apex and Meckel`s cave.* Journal of Neurosurgery. 2010; 113(5): 967-974.
43. Howard BM, **Hofstetter CP**, Wagner PL, Muskin ET, Lavi L, Boockvar JA. *Transformation of a low-grade pineal parenchymal tumor to secondary pineoblastoma.* Neuropathology and Applied Neurobiology. 2009; 35(2): 214-217.
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46. Lilja J, Endo T, **Hofstetter CP**, Westman E, Young J, Olson L, Spenger C. *BOLD visualization of synaptic relay stations of sensory pathways along the neuroaxis in response to graded sensory stimulation of a limb*. J Neuroscience 2006; 26(23): 6330-6336.
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51. Lee I, Bulte J, Schweinhardt P, Douglas T, Trifunovski A, **Hofstetter CP**, Olson L, Spenger C. *In vivo magnetic resonance tracking of olfactory ensheathing glia grafted into the rat spinal cord.* Experimental Neurology 2004; 187(2): 509-516.

52. **Hofstetter CP**, Schweinhard P, Spenger C, Olson L, *Numb rats walk – a behavioral and fMRI comparison of mild and moderate spinal cord injury*. Eur J Neurosci 2003; 18(11): 3061-3068.

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BOOK CHAPTERS

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2. **Hofstetter CP,** Wang YM. *Spinal osteotomies*. AANS MOC review book. Ed: Mummaneni . Thieme Medical Publishers, Inc. In Press.
3. **Hofstetter CP,** Wang YM. *Spinal infections*. AANS MOC review book. Ed: Mummaneni . Thieme Medical Publishers, Inc. In Press.
4. **Hofstetter CP,** Wang YM. *Complications of Buttress plating multilevel anterior cervical corpectomies*. Complications of Spinal Instrumentation. Ed: Vaccaro AR, Kim D and Radcliff K. In Press.
5. **Hofstetter CP**, Moshel Y, Anand VK, Schwartz TH. *Extended endonasal, endoscopic transsphenoidal versus craniotomy for giant pituitary macroadenomas*. Endoscopic and Pituitary Surgery. Ed: Schwartz TH, Anand VK. Thieme Medical Publishers, Inc. 2012,
6. **Hofstetter CP**, Härtl R. *Surgical Use of Spinal Fusion Promoting Substances.* Fundamentals of Operative Techniques in Neurosurgery. Ed: Connolly ES, Choudhri TF, Huang J, McKhann GM, II, Komotar RJ, Mocco J. 2nd edition, Thieme 2010, 617-621.
7. Olson L, Widenfalk J, Josephson A, Greitz D, Klason T, Kiyotani T, Lipson A, Ebendal T, Cao Y, **Hofstetter, CP**, Schwartz E, Prockop D, Manson S, Jurban M, Lindqvist E, Lundströmer K, Nosrat C, Brene S, Spenger C. *Experimental spinal cord injury models: protective and repair strategies.* Tissue Engineering for Therapeutic Use 2001; 5: 21-36. Eds. Y Ikada and N. Oshima. Elsevier Science.

PUBLISHED BOOKS, VIDEOS, SOFTWARE

1. **Hofstetter CP**, Ruetten S, Zhou Y, Wang MY. Pocketatlas of Endoscopic Spine Surgery, Thieme Medical Publishers, Inc. In Press

OTHER PUBLICATIONS

1. **Hofstetter CP**, Brecker C, Wang MY. *Coccygectomy-current views and controversies.* Journal of contemporary spine surgery. Contemporary Spine Surgery. 2015; April 4.

2. **Hofstetter CP**, Wang MY. *Burst fractures.* Journal of Neurosurgery Spine. 2014; February 20.
3. **Hofstetter CP,** Wang MY. *Diagnostic and therapeutic challenges of cervical myelopathy.* World Neurosurgery. 2014; February 12.
4. **Hofstetter CP,** Wang MY. *Neurologically intact thoracolumbar burst fractures – The controversy goes MIS*. Journal of Neurosurgery Spine. 2013; December 20.
5. **Hofstetter CP**, James AR, Härtl R. *It takes two to tango: Activation of cortex and lumbosacral circuitry restores locomotion in spinal cord injury.* World Neurosurgery. 2012; Sep 5.
6. **Hofstetter CP**, Schwartz TH. *Can we ever separate the tool and the fool?* World Neurosurgery. 2011; Nov 7.
7. **Hofstetter CP**, Hartl R, Schwartz TH. *Pituitary adenomas in Nigeria-Surgical and societal challenges.* World Neurosurgery. 2011; Nov 7.
8. **Hofstetter CP**, Härtl R, *Hypothermia for traumatic brain injury.* Neurology Alert 2011; 29 (8): 57-58.
9. **Hofstetter CP**, Boockvar JA. *Generation of neural stem cells: a team approach*. Neurosurgery 2010; 67 (6): N22 – 23.
10. **Hofstetter CP**, Boockvar JA. *Tapping an abundant resource: engineering pluripotetn stem cells from blood*. Neurosurgery 2010; 67 (4): N25.
11. **Hofstetter CP**, Boockvar JA. *Neural stem cells: targeting glioma in 3-dimensions*. Neurosurgery 2010; 66 (6): N15.
12. **Hofstetter CP**, Boockvar JA. *Forcing tumor stem cells to an end*. Neurosurgery 2010; 66 (4): N17 – 18.
13. **Hofstetter CP**, Boockvar JA. *Stem cell based growth factor delivery to the injured spinal cord.* Neurosurgery 2010; 66(2): N16-17.
14. **Hofstetter CP**, Boockvar JA. *Reduction of seizures by transplantation of embryonic GABAergic interneurons into Kv1.1 mutant mice*. Neurosurgery. 2009; 65(6): N8-9.
15. **Hofstetter CP**, Boockvar JA. *Recreating Glioblastoma Multiorme in cell culture dish*. Neurosurgery. 2009; 65(1): N11.

MANUSCRIPTS SUBMITTED

1. Guest JD, **Hofstetter CP**, Ropper AE, Aimetti AA, Layer RT, Moore SW, Ulich TR, Theodore N. *Implantation of a biodegradable scaffold in the spinal cord after actute porcine contusion injury.* Manuscript submitted.
2. **Hofstetter CP**, Olson L. *Stereological assessment of corticospinal tract axons following contusion injury of the rat spinal cord.* Manuscript submitted.

ABSTRACTS

1. Clinical outcomes Following MIS vs. Endoscopic Laminectomy; 34th annual AANS/CNS Spine Section Meeting; Orlando, FL March 2018.
2. Intra- and Perioperative Complications Associated with Endoscopic Spine Surgery: A Multi-institutional Case Series; 34th annual AANS/CNS Spine Section Meeting; Orlando, FL March 2018.

3. *Contrast-enhanced ultrasound to visualize and quantify local blood flow and perfusion after traumatic spinal cord injury*; 34th annual AANS/CNS Spine Section Meeting; Orlando, FL March 2018.
4. *Transcutaneous electrical spinal stimulation: Preliminary clinical results and novel translational model;* ISNR annual meeting, Asilomar, CA; December 2017
5. *Contrast-enhanced ultrasound to visualize and quantify local blood flow and perfusion after traumatic spinal cord injury;* ISNR annual meeting, Asilomar, CA; December 2017
6. *Contrast-enhanced ultrasound to visualize and quantify local blood perfusion after traumatic spinal cord injury;* 47th annual Society for Neuroscience conference, *Washington, DC; November 2017*
7. *Surgical Decompression Relieving Intraspinal Pressure Can Limit Secondary Damage After Acute Spinal Cord Injury;* 46th annual Society for Neuroscience conference, San Diego, CA; November 2016.
8. *Biomimetic injectable 3D hydrogels with aligned topography for neural tissue engineering* 45th annual Society for Neuroscience conference, Chicago, IL; October 2015.
9. *Minimally invasive foraminotomy through tubular retractors via a contralateral approach in patients with unilateral radiculopathy;* 30th annual AANS/CNS Spine Section Meeting; Orlando, FL March 2014.
10. *Unilateral tubular approach for bilateral laminectomy: Effect on ipsilateral and contralateral buttock and leg pain;* 30th annual AANS/CNS Spine Section Meeting, Orlando, FL; March 2014.
11. *Impact of cage height, width and positioning on clinical and radiographic outcome of extreme lateral interbody fusion*; 29th annual AANS/CNS Spine Section Meeting, Phoenix, AZ; March 2013.
12. *Midterm experience with expandable PEEK spacers for interbody fusion for Degenerative Lumbar Disease;* 29th annual AANS/CNS Spine Section Meeting, Phoenix, AZ; March 2013.
13. *Volumetric classification for giant pituitary macroadenomas predicts outcome and morbidity of endoscopic endonasal transsphenoidal surgery;* NASBS, Scottsdale, AZ; February 2011.
14. *Extreme lateral interbody fusion for treatment of degenerative lumbar spondylosis;* SMISS Annual Meeting, Miami, FL; November 2010.
15. *Hypoxia induces protein phosphatase 2A enzymatic activity in glioblastoma multiforme*; 15th Annual Scientific Meeting, Society for NeuroOncology, Montreal, Canada; November 2010.
16. *High Protein Phosphatase 2A Enzymatic Activity Correlates with Poor Prognosis in Patients with GBM*; AANS Annual Meeting, Philadelphia, PA; May 2010.
17. *Genetically targeted disruption of respiratory chain dysfunction in dopamine Neurons leads to key parkinsonian pathology and symptoms in mice;* 35th Annual Meeting, Society for Neuroscience, Washington, DC; November 2005.
18. *Spontaneous recovery of sensory function following spinal cord injury assessed by fMRI*; 34th Annual Meeting, Society for Neuroscience, San Diego, CA; October 2004.
19. *Directed differentiation of adult neural stem cells improves effects of stem cell-based spinal cord injury treatment*; 34th Annual Meeting, Society for Neuroscience, San Diego, CA; October 2004.
20. *Assessment of spinal cord activation during sensory stimulation using fMRI;* 34th Annual Meeting, Society for Neuroscience, San Diego, CA; October 2004.

21. *Stereological quantification of the corticospinal tract following spinal cord injury*; 33th Annual Meeting, Society for Neuroscience, New Orleans, LA; November 2003.
22. *Regulation of small Rho-GTPases following spinal cord injury;* 33th Annual Meeting, Society for Neuroscience, New Orleans, LA; November 2003.
23. *Ethanol consumption induces cell proliferation in hippocampus*; 33th Annual Meeting, Society for Neuroscience, New Orleans, LA; November 2003
24. *Transneuronal invasion of the spinal cord by pseudorabies virus following injection into rat dorsal root ganglia*; 32th Annual Meeting, Society for Neuroscience, Orlando, FL; November 2002 .
25. *Spontaneous recovery of the sensory system after spinal cord injury; a functional MRI study*; 32th Annual meeting, Society for Neuroscience, Orlando, FL; November 2002.
26. *Grafting neurogenin-2 transfected neural stem cells to the injured spinal cord;* 32th Annual meeting, Society for Neuroscience, Orlando, FL; November 2002.
27. *Spinal cord repair strategies: the use of adult stem cells;* 2nd Annual Mesenchymal & Nonhematopoietic Stem Cell Conference, New Orleans, LA; September 2002.
28. *Marrow stromal cells form guiding strands in the injured spinal cord;* 31th Annual Meeting, Society for Neuroscience, San Diego, FL; November 2001.

INVITED LECTURES

12/2017	My path to MIS Endoscopy; Espanding the armamentarium of the complex spine surgeon; 11th New York City Minimally Invasive Spine, Spinal Endoscopy, Robotics & Navigation Symposium, Weill Cornell Medical Center, New York, NY
12/2017	Over the top MIS decompression with and without MIS transforaminal lumbar interbody fusion – Step – by – Step technique, AO spine Surgeon’s Cockpit, Davos, Switzerland
10/2017	Interlaminar lumbar stenosis decompression: Can it replace traditional laminectomy? 32st Annual Meeting, NASS, Orlando, FL
10/2017	Lumbar Decompression and Discectomy: Microscope versus Endoscope; 32st Annual Meeting, NASS, Orlando, FL
06/2017	Endoscopic Discectomy and Fusion using IntraLIF; Seattle Science Foundation, Seattle, WA
04/2017	How to Adopt Endoscopy: Training for Team & Fellows; 85th Annual Meeting, AANS, Los Angeles, CA
04/2017	The interlaminar endoscopic approach – advancing MIS; ISASS – 17th Annual Conference, Boca Raton, FL
10/2016	Pushing the Limits of Decompression with Endoscopic Spinal Surgery; Minimally Invasive Procedures to Minimize Exposure and Dissection; 31st Annual Meeting, NASS, Boston, MA
10/2016	Endoscopic Approaches to the Cervical and Lumbar spine; Minimally Invasive Lumbar Fusion Surgeries; 2017 CNSCN2016, Xi An, China
06/2016	Better Spinal Decompression Surgery using Next Generation Minimally Invasive Spine Surgery; 2016 Annual Meeting, WSANS, Cle Elum, WA

05/ 2016	Interlaminar Endoscopic approach; 84th Annual Meeting, AANS, Chicago, IL
03/2016	Explorative Meta-analysis on Dose-related Efficacy and Morbidity of Bone Morphogenetic Protein in Spinal Arthrodesis Surgery; 32st Annual Meeting, AANS/CNS Spine Section, Orlando, FL
03/2016	Early Experience with Endoscopic Revision of Lumbar Arthrodesis Constructs; 32st Annual Meeting, AANS/CNS Spine Section, Orlando, FL
03/2016	Characterization Intraspinal Pressure Following Traumatic Rodent Spinal Cord Injury; 32st Annual Meeting, AANS/CNS Spine Section, Orlando, FL
01/2016	Epidural stimulation for chronic cervical spinal cord injury; SCI Forum, UW, Seattle, WA
10/2015	*Characterization of intraspinal pressure following traumatic rodent spinal cord injury;* 45th Annual Meeting, Society for Neuroscience, Chicago, IL.
10/2015	*Pain Management following Discharge from Spine Surgery;* 30th Annual Meeting, NASS, Chicago, IL.
10/2015	*Minimally invasive TLIF;* 30th Annual Meeting, NASS, Chicago, IL.
092015	*Advances in Minimally Invasive Spine Surgery*; UW CME course, Missoula, MT
04/2014	*Extreme Lateral Interbody fusion for Unilateral Symptomatic Vertical Foraminal Stenosis;* Annual Meeting, ISASS, Miami, FL
05 2014	*Endoscopic Lumbar Foraminoplasty: A Cadaveric Study*; Annual Meeting, ISASS, Miami, FL
032014	*Endoscopic foraminal decompression;* Annual Meeting of the AANS/CNS Spine section, Orlando, FL
09/2013	*Optimizing indirect foraminal decompression by Extreme Lateral Interbody Fusion;* Annual Meeting, Florida Neurosurgical Society, Palm Beach, FL
03/2013	*Minimally invasive laminectomy through tubular retractors for lumbar spinal stenosis in patients with and without pre-operative spondylolisthesis: clinical outcome and re-operation rate;* 29th Annual Meeting, AANS/CNS Spine Section, Phoenix, AZ
12/2010	*PP2A activity protects hypoxic tumor stem cells from apoptosis;* Grand Rounds, Vienna, Austria
05/2007	*MRI-based imaging techniques: From the lab bench to neurosurgical practice*; Nobel Conference, Stockholm, Sweden
10/2004	*Directed differentiation of adult neural stem cells reduces side effects of stem cell based spinal cord injury treatment*; 34th Annual Meeting, Society for Neuroscience, San Diego, CA
01/2003	*Marrow stromal cell transplantation in spinal cord injury;* Grand Rounds, Dept. of Neurosurgery, Medical College of Wisconsin, Milwaukee, WI
12/2002	*Cell transplantation therapy in spinal cord injury;* 13th NECTAR meeting, Amsterdam, Belgium
05/2002	*Novel methods and repair strategies in spinal cord injury,* Department of Neuroscience, Uppsala University, Uppsala, Sweden

Washington State Health Care Authority

Agency medical director comments

Surgery for lumbar radiculopathy

Gary Franklin, MD, MPH
Medical Director, Department of Labor and Industries
Research Professor, University of Washington
Co-chair, WA Agency Medical Director's Group

May 18, 2018

Washington State Health Care Authority

State Agency

- Main concern over minimally invasive surgery (MID/S)
  - 9 procedures, 14 RCTs, most low-very low quality
  - Can't lump these together in a grade analysis
- Data on open procedures solid enough to cover with conditions
- Repeat surgery-only covered in limited circumstances

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Background

- The most common etiology of lumbar radiculopathy is nerve root compression caused by a **disc herniation** or **spinal stenosis**, which is, narrowing of the lateral recess, or the neural foramen due to degenerative arthritis affecting the spine
- Severity of lumbar radiculopathy
  - Pure sensory/painful radicular pattern - radicular pain and a segmental pattern of sensory dysfunction but no other neurologic deficits
  - Mild motor deficit pattern - radicular pain, sensory dysfunction, and mild nonprogressive segmental motor weakness and/or reflex change
  - Severe motor deficit pattern - radicular pain and sensory dysfunction with severe or worsening motor deficits
- For this report, NOT dealing with central stenosis/cauda equina compression

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The procedures

- The purpose of surgery for symptomatic lumbar radiculopathy is to relieve symptoms by decompressing the affected nerve
- A variety of discectomy techniques are available:
  - The open discectomy (OD) is performed with a standard surgical incision, often with the aid of eyepiece (loupe) magnification. It frequently involves a laminectomy
  - Microdiscectomy (MD) involves a smaller incision in the back, with visualization through an operating microscope, followed by a hemilaminectomy and removal of the disc fragment compressing the affected nerve or nerves.
  - Minimally invasive techniques (MID/S):
    - Nine different techniques, 14 RCTs
    - Direct visualization rarely used
    - Indirect visualization, via microscope/camera or loupe magnification

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Federal oversight of medical interventions

	Drugs	Medical devices	Surgical procedures
Required for FDA approval	2 prospective, placebo-controlled RCTs	"Substantial equivalence" to pre-existing device	No approval requirements
Study outcomes	Disease-related endpoints	Engineering performance only	None
Published studies with patient-orientated endpoints	Common	Uncommon	Not considered
Patient population	Narrowly defined set of conditions (e.g., depression, dementia)	Varies widely (e.g., implantable defibrillators, laproscopes)	Not considered
Post-marketing evaluation?	Sporadic, sometimes high quality	Rare, usually low quality	None

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Most new MID are approved based on 510k equivalence - no study required

EG., Disc-FX system-approved 12/28/2005

"We have reviewed your Section 510(k) premarket notification of intent to market the device referenced above and have determined the device is substantially equivalent (for the indications for use stated in the enclosure) to legally marketed predicate devices marketed in interstate commerce prior to May 28, 1976, the enactment date of the Medical Device Amendments, or to devices that have been reclassified in accordance with the provisions of the Federal Food, Drug, and Cosmetic Act (Act) that do not require approval of a premarket approval application (PMA). You may, therefore, market the device, subject to the general controls provisions of the Act. The general controls provisions of the Act include requirements for annual registration, listing of devices, good manufacturing practice, labeling, and prohibitions against misbranding and adulteration."

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Agency medical director concern level
MID/S vs. OD/MD

- Safety = Medium
- Efficacy = Medium-High
- Cost = High

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Current state agency policy

Description	Medicaid	PEBB/UMP	LNI
OD/MD (Laminectomy, laminotomy, discectomy, foraminotomy)	PA	PA	PA
MID/S (Endoscopic decompression procedures CPT 62380)	PA	PA	PA
MID/S (Percutaneous decompression procedures under indirect image guidance [e.g., fluoroscopic, CT] CPT 0275T)	NC	C	NC

C: Covered
NC: Not covered
PA: Prior authorization required

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Washington State Health Care Authority

Utilization: Surgical decompression procedures – Medicaid

Medicaid MCO	2015	2016	2017*
Unique Patients w/Diagnosis of Radiculopathy	320	352	256
Total Treatments w/Diagnosis of Radiculopathy	351	394	242
Treatments w/o Diagnosis	476	501	378
Total Dollars Paid by Treatments w/Diagnosis	$1,835,396	$1,779,602	$1,311,784
Average Paid Dollars/Patient w/Diagnosis	$5,754	$6,425	$3,780

Medicaid HCA	2015	2016	2017
Unique Patients w/Diagnosis	25	29	3
Total Treatments w/Diagnosis	25	28	3
Treatments w/o Diagnosis	42	37	6
Total Dollars Paid by Treatments w/Diagnosis	$110,476	$88,391	$24,329
Average Paid Dollars/Patient w/Diagnosis	$4,419	$3,048	$8,110

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Utilization: Surgical decompression procedures L&I, PEBB/UMP and PEBB/Medicare

L&I	2015	2016	2017
Unique Patients	223	231	213
Total Treatments with Diagnosis of Radiculopathy	229	240	216
Treatments w/o Diagnosis of Radiculopathy	1	1	1
Total Dollars Allowed by Treatments w/Diagnosis	$2,657,263	$3,333,749	$3,243,177
Average Dollars Allowed/Patient w/Diagnosis	$11,916	$14,431.81	$15,226.18

PEBB/UMP	2015	2016	2017
Unique Patients w/Diagnosis	76	91	79
Total Treatments w/Diagnosis	79	96	83
Treatments w/o Diagnosis	192	185	142
Total Dollars Paid by Treatments w/Diagnosis	$675,955	$943,363	$785,274
Average Paid Dollars/Patient w/Diagnosis	$8,894	$10,367	$9,940

PEBB/Medicare	2015	2016	2017
Unique Patients w/Diagnosis	73	39	39
Total Treatments w/Diagnosis	82	42	41
Treatments w/o Diagnosis	144	111	101
Total Dollars Paid by Treatments w/Diagnosis	$52,834	$35,125	$33,866
Average Paid Dollars/Patient w/Diagnosis	$724	$901	$868

Effectiveness – open surgical procedures (OD)

- 7 RCTs compared surgery to conservative management (probably most valid comparator)
  - Pain: surgery reduces pain more than conservative care for the short term (up to 26 weeks), but no difference in the long run (1-8 years)
  - Function: surgery improves function more than conservative care for the short term (up to 26 weeks), but no difference in the long run (1-8 years)
  - QoL, neurologic symptoms and return to work: either similar or improved by about the same amount.
- Quality of evidence – very low or low

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Effectiveness – open "micro" procedures (MD)

- Compared to standard procedures
  - Pain reduction: similar for both the short term (6 weeks) and the long term (26 weeks - 2 years)
  - Function improvement: similar (26 weeks – 2 years)
  - QoL: Similar (26 weeks – 2 years)
  - Return to work: similar duration of postoperative work disability (10.4 weeks for "micro" vs. 10.1 weeks for standard.
- Quality of evidence – very low or low

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Effectiveness – minimally invasive procedures (MID/S)

- Compared to standard procedures
  - Pain reduction, function improvement, QoL and neurologic symptoms improvement: similar for either the short term (up to 26 weeks) or the long term (1-2 years)
  - Return to work: reduces the duration of postoperative disability by 4-15 weeks (quality of the evidence is very low)
- Quality of evidence – very low, low or moderate
- These procedures are all quite different - cannot lump them

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Minimally invasive procedures (MID/S): Examples of troubles

Ref 36-Chatterjee et al, Spine 1995; 20: 734-38

- Automated percutaneous lumbar discectomy (APLD) vs. microdiscectomy (MD) for small contained discs (no clinical criteria)
- Randomized, independent assessment of outcome-Macnab outcome classification
- APLD-9/31 (29%) satisfactory outcome (MID/S)
- Micro-32/40 (80%) satisfactory outcome (MD)
- 20/22 APLD with unsatisfactory outcome opted for another surgery
- Trial stopped early due to poor outcomes
- UK = Public funded, well designed trial

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Ref 37: Brouwer et al, Spine Journal 2015; 15: 857-865.

- Percutaneous laser disc decompression (MID/S) vs. microdiscectomy (MD)
- RCT with non-inferiority design, no blinding
  - N=115 with sciatica and disc herniation
- Public funding-Healthcare Insurance Board
  - Netherlands academic institutions
- Outcomes: Roland-Morris (primary) and VAS
  - Roland-Morris non-inferior at 8 and 52 weeks
- Speedier recovery in conventional surgery
- Reoperations percutaneous (38%) vs. conventional (16%)

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Cochrane review (2014): Minimally invasive (MID/S) vs. micro/open discectomy (OD/MD)

- Cochrane Database system Rev 2014
  - *Not included in RTI-UNC report
- Eleven studies; 7/11 had high risk of bias
- MID/S: Higher risk of re-hospitalization due to recurrent disc herniation, increased dural tears and slightly worse pain outcomes

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5-year follow-up of the best MID/S study (Arts, JAMA)

*Not included in RTI-UNC report

- Tubular discectomy (MID/S) vs. conventional microdiscectomy (MD)
- No clinically significant differences in main clinical outcomes (RMDQ-Sciatica, VAS) at any point during 5 yrs f/u (63%)-mean functional outcome difference of 0.9 favoring conventional microdiscectomy NS
- Reop rate 18% tubular discectomy vs. 13% microdiscectomy (p=0.29)
  - Total reops 39 Tubular vs. 23 Micro (p=0.10)
  - 6 patients in tubular group ended up with instrumented fusion vs. none in conventional microdiscectomy (p=0.03)

Overdevest GM et al. J Neurol Neurosurg Paychiat 2017; 88: 1008-16.

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RTW outcomes with MID/S

Ref 26-Thome, 2005-sequestrectomy vs. microdiscectomy; COI not reported

- N=84; outcome 4-6 mos and 12-18 mos; No clinical criteria for entry
- Prolo score-combination of pain interference and capacity for RTW-1 (poor) 5(excellent) x2=total score 2-10-N/S difference at 4-6 months; and SF-36 physical function-N/S

Ref 41-Hermantin, 1999-video assisted arthroscopic microdiscectomy (O/P) vs. open discectomy (hospitalized); stated COI

- Study conducted in surgeon's office N=60; litigation and workers' comp cases excluded
- Outcomes all patient self-report
- Mean duration of time lost from work or until resumption of normal activities 49 days vs. 27 days; no tests of significance done
- Overall outcomes excellent in both groups (93-97%)

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Ref 29: Ruetten et al, 2008

- German study, no COI
- N=200, randomized to endoscopic (MID/S) vs. conventional microsurgical discectomy (MD)
- Outcomes from patient instruments (VAS, NASS, Oswestry)
  - Exam at baseline (day 1) and at 3, 6, 12, and 24 months. Outcome examiners not involved in surgery but can't tell if blinded.
- 3 reops, 3 fusions not included in f/u
- Reop rates N/S (6.6% End vs. 5.7% micro)
  - 2 Endo patients had 2nd reop
- Mean post-op work disability less in endo group (25 days) vs. micro group (49 days, p<0.01)
  - Can't tell what proportion of patients had pre-op OR post-op disability-no methods presented

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Ref 32: Mayer, 1993

- N = 40; "preliminary results"; RCT; COI not available
- Endoscopic microdiscectomy vs. microsurgical discectomy
- 2-year f/u
- Equivalent clinical outcomes
- 95% of endo vs. 72.2% of micro had returned to previous occupation
  - No methods available
  - Not primary outcome

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Effectiveness – repeat surgery

- Almost nothing on this

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Worse surgical outcomes in workers compensation*

Association between compensation status and unsatisfactory outcome

Procedure	# Studies	OR (95% CI)
Shoulder acromioplasty	13	4.48 (2.71-7.40)
Lumbar spine fusion	19	4.33(2.81-6.62)
Lumbar spine discectomy	**24**	**4.77 (3.51-6.50)**
Carpal tunnel decompression	10	4.24 (2.43-7.40)

Harris et al, Association between compensation status and outcome after surgery. A Meta-analysis. JAMA 2005; 293: 1644-52.

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Safety – Surgery

- Surgical morbidity (SPORT trial)
  - Dural tear or spinal fluid leaks – 4.0%
  - Superficial postoperative wound infection – 1.6%
  - Vascular injury – 0.4%
  - Other intraoperative complications – 0.81%
  - Other unspecified postoperative complications (microdiscectomy) – 3.6%
- Reoperation rate (0% - 10%)
- Compared to nonsurgical interventions
  - All-cause mortality: no difference
  - Persistent opioid use: no difference
- Post-laminectomy syndrome, failed back surgery syndrome: **epidural scarring of unknown prevalence**

Reoperations

Martin et al (Spine Journal 2012; 12: 89-97) population-based study using WA state hospital discharge data

- Hospital reoperation rates:
  - 90 days - 1.9% (1.1-3.4%)
  - 1 yr - 6.4% (2.8-12.5%)
  - 4 yrs - 13.8% (8.1-24.5%)
- Variation of reop rates was greater for surgeons than across hospitals

Safety – Minimally invasive vs. standard surgery

- Questions about higher re-op rates in MID/S
- Quality of evidence: very low or low

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Cost-effectiveness

- Surgery may be cost-effective depending on a decision-makers willingness to pay threshold
- The evidence on cost-effectiveness for MID/S compared to standard approaches (OD/MD) is inconclusive and methodologically inconsistent
- Microdiscectomy (MD) and discectomy (OD) are comparable with respect to efficacy and safety, but microdiscectomy costs may be higher
  - Patient presentation may influence surgical decision

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Sample private payers' policies

(From the evidence report)

Procedure	Medicare	Premera	Regence	Cigna	United	Aetna	Humana	Kaiser
OD/MD (Laminectomy, laminotomy, discectomy, foraminotomy)	—	✓[a]	—	—	—	✓[a]	✓[a]	—
MID/S Automated percutaneous lumbar disc decompression	✕[b]	✕	✕	✕	✕	✓[c]	✕	—
MID/S (Percutaneous) endoscopic discectomy	✕	✕	✕	✕	✕		No additional reimburse ment.	—
MID/S (Percutaneous) laser discectomy	✕	✕	✕	✕	✕	No additional reimburse ment.	✕	—
MID/S Percutaneous nucleoplasty with coablation technology	✕	✕	✕	✕	✕		—	—

Spine SCOAP outcomes after spine surgery

- N=1965 spine surgery candidates with baseline and at least one follow up interview; 80.6% with elective fusion
- Overall 306/528 (58%) improved in Oswestry by at least 15/100 points at 12 months among those with moderate/severe symptoms
- Odds of functional improvement if:
  - Workers comp 0.20 p<.001
  - Current smoker 0.43 p<.01
- Odds of NRS back pain improvement if:
  - Rx opiate use 0.65 p<.65

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State agency recommendation

- OD/MD (Lumbar laminectomy, laminotomy, discectomy, foraminotomy) are covered with conditions
  - Adult patients with lumbar radiculopathy with subjective and objective neurologic findings that are corroborated with an advanced imaging test (CT scan, MRI or myelogram)
  - Failure to improve with minimal four weeks of non-surgical care
    - Unless progressive motor weakness is present
- MID/S (APLD, Percutaneous laser, endoscopic, nucleoplasty, etc)- Not covered
  - Concern on higher cost, low quality data and substantial questions about greater re-operation rate

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State agency recommendation

- Re-operation - covered with conditions
  - Only for recurrent symptoms that occur after a period of clinically meaningful improvement in pain and function lasting at least 6 months, and clear cut evidence of a recurrent disc herniation
  - If a recurrent or residual HNP, seen on a postpoperative MRI, is equal in size or larger than the original HNP, earlier surgical intervention may be required (6 weeks as opposed to 6 months would be reasonable)
  - Absence of co-morbidities that could explain lack of improvement, such as smokers, opioids, workers compensation

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Questions?

More Information:

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www.hca.wa.gov/about-hca/health-technology-assessment/surgery-for-symptomatic-lumbar-radiculopathy

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Spine SCOAP outcomes after spine surgery

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- Odds of NRS back pain improvement if:
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CURRICULUM VITAE
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PERSONAL DATA

Place of Birth:	St. Pölten, Austria
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Date of Birth:	02/27/1977

EDUCATION

09/95 to 01/05	M.D., University of Vienna, Vienna, Austria
09/00 to 05/05	Ph.D., Karolinska Institute, Stockholm, Sweden

POSTGRADUATE TRAINING

07/05 to 06/06	Pre-Residency Fellowship, Mayo Clinic, Rochster, MN
07/05 to 06/06	Internship, Weill Cornell Medical College, New York, NY
07/06 to 06/13	Neurosurgery Residency, Weill Cornell Medical College, New York, NY
07/13 to 06/14	Complex spine fellowship, University of Miami, Miami, FL

FACULTY POSITIONS

09/14-present	Assistant Professor, Department of Neurological Surgery, University of Washington, Seattle WA

HOSPITAL APPOINTMENTS

06/14 to 08/14	Locum tenant, San Juan Regional Medical Center, Farmington, NM
06/14-present	Director of Spine surgery, University of Washington Medical Center, Department of Neurological Surgery, Seattle, WA
06/14-present	Neurosurgeon, Harborview Medical Center, Department of Neurological Surgery Seattle, WA

HONORS

2012	Distinguished Housestaff Award, NewYork-Presbyterian Hospital, NY
2010	Research Fellowship, Neurosurgical Research Educational Fund
2010	Andlinger Residency Exchange Fellowship, Austrian-American Foundation
2006	Chorafas Prize for Best Doctoral Thesis, Karolinska Institute, Sweden
2002	Karolinska Institute Travel Grant, Stockholm, Sweden
2002	Golges Grant, Stockholm, Sweden
2000	Siegfried Ludwig Educational Grant, St. Pölten, Austria
1999	Erasmus Grant, University of Vienna, Vienna, Austria

1995	First Place, Eighth Annual Russian Olympiad, Moscow, Russia

BOARD CERTIFICATION

2017-present	American Board of Neurological Surgery

MEDICAL LICENSURE

2014-present	Washington (MD60464459)
2014 to 2017	New Mexico (MD2014-0310)
2013 to 2015	Florida (ME116257)
2009 to 2015	New York State (255163)

PROFESSIONAL ORGANIZATIONS

2014– present	AANS/CNS Section on Disorders of the Spine and Peripheral Nerves, Member
2014– present	North America Spine Society (NASS), Member
2007– present	International Society for the Advancement of Spine Surgery (ISASS), Member
2007– present	Congress of Neurological Surgeons, Member
2001– present	American Association of Neurological Surgeons, Member
2001– present	Society for Neuroscience, Member

TEACHING RESPONSIBILITIES

2014-present	Teaching residents surgical and medical management of patients with neurosurgical ailments.

Recent CME Courses taught:

04/2018	Instructor: Endoscopic spinal Surgery, Global spine congress, Singapore
04/2018	Course Co-chair: Advanced endoscopic course, Irvin, CA
01/2018	Course Co-chair: Advanced endoscopic course, Irvin, CA
12/2018	Instructor: Surgeon's Cockpit: Training of MISS AO spine, Davos, Switzerland
12/2018	Instructor: Endoscopic spinal Surgery, 11th New York City Minimally Invasive Spine, Spinal Endoscopy, Robotics & Navigation Symposium, Weill Cornell Medical Center, New York, NY
10/2017	Endoscopic TLIF Lab course, Boston, MA
10/2017	Endoscopic TLIF Lab course, Boston, MA
09/2017	Advanced Endoscopic spine surgery course, Salzburg, Austria
07/2017	Mazor and O-arm course, California

07/2017	Course Co-chair: Advanced endoscopic course, Irvin, CA
07/2017	Course Co-chair: Advanced endoscopic course, Irvin CA
06/2017	Course Co-chair: Advanced endoscopic spinal Surgery Axis Research, Irvine, CA
05/2017	Instructor: Endoscopic spinal Surgery, NeuroSpine Symposium, Houston Methodist Hospital, Houston, TX
06/2017	Instructor: Advanced MIS Techniques Seattle Science Foundation, Seattle, WA
05/2017	Instructor: Endoscopic spinal Surgery NeuroSpine Symposium, Houston Methodist Hospital, Houston, TX
03/2017	Instructor: Endoscopic spinal Surgery Surgical Innovations Lab, Weill Cornell Medical Center, New York, NY
2014–present	Course chairman and Instructor, Minimally Invasive Spine Surgery Hands-on Course 29th and 30th annual NASS meeting.
07/2016	Instructor: Endoscopic interlaminar spinal Surgery Surgical Innovations Lab, Las Vegas, NV
05/2016	Instructor: Endoscopic Lumbar spinal Surgery 85th annual AANS meeting, Chicago, IL
2012 – 2013	Instructor, Endoscopic Spine Workshops Surgical Innovations Lab, Weill Cornell Medical Center, New York, NY
09/2011	Lecturer, Neurosurgery, Spine, and Neurotrauma Open Medical Institute, Salzburg, Austria
2000 – 2005	Head Teaching Assistant Department of Anatomy, Karolinska Institute, Stockholm, Sweden
1997 – 1999	Head Teaching Assistant Department of Anatomy, University of Vienna, Vienna, Austria

List trainees taught during last five years,

Zin Khaing, Ph.D., Rachel Bakemore, Thank Tuong, Selena Muong, Brian Kim, Michael Cruz, Jeffrey Hyde, Dane DeWees, Fatma Inanici, M.D., Zeinab Birjandian, M.D., Anna Marie Yanny, Lynn McGrath, M.D., Ashley Gaing, Kayla Shade, Brian Kim, Aubrey Sonnenfeld, Anna-Sophie Hofer, M.D.

EDITORIAL RESPONSIBILITIES

2015-present World Neurosurgery, Reviewer

2016-present International Journal of Spine Surgery, Reviewer

SPECIAL NATIONAL RESPONSIBILITIES

2015-present NASS, Member of the scientific committee

2016-present AANS/CNS Section on Disorders of the Spine and Peripheral Nerves, Member of the scientific committee

RESEARCH FUNDING, PAST AND CURRENT

Craig Neilsen Foundation (PI: Hofstetter) 07/31/18 – 07/30/20
Ultrafast contrast-enhanced ultrasound to measure local blood flow after SCI
The primary goal of this project is to develop ultrafast contrast-enhanced ultrasound to identify tissue in vicinity of a spinal cord lesion at risk for secondary-injury

WACIC, Washington State Spinal Cord Injury Consortium (PI: Hofstetter) 11/01/17-06/30/19
Contrast enhanced-ultrasound to identify potentially viable tissue within the penumbra of human spinal cord injury
The primary aim of this project was to collect contrast enhanced-ultrasound data characterizing the potentially salvageable penumbra of traumatic spinal cord injuries.

WACIC, Washington Spinal Cord Injury Consortium (PI: Moritz) 11/13/17-06/30/19
Transcutaneous spinal stimulation to improve hand & arm function for people with chronic cervical spinal cord injury
We perform a clinical trial of transcutaneous electrical stimulation in patients with chronic cervical spinal cord injury aiming to improve upper extremity function.
Role: Co-Investigator

WACIC, Washington Spinal Cord Injury Consortium (PI: Perlmutter) 11/13/17-06/30/19
Therapeutic Transcutaneous Spinal Stimulation for Improved Recovery after Cervical Spinal Cord Injury in the Rat
Development of translational rodent model for transcutaneous to reproduce the extremely favorable results we have seen in our clinical trial with cervical spinal cord stimulation.
Role: Co-Investigator

University of Washington Royalty Research Fund (PI: Hofstetter) 6/1/2016 – 5/31/2017
Ultrasound-based assessment of spinal perfusion following traumatic spinal cord injury
The primary aim of this project is to determine the contribution of elevated intraspinal pressure towards hypoperfusion of the acutely injured spinal cord

University of Washington Royalty Research Fund (PI: Hofstetter) 6/1/2016 – 5/31/2017
Ultrasound-based assessment of spinal perfusion following traumatic spinal cord injury
The primary aim of this project is to determine the contribution of elevated intraspinal pressure towards hypoperfusion of the acutely injured spinal cord.

University of Washington Institute of Translational Health Sciences (PI: Hofstetter) 6/1/2016 – 5/31/2017
Immunomodulatory 3D scaffold to promote neuronal regeneration after spinal cord injury
The primary aim of this project is to develop novel scaffolds alter the phenotypes of local macrophages and herby reduce local scar formation and promote tissue regeneration.

University of Washington Institute of Translational Health Sciences (PI: Perlmutter) 6/1/2015 - 5/31/2016
Role: Co-investigator
An NHP Model for Cervical Myelopathy and Therapeutic Use of Electrical Stimulation.
The primary aim of this project is to establish a primate model of cervical myelopathy using a chronic compression device.

BIBLIOGRAPHY

PEER REVIEWED JOURNAL ARTICLES

1. Birjandian Z, Emerson S, Telfeian AE, **Hofstetter CP**. *Interlaminar endoscopic lateral recess decompression – surgical technique and early clinical results.* Journal of Spine Surgery. 2017; 3 (2): 123-132.
2. Telfeian AE, Punsoni ME, Klinge PE, Gokaslan ZE, **Hofstetter CP**. *Minimally-Invasive Endoscopic Spinal Cord Untethering: Case Report.* Journal of Spine Surgery. 2017; 3 (2): 278-282.
3. Krok G, Telfeian AE, Wagner R, **Hofstetter CP**, Iprenburg M. *Contralateral facet-sparing sublaminar endoscopic foraminotomy for the treatment of lumbar lateral recess stenosis: technical note.* Journal of Spine Surgery. 2017; 3 (2): 260-266.
4. Ruzevick JJ, Wagner T, Chen E, **Hofstetter CP**. *Periprostetic Osteolysis After 2 Level Cervical Disc Arthroplasty Featuring Artificial Nucleus.* Jacobs Journal of Spine. 2017; 1 (1).
5. Alimi M, Navarro-Ramirez R, Perrech M, Berlin C, **Hofstetter CP**, Moriguchi Y, Elowitz E, Hartl R. *The impact of Cage Dimensions, Positioning, and Side of Approach in Extreme Lateral Interbody Fusion.* Clin Spine Surgery. 2017; E2380.
6. Khaing ZZ, Cates LN, Fischedick AE, McClintic AM, Mourad PD, **Hofstetter CP.** *Temporal and Spatial Evolution of Raised Intraspinal Pressure after Traumatic Spinal Cord Injury*. J Neurotrauma. 2017; 34 (2): 645-651.
7. Khaing ZZ, Ehsanipour A, **Hofstetter CP**, Seidlits SK. *Injectable Hydrogels for Spinal Cord Repair: A Focus on Swelling and Intraspinal Pressure.* Cells Tissues Organs. 2016; 202 (1-2): 67 - 84.

8. Alimi M, Navarro-Ramirez R, Parikh K, Njoku I, **Hofstetter CP**, Tsiouris AJ, Hartl R. *Radiographic and Clinical Outcome of Silicate-substituted Calcium Phophate (Si-CaP) Ceramic Bone Graft in Spinal Fusion Procedures.* Clin Spine Surgery. 2017; 30 (6): E845-E852.

9. Alimi M, **Hofstetter CP**, Torres-Campa JM, Navarro-Ramirez R, Cong GT, Njoku I, Hartl R. *Unilateral tubular approach for bilateral lamintomy: Effect on ipsilateral and contralateral buttock and leg pain.* Eur Spine. 2017; 26 (2): 289-396.

10. Alimi M, , Njoku I, **Hofstetter CP**, Tsiouris AJ, Kesavabhotla K, Bookvar J, Navarro-Ramirez R, Hartl R. *Anterior Cervical Discectomy and Fusion (ACDF): Comparison Between Zero Profile Implants and Anterior Cervical Plate and Spacer.* Cureus. 2016; 8 (4): e573.

11. Madhavan K, Chieng LO, McGrath L, **Hofstetter CP,** Wang MY. *Early Experience with endoscopic foraminotomy in patients with moderate degenerative Deformity.* Neurosurgical focus. 2016; 40 (2): E6.

12. Madhavan K, Chieng LO, Wang MY*,* **Hofstetter CP,** Wang MY Transforaminal Endoscopic Discectomy to relieve sciatica and delay fusion in a 31 year-old with pars defects and low grade spondylolisthesis. Neurosurgical focus. 2016; 40 (2): E4.

13. McGrath L, Madhavan K, Chieng LO, Wang MY*,* **Hofstetter CP.** *Early experience with endoscopic revision of lumbar spinal fusions,* Neurosurgical focus. 2016; 40 (2): E2.

14. **Hofstetter CP**, Hofer A, Levi AD*. Explorative meta-analysis on dose-related efficacy and morbidity of bone morphogenetic protein in spinal arthrodesis surgery*. Journal o*f* Neurosurgery Spine. 2016; 24(3): 457-475.

15. **Hofstetter CP**, Alimi M, Tsiouris AJ, Elowitz E, Hartl R. *Extreme lateral interbody fusion for unilateral symptomatic vertical foraminal stenosis.* European Spine Journal. 2015; Suppl 3:346-52.

16. Alimi M, Shin BJ**,** Macielak **M, Hofstetter CP**, Njoku I, Hartl R. *Expandable Polyaryl-Ether-Ketone Spacers for Interbody Distraction in the Lumbar Spine.* Global Spine Journal. 2015; 5(3):169-67.

17. Evins AI, Banu M, Njoku I, Elowitz EH, Härtl R, **Hofstetter CP**. *Endoscopic Lumbar Foraminoplasty: A Cadaveric Study.* Journal of Clinical Neuroscience. 2015; 22(4): 730-734.

18. Alimi M, **Hofstetter CP**, Pyo SY, Paulo D, Hartl R. *Minimally invasive laminectomy for lumbar spinal stenosis in patients with and without preoperative spondylolisthesis: clinical outcome and reoperation rates. Journal of* Neurosurgery Spine. 2015; 22(4); 339-352.

19. **Hofstetter CP**, Hofer A, Wang MY. *The economic impact of minimally invasive lumbar surgery*. World Journal of Orthopedics, 2015; 6(2): 190-201.

20. Alimi M, **Hofstetter CP**, Cong GT, Tsiouris J, James AR, Paulo D, Elowitz E, Hartl R. *Radiological and clinical outcomes following extreme lateral interbody fusion.* Journal of Neurosurgery Spine. 2014; 20(6): 623-635.

21. Alimi M, Njoku I, Cong GT, Pyo SY, **Hofstetter CP**, Grunert P, Hartl R. *Minimally Invasive Foraminotomy Through Tubular Retractors Via a Contralateral Approach in Patients with Unilateral Radiculopathy.* Neurosurgery. 2014; 10 Suppl 3: 436 – 447.

22. **Hofstetter CP**, Shin BJ, Tsiouris AJ, Elowitz E, Hartl R. R*adiographic and clinical outcome after 1- and 2-level transsacral axial interbody fusion.* Journal of Neurosurgery Spine 2013; 19(4): 454-463.

23. Jakimovski D, Bonci G, Attia M, Shao H, **Hofstetter CP,** Tsiouris A, Anand V, Schwartz TH. *Incidence and significance of intraoperative CSF leak in endoscopic pituitary surgery using intrathecal fluorescein.* World Neurosurgery. 2014; 82(3-4): e513-523.

24. **Hofstetter CP**, Kesavabhotla K, Boockvar. *Zero-profile Anchored Spacer Reduces Rate of Dysphagia, Compared to ACDF With Anterior Plating.* J Spinal Disord Tech. 2015; 28(5): E284-290.

25. Mascarenhas L, Moshel YA, Bayad F, Szentirmai O, Salek A, Leng LZ, **Hofstetter CP**, Placantonakis DG, Tsiouris AJ, Anand VK, Schwartz TH. *The transplanum transtuberculum approaches for suprasellar and sellar-suprasellar lesions: Avoidance of Cererospinal fluid leak and lessons learned.* World Neurosurgery. 2014; 82(1-2):186-195.

26. Burkhardt J, **Hofstetter CP,** Santillan A, Shin BJ, Foley CP, Ballon Dj, Gobin P and Boockvar JA. *Orthotopic Glioblastoma Stem-like Cell Xenograft Model to Evaluate Intra-arterial Delivery of Bevacizumab: From Bedside to Bench.* Journal of Clinical Neuroscience. 2012; 19 (11): 1568 - 1572.

27. Burkhardt J, Santillan A, **Hofstetter CP,** Christos P, Berry N, Shin BJ, Foley CP, Ballon DJ, Gobin PY, Boockvar JA. *Intra-arterial Bevacizumab with blood brain barrier disruption in a glioblastoma xenograft model.* J Exp Ther Oncol. 2012; 10 (1): 31 – 7.

28. Burkhardt J, Riina H, Shin BJ, Christos P, Kesavabhotla K, **Hofstetter CP,** Tsiouris J, Boockvar JA. *Intra-Arterial Delivery of Bevacizumab after Blood Brain Barrier Disruption for the Treatment of Recurrent Glioblastoma: Progression Free Survival and Overall Survival.* World Neurosurgery. 2012; 77 (1): 130 - 4.

29. Miller JP, Yeh N, **Hofstetter CP**, Keskin D, Goldstein AS, Koff A. *P27kip1 levels reflect a nexus of oncogenic signaling during cell transformation.* J Biol Chem. 2012; 287 (24): 19775 - 85.

30. Nagineni V, James AR, Alimi M**, Hofstetter CP**, Shin BJ, Tsiouris AP, Hartl R. *Silicate-substitute Calcium Phosphate Ceramic Bone Graft Replacement for Spinal Fusion Procedures*. Spine. 2012; 37(20): E1264-1272.

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32. Rivadeneira DE, Lee SW, Ng PC, Hartl R**, Hofstetter CP**. *Best Practices in Prevention, Detection and Treatment of Colorectal Perforations During Axial Lumbar Interbody Fusion.* Techniques in Orthopaedics. 2012; 27(3): 209-217.

33. **Hofstetter CP,** Anand VK, Schwartz TH. *Endoscopic transsphenoidal pituitary surgery*. Operative techniques in Otolaryngology-Head and Neck Surgery. 2011; 22(3): 206 – 214.

34. **Hofstetter CP**, James AR, Hartl R. *Revision strategies for AxiaLIF.* Neurosurgical Focus. 2011; October; 31(4): E17.

35. **Hofstetter CP**, Nanaszko M, Mubita L, Tsiouris J, Anand VK, Schwartz TH. *Volumetric classification of pituitary macroadenomas predicts outcome and morbidity following endoscopic endonasal transsphenoidal surgery*. Pituitary. 2012; 15(3): 450-463.

36. Burkhardt J, Riina H, Shin BJ, Moliterno JA, **Hofstetter CP,** Boockvar JA. *Intra-arterial chemotherapy for malignant gliomas: a critical analysis*. Interventional Neuroradiology 2011; 17(3): 286-295.

37. **Hofstetter CP**, Shin BJ, Mubita L, Anand VK, Boockvar JA, Schwartz TH. *Endoscopic endonasal transsphenoidal surgery for functional pituitary adenomas.* Neurosurgical focus 2011; 30 (4): E10.
38. Gürsel DB, Beyene RT, **Hofstetter CP**, Greenfield JP, Souweidane MM, Kaplitt M, Arango-Lievano M, Howard B, Boockvar JA, *Optimization of glioblastoma multiforme stem cell isolation, transfection and transduction*. Journal of Neuro-Oncology 2011; 104(2): 509-522.
39. **Hofstetter CP**, Mannah RM, Mubita L, Anand VK, Kennedy JW, Dehdashti AR, Schwartz TH. *Endoscopic endonasal transsphenoidal surgery for growth hormone-secreting pituitary adenomas.* Journal of Neurosurgery Focus 2010; 29(4) : E6.
40. Boockvar JA, Tsiouris AJ, **Hofstetter CP**, Kesavabhotia K, Seedial SM, Mubita L, Pannula S, Schwartz T, Stieg P, Greenfield J, Zimmerman R, Knopman J, Scheff RJ, Lavi E, Riina HA, *Safety and Efficacy of superselective intraarterial cerebral infusion of bevacizumab after osmotic blood brain barrier disruption for recurrent malignant glioma*. Journal of Neurosurgery 2010; 114 (3): 624 – 632.
41. **Hofstetter CP**, Chou D, Newman CB, Aryan HE, Girardi F, Härtl R, *Posterior approach for thoracolumbar corpectomies with expandable cage placement and cirumferential arthrodesis. A multicenter case series of 67 patients.* Journal of Neurosurgery Spine 2011; 14 (3): 388 – 397.
42. **Hofstetter CP**, Singh A, Anand VK, Kacker A, Schwartz TH. *The endoscopic, endonasal, transmaxillary transpterygoid approach to the pterygopalatine fossa, infratemporal fossa, petrous apex and Meckel`s cave.* Journal of Neurosurgery. 2010; 113(5): 967-974.
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44. Ekstrand MI, Terzioglu M, Galter D, Zhu S, **Hofstetter CP**, Lindqvist E, Thams S, Bergstrand A, Hansson FS, Trifunovic A, Hoffer B, Cullheim S, Mohammed AH, Olson L, Larsson NG. *Progressive parkinsonism in mice with respiratory-chain-deficient dopamine neurons.* Proc Natl Acad Sci USA. 2007; 104: 1325-1330.
45. Brumovsky PR, **Hofstetter CP**, Olson L, Villar M, Hökfelt T. *Several populations of Y1R-positive neurons in the dorsal horn and area X of the rat spinal cord*. Neuroscience 2006; 138(4): 1361-1376.
46. Lilja J, Endo T, **Hofstetter CP**, Westman E, Young J, Olson L, Spenger C. *BOLD visualization of synaptic relay stations of sensory pathways along the neuroaxis in response to graded sensory stimulation of a limb*. J Neuroscience 2006; 26(23): 6330-6336.
47. **Hofstetter CP**, Holmström N, Lilja J, Schweinhardt P, Hao JX, Spenger C, Wiesenfeld-Hallin Z, Kurpad SN, Frisen J, Olson L. *Induction of allodynia limits usefulness of neural stem cells in spinal cord injury; directed differentiation improves outcome.* Nature Neuroscience 2005; 8(13): 236-253.
48. **Hofstetter CP**, Card PJ, Olson L. *A spinal pathway connecting primary afferents to the segmental sympathetic outflow system*. Experimental Neurology. 2005; 194(1): 128-138.
49. Erschbamer M, **Hofstetter CP**, Olson L. *RhoA, RhoB, RhoC, Rac1, Cdc42, and Tc10 mRNA levels in spinal cord, sensory ganglia, and corticospinal tract neurons and long-lasting specific changes following spinal cord injury*. Journal of Comparative Neurology 2005; 484(2): 224-233.
50. Åberg E, **Hofstetter CP**, Olson L, Brene S. *Moderate ethanol consumption in adult mice increases hippocampal cell proliferation and neurogenesis in adult mouse*. International J of Neuropsychopharmacology 2005; 8: 1-11.

51. Lee I, Bulte J, Schweinhardt P, Douglas T, Trifunovski A, **Hofstetter CP**, Olson L, Spenger C. *In vivo magnetic resonance tracking of olfactory ensheathing glia grafted into the rat spinal cord.* Experimental Neurology 2004; 187(2): 509-516.

52. **Hofstetter CP**, Schweinhard P, Spenger C, Olson L, *Numb rats walk – a behavioral and fMRI comparison of mild and moderate spinal cord injury*. Eur J Neurosci 2003; 18(11): 3061-3068.

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BOOK CHAPTERS

1. Young CC, Chiarelli PA, **Hofstetter CP.** *Injuries to the cervical spine*. Principles Neurological Surgery 4th. Ed: Ellenbogen . ElSEVIER. In Press.
2. **Hofstetter CP,** Wang YM. *Spinal osteotomies*. AANS MOC review book. Ed: Mummaneni . Thieme Medical Publishers, Inc. In Press.
3. **Hofstetter CP,** Wang YM. *Spinal infections*. AANS MOC review book. Ed: Mummaneni . Thieme Medical Publishers, Inc. In Press.
4. **Hofstetter CP,** Wang YM. *Complications of Buttress plating multilevel anterior cervical corpectomies*. Complications of Spinal Instrumentation. Ed: Vaccaro AR, Kim D and Radcliff K. In Press.
5. **Hofstetter CP**, Moshel Y, Anand VK, Schwartz TH. *Extended endonasal, endoscopic transsphenoidal versus craniotomy for giant pituitary macroadenomas*. Endoscopic and Pituitary Surgery. Ed: Schwartz TH, Anand VK. Thieme Medical Publishers, Inc. 2012,
6. **Hofstetter CP**, Härtl R. *Surgical Use of Spinal Fusion Promoting Substances.* Fundamentals of Operative Techniques in Neurosurgery. Ed: Connolly ES, Choudhri TF, Huang J, McKhann GM, II, Komotar RJ, Mocco J. 2nd edition, Thieme 2010, 617-621.
7. Olson L, Widenfalk J, Josephson A, Greitz D, Klason T, Kiyotani T, Lipson A, Ebendal T, Cao Y, **Hofstetter, CP**, Schwartz E, Prockop D, Manson S, Jurban M, Lindqvist E, Lundströmer K, Nosrat C, Brene S, Spenger C. *Experimental spinal cord injury models: protective and repair strategies.* Tissue Engineering for Therapeutic Use 2001; 5: 21-36. Eds. Y Ikada and N. Oshima. Elsevier Science.

PUBLISHED BOOKS, VIDEOS, SOFTWARE

1. **Hofstetter CP**, Ruetten S, Zhou Y, Wang MY. Pocketatlas of Endoscopic Spine Surgery, Thieme Medical Publishers, Inc. In Press

OTHER PUBLICATIONS

1. **Hofstetter CP**, Brecker C, Wang MY. *Coccygectomy-current views and controversies.* Journal of contemporary spine surgery. Contemporary Spine Surgery. 2015; April 4.

2. **Hofstetter CP**, Wang MY. *Burst fractures.* Journal of Neurosurgery Spine. 2014; February 20.
3. **Hofstetter CP,** Wang MY. *Diagnostic and therapeutic challenges of cervical myelopathy.* World Neurosurgery. 2014; February 12.
4. **Hofstetter CP,** Wang MY. *Neurologically intact thoracolumbar burst fractures – The controversy goes MIS*. Journal of Neurosurgery Spine. 2013; December 20.
5. **Hofstetter CP**, James AR, Härtl R. *It takes two to tango: Activation of cortex and lumbosacral circuitry restores locomotion in spinal cord injury.* World Neurosurgery. 2012; Sep 5.
6. **Hofstetter CP**, Schwartz TH. *Can we ever separate the tool and the fool?* World Neurosurgery. 2011; Nov 7.
7. **Hofstetter CP**, Hartl R, Schwartz TH. *Pituitary adenomas in Nigeria-Surgical and societal challenges.* World Neurosurgery. 2011; Nov 7.
8. **Hofstetter CP**, Härtl R, *Hypothermia for traumatic brain injury.* Neurology Alert 2011; 29 (8): 57-58.
9. **Hofstetter CP**, Boockvar JA. *Generation of neural stem cells: a team approach*. Neurosurgery 2010; 67 (6): N22 – 23.
10. **Hofstetter CP**, Boockvar JA. *Tapping an abundant resource: engineering pluripotetn stem cells from blood*. Neurosurgery 2010; 67 (4): N25.
11. **Hofstetter CP**, Boockvar JA. *Neural stem cells: targeting glioma in 3-dimensions*. Neurosurgery 2010; 66 (6): N15.
12. **Hofstetter CP**, Boockvar JA. *Forcing tumor stem cells to an end*. Neurosurgery 2010; 66 (4): N17 – 18.
13. **Hofstetter CP**, Boockvar JA. *Stem cell based growth factor delivery to the injured spinal cord.* Neurosurgery 2010; 66(2): N16-17.
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MANUSCRIPTS SUBMITTED

1. Guest JD, **Hofstetter CP**, Ropper AE, Aimetti AA, Layer RT, Moore SW, Ulich TR, Theodore N. *Implantation of a biodegradable scaffold in the spinal cord after actute porcine contusion injury.* Manuscript submitted.
2. **Hofstetter CP**, Olson L. *Stereological assessment of corticospinal tract axons following contusion injury of the rat spinal cord.* Manuscript submitted.

ABSTRACTS

1. Clinical outcomes Following MIS vs. Endoscopic Laminectomy; 34th annual AANS/CNS Spine Section Meeting; Orlando, FL March 2018.
2. Intra- and Perioperative Complications Associated with Endoscopic Spine Surgery: A Multi-institutional Case Series; 34th annual AANS/CNS Spine Section Meeting; Orlando, FL March 2018.

3. *Contrast-enhanced ultrasound to visualize and quantify local blood flow and perfusion after traumatic spinal cord injury*; 34th annual AANS/CNS Spine Section Meeting; Orlando, FL March 2018.
4. *Transcutaneous electrical spinal stimulation: Preliminary clinical results and novel translational model;* ISNR annual meeting, Asilomar, CA; December 2017
5. *Contrast-enhanced ultrasound to visualize and quantify local blood flow and perfusion after traumatic spinal cord injury;* ISNR annual meeting, Asilomar, CA; December 2017
6. *Contrast-enhanced ultrasound to visualize and quantify local blood perfusion after traumatic spinal cord injury;* 47th annual Society for Neuroscience conference, *Washington, DC; November 2017*
7. *Surgical Decompression Relieving Intraspinal Pressure Can Limit Secondary Damage After Acute Spinal Cord Injury;* 46th annual Society for Neuroscience conference, San Diego, CA; November 2016.
8. *Biomimetic injectable 3D hydrogels with aligned topography for neural tissue engineering* 45th annual Society for Neuroscience conference, Chicago, IL; October 2015.
9. *Minimally invasive foraminotomy through tubular retractors via a contralateral approach in patients with unilateral radiculopathy;* 30th annual AANS/CNS Spine Section Meeting; Orlando, FL March 2014.
10. *Unilateral tubular approach for bilateral laminectomy: Effect on ipsilateral and contralateral buttock and leg pain;* 30th annual AANS/CNS Spine Section Meeting, Orlando, FL; March 2014.
11. *Impact of cage height, width and positioning on clinical and radiographic outcome of extreme lateral interbody fusion*; 29th annual AANS/CNS Spine Section Meeting, Phoenix, AZ; March 2013.
12. *Midterm experience with expandable PEEK spacers for interbody fusion for Degenerative Lumbar Disease;* 29th annual AANS/CNS Spine Section Meeting, Phoenix, AZ; March 2013.
13. *Volumetric classification for giant pituitary macroadenomas predicts outcome and morbidity of endoscopic endonasal transsphenoidal surgery;* NASBS, Scottsdale, AZ; February 2011.
14. *Extreme lateral interbody fusion for treatment of degenerative lumbar spondylosis;* SMISS Annual Meeting, Miami, FL; November 2010.
15. *Hypoxia induces protein phosphatase 2A enzymatic activity in glioblastoma multiforme*; 15th Annual Scientific Meeting, Society for NeuroOncology, Montreal, Canada; November 2010.
16. *High Protein Phosphatase 2A Enzymatic Activity Correlates with Poor Prognosis in Patients with GBM*; AANS Annual Meeting, Philadelphia, PA; May 2010.
17. *Genetically targeted disruption of respiratory chain dysfunction in dopamine Neurons leads to key parkinsonian pathology and symptoms in mice;* 35th Annual Meeting, Society for Neuroscience, Washington, DC; November 2005.
18. *Spontaneous recovery of sensory function following spinal cord injury assessed by fMRI*; 34th Annual Meeting, Society for Neuroscience, San Diego, CA; October 2004.
19. *Directed differentiation of adult neural stem cells improves effects of stem cell-based spinal cord injury treatment*; 34th Annual Meeting, Society for Neuroscience, San Diego, CA; October 2004.
20. *Assessment of spinal cord activation during sensory stimulation using fMRI;* 34th Annual Meeting, Society for Neuroscience, San Diego, CA; October 2004.

21. *Stereological quantification of the corticospinal tract following spinal cord injury*; 33th Annual Meeting, Society for Neuroscience, New Orleans, LA; November 2003.
22. *Regulation of small Rho-GTPases following spinal cord injury;* 33th Annual Meeting, Society for Neuroscience, New Orleans, LA; November 2003.
23. *Ethanol consumption induces cell proliferation in hippocampus*; 33th Annual Meeting, Society for Neuroscience, New Orleans, LA; November 2003
24. *Transneuronal invasion of the spinal cord by pseudorabies virus following injection into rat dorsal root ganglia*; 32th Annual Meeting, Society for Neuroscience, Orlando, FL; November 2002 .
25. *Spontaneous recovery of the sensory system after spinal cord injury; a functional MRI study*; 32th Annual meeting, Society for Neuroscience, Orlando, FL; November 2002.
26. *Grafting neurogenin-2 transfected neural stem cells to the injured spinal cord;* 32th Annual meeting, Society for Neuroscience, Orlando, FL; November 2002.
27. *Spinal cord repair strategies: the use of adult stem cells;* 2nd Annual Mesenchymal & Nonhematopoietic Stem Cell Conference, New Orleans, LA; September 2002.
28. *Marrow stromal cells form guiding strands in the injured spinal cord;* 31th Annual Meeting, Society for Neuroscience, San Diego, FL; November 2001.

INVITED LECTURES

12/2017	My path to MIS Endoscopy; Espanding the armamentarium of the complex spine surgeon; 11th New York City Minimally Invasive Spine, Spinal Endoscopy, Robotics & Navigation Symposium, Weill Cornell Medical Center, New York, NY
12/2017	Over the top MIS decompression with and without MIS transforaminal lumbar interbody fusion – Step – by – Step technique, AO spine Surgeon's Cockpit, Davos, Switzerland
10/2017	Interlaminar lumbar stenosis decompression: Can it replace traditional laminectomy? 32st Annual Meeting, NASS, Orlando, FL
10/2017	Lumbar Decompression and Discectomy: Microscope versus Endoscope; 32st Annual Meeting, NASS, Orlando, FL
06/2017	Endoscopic Discectomy and Fusion using IntraLIF; Seattle Science Foundation, Seattle, WA
04/2017	How to Adopt Endoscopy: Training for Team & Fellows; 85th Annual Meeting, AANS, Los Angeles, CA
04/2017	The interlaminar endoscopic approach – advancing MIS; ISASS – 17th Annual Conference, Boca Raton, FL
10/2016	Pushing the Limits of Decompression with Endoscopic Spinal Surgery; Minimally Invasive Procedures to Minimize Exposure and Dissection; 31st Annual Meeting, NASS, Boston, MA
10/2016	Endoscopic Approaches to the Cervical and Lumbar spine; Minimally Invasive Lumbar Fusion Surgeries; 2017 CNSCN2016, Xi An, China
06/2016	Better Spinal Decompression Surgery using Next Generation Minimally Invasive Spine Surgery; 2016 Annual Meeting, WSANS, Cle Elum, WA

05/ 2016	Interlaminar Endoscopic approach; 84th Annual Meeting, AANS, Chicago, IL
03/2016	Explorative Meta-analysis on Dose-related Efficacy and Morbidity of Bone Morphogenetic Protein in Spinal Arthrodesis Surgery; 32st Annual Meeting, AANS/CNS Spine Section, Orlando, FL
03/2016	Early Experience with Endoscopic Revision of Lumbar Arthrodesis Constructs; 32st Annual Meeting, AANS/CNS Spine Section, Orlando, FL
03/2016	Characterization Intraspinal Pressure Following Traumatic Rodent Spinal Cord Injury; 32st Annual Meeting, AANS/CNS Spine Section, Orlando, FL
01/2016	Epidural stimulation for chronic cervical spinal cord injury; SCI Forum, UW, Seattle, WA
10/2015	*Characterization of intraspinal pressure following traumatic rodent spinal cord injury;* 45th Annual Meeting, Society for Neuroscience, Chicago, IL.
10/2015	*Pain Management following Discharge from Spine Surgery;* 30th Annual Meeting, NASS, Chicago, IL.
10/2015	*Minimally invasive TLIF;* 30th Annual Meeting, NASS, Chicago, IL.
092015	*Advances in Minimally Invasive Spine Surgery*; UW CME course, Missoula, MT
04/2014	*Extreme Lateral Interbody fusion for Unilateral Symptomatic Vertical Foraminal Stenosis;* Annual Meeting, ISASS, Miami, FL
05 2014	*Endoscopic Lumbar Foraminoplasty: A Cadaveric Study*; Annual Meeting, ISASS, Miami, FL
032014	*Endoscopic foraminal decompression;* Annual Meeting of the AANS/CNS Spine section, Orlando, FL
09/2013	*Optimizing indirect foraminal decompression by Extreme Lateral Interbody Fusion;* Annual Meeting, Florida Neurosurgical Society, Palm Beach, FL
03/2013	*Minimally invasive laminectomy through tubular retractors for lumbar spinal stenosis in patients with and without pre-operative spondylolisthesis: clinical outcome and re-operation rate;* 29th Annual Meeting, AANS/CNS Spine Section, Phoenix, AZ
12/2010	*PP2A activity protects hypoxic tumor stem cells from apoptosis;* Grand Rounds, Vienna, Austria
05/2007	*MRI-based imaging techniques: From the lab bench to neurosurgical practice*; Nobel Conference, Stockholm, Sweden
10/2004	*Directed differentiation of adult neural stem cells reduces side effects of stem cell based spinal cord injury treatment*; 34th Annual Meeting, Society for Neuroscience, San Diego, CA
01/2003	*Marrow stromal cell transplantation in spinal cord injury;* Grand Rounds, Dept. of Neurosurgery, Medical College of Wisconsin, Milwaukee, WI
12/2002	*Cell transplantation therapy in spinal cord injury;* 13th NECTAR meeting, Amsterdam, Belgium
05/2002	*Novel methods and repair strategies in spinal cord injury,* Department of Neuroscience, Uppsala University, Uppsala, Sweden

Washington State Health Care Authority

Order of Scheduled Presentations:

Surgery for symptoms of lumbar radiculopathy

	Name
1	Jean-Christophe Leveque, MD

Disclosure

Any unmarked topic will be considered a “Yes”

	Potential Conflict Type	Yes	No
1.	Salary or payments such as consulting fees or honoraria in excess of $10,000.	X	
2.	Equity interests such as stocks, stock options or other ownership interests.		X
3.	Status or position as an officer, board member, trustee, owner.	X	
4.	Loan or intellectual property rights.		X
5.	Research funding.	X	
6.	Any other relationship, including travel arrangements.		X

If yes, list name of organizations that relationship(s) are with and for #6, describe other relationship:

Nuvasive: speaker/trainer for surgical skills, receive honoraria for this activity

IIMAC: Washington State L&I Committee, serve as member

Research Funding: Virginia Mason Research Funding (Wilske) for opioid research 2018-2019

	Potential Conflict Type	Yes	No
7.	Representation: if representing a person or organization, include the name and funding sources (e.g. member dues, governmental/taxes, commercial products or services, grants from industry or government).	X	

If yes to #7, provide name and funding Sources:

Washington State Association of Neurological Surgeons: President, funding from member dues, industry funding of

didactic sessions throughout the year, including annual meeting

*If you believe that you do not have a conflict, but are concerned that it may appear that you do, you may **attach additional sheets** explaining why you believe that you should not be excluded.*

I certify that I have read and understand this Conflict of Interest form and that the information I have provided is true, complete, and correct as of this date.

[redacted] 4/26/18 Jean-Christophe Leveque

Date *Print Name*

So we may contact you regarding your presentation, please provide the following:

Email Address: jc.leveque@virginiamason.org

Phone Number: [redacted]

Washington State HTA Program Draft Evidence Report: Surgery for Symptomatic Lumbar Radiculopathy

Response

American Association of Neurological Surgeons
Congress of Neurological Surgeons
AANS/CNS Section on Disorders of the Spine and Peripheral Nerves
International Society for the Advancement of Spine Surgery
North American Spine Society
Washington State Association of Neurological Surgeons

Cited Literature Does Not Warrant a Policy Change

- We do not believe that there is a substantial change in evidence on this topic
- We do not support a change to the current coverage policy
- Have issue with some of the specific elements of the report

Limitations of Studies from Outside the United States

- Majority of studies in HTA were non-U.S. studies
  - Example 1: 18 of 22 RCTs for efficacy question 1 were non-U.S.
  - Example 2: 4 of 6 studies for cost-effectiveness analysis were non-U.S.
- Non-U.S. studies evaluate impact in other health care systems with different socioeconomics and demographics
- Vulnerable to error when applied to U.S.
- Limiting the analysis to the studies from U.S. alone would have been more appropriate

Conclusion on Long-term Outcomes is Inaccurate

- Draft evidence report concludes that compared to non-surgical tx, surgery reduces pain and improves function up to 26 weeks of follow-up but the "*difference does not persist at 1 year or longer*."
- There is substantial high-quality literature that directly contradicts this statement
- One example is SPORT trial:
  - Intent-to-treat analysis: improvement in sciatica bothersomeness index and self-rated improvement at 1 yr and 4 yrs **in favor of surgery** (despite high crossover)
  - As-treated analysis (to address issues with crossover): ***in favor of surgery*** for ***all*** primary and secondary outcome measures (exception: work status) at ***every*** time point, including the latest f/u time point of 4 years. F/u study demonstrated persistence at **8 yrs**
  - Also demonstrated benefit to patients who crossed over to surgery; subset of patients would not have achieved or maintained the beneficial outcome without surgical intervention

Minimally Invasive Surgery

- Outcomes for minimally invasive approaches were comparable to more traditional open discectomy and microdiscectomy in the draft evidence report
- Minimally invasive techniques may have distinct patient advantages, and choice based on patient factors, as most surgeons are adept at both
- We support the continued use of minimally invasive approaches for appropriately selected patients

Inherent Limitations to Meta-analysis

- A primary concern of this study design relates to patient heterogeneity
  - patients from different studies often represent distinct patient populations
  - grouping of these patients together often inappropriate
- Significant bias introduced when defining inclusion/exclusion criteria
  - Arbitrarily including RCTs from abroad and excluding important U.S.-based observational studies—do not agree with many of these assumptions

Conclusion

- Surgery remains a cornerstone treatment option for patients with lumbar radiculopathy when considering both therapeutic value and cost-effectiveness
- Cited literature does not warrant a policy change

References

- Weinstein JN, Lurie JD, Tosteson TD, et al. Surgical versus nonoperative treatment for lumbar disc herniation: four-year results for the Spine Patient Outcomes Research Trial (SPORT). *Spine (Phila Pa 1976).* Dec 1 2008;33(25):2789-2800.
- Lurie JD, Tosteson TD, Tosteson AN, et al. Surgical versus nonoperative treatment for lumbar disc herniation: eight-year results for the spine patient outcomes research trial. *Spine (Phila Pa 1976).* Jan 1 2014;39(1):3-16.
- Dasenbrock HH, Juraschek SP, Schultz LR, et al. The efficacy of minimally invasive discectomy compared with open discectomy: a meta-analysis of prospective randomized controlled trials. *J Neurosurg Spine.* May 2012;16(5):452-462.
- Clark AJ, Safaee MM, Khan NR, Brown MT, Foley KT. Tubular microdiscectomy: techniques, complication avoidance, and review of the literature. *Neurosurg Focus.* Aug 2017;43(2):E7.
- Smith JS, Ogden AT, Shafizadeh S, Fessler RG. Clinical outcomes after microendoscopic discectomy for recurrent lumbar disc herniation. *J Spinal Disord Tech.* Feb 2010;23(1):30-34.
- Eysenck HJ. Meta-analysis and its problems. *BMJ.* Sep 24 1994;309(6957):789-792.

RTI INTERNATIONAL

RTI-University of North Carolina
Evidence-based Practice Center

UNC THE CECIL G. SHEPS CENTER FOR HEALTH SERVICES RESEARCH

Surgery for Lumbar Radiculopathy/Sciatica

Health Technology Assessment
State of Washington Health Care Authority

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Leila Kahwati, MD MPH
Associate Director, RTI-UNC EPC

May 18, 2018
LKahwati@rti.org

Overview of presentation

- Background
- Methods
  - Strength of evidence grading
- Results
  - Primary research synthesis
  - Clinical practice guideline synthesis
- Discussion
  - Summary of evidence
  - Limitations
  - Payor coverage policies

2 Pages in Report: N/A

Background

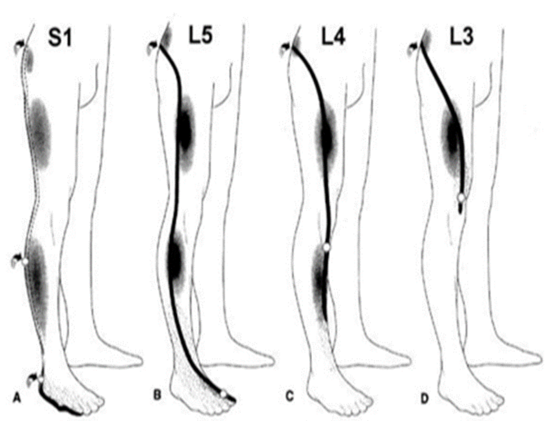
3 Pages in Report: 3-6

Lumbar Radiculopathy/Sciatica

A ***clinical*** syndrome characterized by radiating leg pain, with or without motor weakness, and sensory disturbances in a myotomal or dermatomal distribution.

Results from spinal nerve root compression
- Disc herniation
- Spondylosis
- Various other pathological processes

Treatment objective is symptom relief through nonsurgical management of symptoms, surgical intervention to address the underlying causative mechanism, or both.



4 Page in Report: 3

Image obtained from http://www.neuroanatomy.wisc.edu/SClinic/Radiculo/Radiculopathy.htm#sciatic

Epidemiology

- Prevalence estimates vary
  - Lifetime 3% to 43%
  - Period (1 year) 2.2% to 34%
  - Point 1.6% to 13.4%
- Risk factors:
  - Prior history of trauma
  - Prolonged driving
  - Pregnancy
  - Job requiring manual labor
  - Prior history of axial low back pain

5 Page in Report: 4

Technology Description

- **Standard, open procedures including microsurgical approaches**
  - Disc removal procedures
    - Examples: Discectomy and microdiscectomy
  - Decompressive procedures
    - Examples: Laminectomy, laminotomy, foraminotomy
- **Minimally-invasive surgeries (MIS)**
  - Use direct (endoscopic) or indirect visualization (percutaneous)
  - Use various approaches for disc removal, destruction, and decompression
    - Mechanical (manual or automated)
    - Laser-assisted techniques
    - Radiofrequency thermal ablation
    - Coblation (plasma)

6 Pages in Report: 4-5

Regulatory Status

U.S. Food and Drug Administration (FDA) clears surgical instruments and devices used, typically through the 510(k) process.

- "aspiration of disc material during percutaneous discectomies"
- "cutting, grinding and aspirating intervertebral disc material during discectomy"
- "ablation and coagulation of intervertebral disc material during discectomy" or "coagulation and decompression of disc material"

- Arthroscopes, endoscopes, and related accessories
- Laser instruments are cleared for incision, excision, resection, ablation, vaporization, and coagulation of tissue during surgical procedures

7 Pages in Report: 5-6

Policy Context for Washington

Topic selection

Area of concern	Level of concern
Safety	Medium
Efficacy	Medium
Cost	High

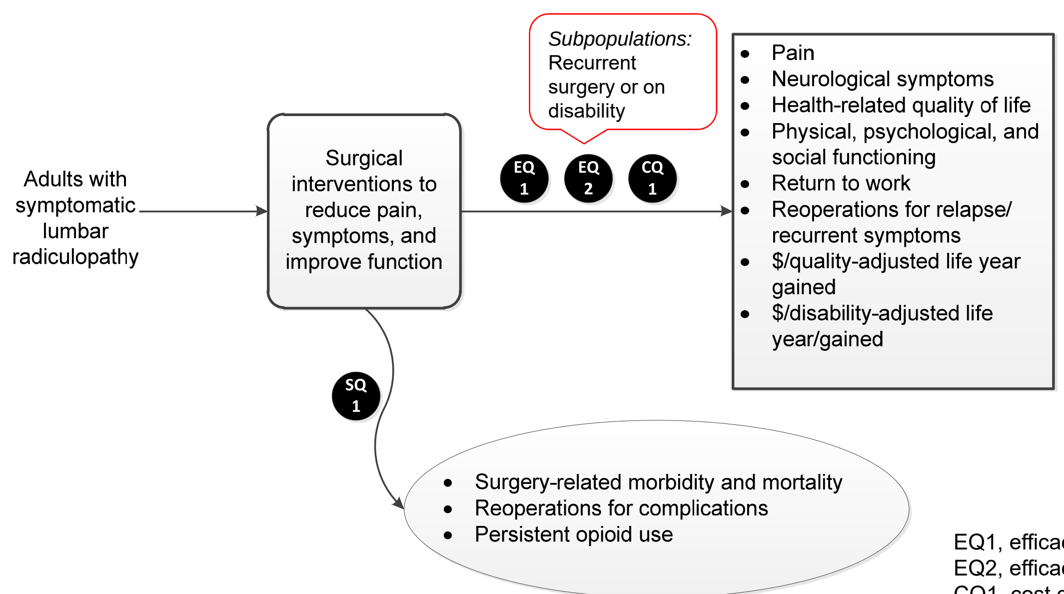
8 Page in Report: 6

Methods

1. Primary Research Synthesis
2. Synthesis of Relevant Clinical Practice Guidelines

9 Pages in Report: 7-14

Analytic Framework



EQ1, efficacy question 1
EQ2, efficacy question 2
CQ1, cost question 1
SQ1, safety question 1

10 Figure 1, Page in Report: 8

Study Selection for Primary Research Review

Population	Age>=18, symptomatic lumbar radiculopathy
Intervention	Surgical interventions primarily for the treatment of radiculopathy. Includes “micro” approaches and minimally-invasive surgical procedures
Comparator	Placebo or no treatment comparators Active comparators: nonsurgical (e.g., physical therapy, pharmacologic treatment) or surgery
Outcomes	EQ1, EQ2: Pain, function/disability, quality of life, neurologic symptoms, return to work SQ1: Mortality, surgical morbidity, reoperations, persistent opioid use CQ1: Cost, cost per QALY, cost per DALY
Study Design	EQ1, EQ2, and SQ1: randomized clinical trial, controlled clinical trials (for all comparisons except surgery vs surgery) CQ1: costs, cost-effectiveness analysis, cost-benefit analysis, cost-utility analysis
Setting	Inpatient or outpatient settings in countries categorized as “very high” on United Nations Human Development Index

11 Table 2
Pages in Report: 9-10

What is Excluded from this HTA:

- ***Populations:*** cauda equina syndrome, neurogenic claudication or symptoms related primarily to central spinal stenosis, spondylolisthesis, nonradicular leg or low back pain
- ***Interventions or Comparators:***
  - Spinal fusion, arthroplasty, artificial disc replacement, interspinous process decompression, minimally-invasive procedures designed for treating discogenic low back pain
  - Chemonucleolysis or biologic (e.g., stem cells, mesenchymal cells) agents.
- ***Study Designs:***
  - Observational studies
  - “as treated” or “per protocol” analyses from RCTs

12 Page in Report: 12

Outcome Measurement and Interpretation

- Varied across studies; for synthesis we defined the following:
  - **Short-term**: 4 weeks up to 12 weeks
  - **Medium-term**:12 weeks up to 52 weeks*
  - **Long-term**: 52 weeks or longer

*in actuality no studies reported outcomes between 26 and 52 weeks, so empirically outcomes reported as medium term represent those measured between 12 and 26 weeks.

- We concluded between-group differences if:
  - Magnitude of difference were above the minimally important difference (MID) threshold, AND
  - Estimates of the difference were precise enough to exclude a null effect (i.e., statistical significance)

13 Pages in Report: 13-14

Risk of Bias

- Risk of bias (study quality) is assessed at the individual study level
  - Cochrane Risk of Bias version 2.0 instrument
    - High risk of bias
    - Some concerns for bias
    - Low risk of bias
  - Quality of Health Economic Studies instrument
    - Good
    - Fair
    - Poor

14 Pages in Report: 12-14

Strength of the Evidence - Modified GRADE approach

- **Strength of evidence (SOE/certainty) ratings**
  - ○○○○ INSUFFICIENT
  - ⊕○○○ VERY LOW
  - ⊕⊕○○ LOW
  - ⊕⊕⊕○ MODERATE
  - ⊕⊕⊕⊕ HIGH
- **Domains assessed:**
  - Risk of bias
  - Inconsistency
  - Indirectness
  - Imprecision
  - Reporting bias
- Bodies of RCT evidence start at ***HIGH*** SOE based on study design
- Downgrade based on domain assessment
  - No concerns
  - Serious concerns (↓ one level)
  - Very serious concerns (↓ two levels)

15 Table 3
Pages in Report: 12-14

Results

1. Primary Research Synthesis
2. Synthesis of Relevant Clinical Practice Guidelines

16 Pages in Report 15-107

Search Results

- Primary Research Synthesis:
  - Titles/Abstracts screened: **1,861**
  - Full text articles screened: **223**
  - Full text studies included: **25** (from 39 articles)
    - EQ1/EQ2/SQ1: **24 RCTs**
    - CQ1: **7 studies**
- Clinical Practice Guidelines: **14**

17 Figure 2
Page in Report: 15

Organizing Comparisons

- EQ1, SQ1, CQ1
    - Surgery vs. Nonsurgical Interventions
  - Surgery vs. Surgery
    - Minimally-invasive Surgery vs. Standard Surgery
    - Microdiscectomy vs. Discectomy
- EQ2, SQ1
  - Repeat surgery vs. comparator
    - Minimally-invasive repeat surgery vs. nonsurgical intervention
    - Minimally-invasive repeat surgery vs. standard repeat surgery

18 Page in Report: N/A

EQ1 - Study Characteristics (Efficacy)

	Surgical Intervention	Comparator	Population/Setting/Risk of Bias
Efficacy RCTs (k=7)	Microdiscectomy	• Spinal manipulation (*McMorland 2010*[23]) • Physiotherapy (*Osterman 2003*[33])	Patients: diagnosis confirmed with imaging, failed 6 to 12 weeks conservative treatment, no immediate indications for surgery, mean duration of symptoms 8 to 52 weeks Countries: U.S. (2), Canada (1), Greece (1), Finland (1), Netherlands (1), Norway (1) Risk of Bias: high (5), some concerns (1), some/high (1)
	• Percutaneous disc decompression with coblation technology (*Gerszten 2003*[41])	Epidural steroid injection	
	• Percutaneous disc decompression (*Erginousakis 2011*[37]) • Discectomy (*Weber 1983*[26]) • Discectomy/microdiscectomy (*Weinstein 2006 [SPORT]*[22]) • Microdiscectomy (*Peul 2007*[32])	Conservative management	

19 Table 4
Page in Report: 17

EQ1 - Surgery vs. Nonsurgical Interventions (Pain)

VAS 100 Leg Pain (Scale 0 to 100, higher is worse pain, MID 7 to 11)

Short- and medium-term: ⊕⊕○○ LOW Favors surgery **Long-term:** ⊕○○○ VERY LOW No difference	▪ Pain improves in both groups − Improves by 41 to 57 for surgery, 20 to 36.5 for comparator ▪ **Pain improves 6 to 26 points more with surgery** through 26 weeks (k=3,[32,33,41] N=429) ▪ Within-group improvements persist, **no between-group differences** through 52 weeks to 5 years (k=2,[32,33] N=339)

VAS 100 Back Pain

Short- and medium-term: ⊕⊕○○ LOW Favors surgery **Long-term:** ⊕○○○ VERY LOW No difference	▪ Similar treatment effect to VAS 100 Leg Pain, but baseline scores start lower.

20 Table 9
Pages in Report: 29-36

EQ1 - Surgery vs. Nonsurgical Interventions (Pain con't)

SF-36 Bodily Pain (0 to 100, lower is worse pain, MID 3 to 4)

Short- and medium-term: ○○○○ INSUFFICIENT Mixed findings	▪ Pain improves in both groups −Improves by 14.1 to 40.9 for surgery, 17.3 to 30.5 for comparator ▪ **Between-group differences mixed** through 26 weeks (k=4,[22,23,32,41] N=914)
Long-term: ⊕○○○ VERY LOW No difference	▪ Within-group improvements persist, **no between-group differences** through 52 weeks to 8 years (k=2,[22,32] N=784)

Sciatica Index (0 to 24, higher is worse pain, MID 2.4)

Short- and medium-term: ⊕⊕○○ LOW Favors surgery	▪ Pain improves in both groups on both subscales −Improves by 9.0 to 10.7 for surgery, 6.8 to 6.9 for comparator ▪ **Pain improves 2.1 to 4.0 points more with surgery** through 26 weeks (k=2[22,32], N=784)
Long-term: ⊕○○○ VERY LOW No difference	▪ Within-group improvements persist, **no between-group differences** through 52 weeks to 8 years (k=2,[22,32] N=784)

21 Table 9
Pages in Report: 29-36

EQ1 - Surgery vs. Nonsurgical Interventions (Function)

Oswestry Disability Index (0 to 100, higher scores worse function, MID 8 to11)

Short- and medium-term: ⊕○○○ VERY LOW Favors surgery	▪ Function improves in both groups −Improves by 12 to 26 for surgery, 5 to 21.3 for comparator ▪ **Function improves 4.7 to 10 points more with surgery** through 26 weeks (k=3,[22,33,41] N=647)
Long-term: ⊕○○○ VERY LOW No difference	▪ Within-group improvements persists, **no between-group differences** through 52 weeks to 8 years (k=2,[22,33] N=557)

Roland-Morris Disability Ques. (0 to 24, higher scores worse function, MID 2 to 5)

Short- and medium-term: ○○○○ INSUFFICIENT Mixed findings	▪ Function improves in both groups −Improves by 0.7 to 10.4 in surgery, 2.5 to 7.1 for comparator ▪ **Between-group differences mixed** through 26 weeks (k=2,[23,32] N=323)
Long-term: ○○○○ INSUFFICIENT Single study	▪ Within-group improvement persists, **no between-group differences** through 5 years (k=1,[32] N=283)

22 Table 12
Pages in Report: 45-49

EQ1 - Surgery vs. Nonsurgical Interventions (Function con't)

SF-36 Physical Functioning (0 to 100, lower is worse function, MID 3 to 4)

Short- and medium-term: ◯◯◯◯ INSUFFICIENT Mixed findings **Long-term:** ⊕◯◯◯ VERY LOW No difference	▪ Function improves in both groups −Improves by 8.6 to 37.3 for surgery, 7.4 to 27.3 for comparator ▪ **Between-group differences mixed** through 26 weeks (k=3,[22,23,32] N=647) ▪ Within-group improvements persist, **no between-group differences** through 52 weeks to 8 years (k=2,[22,32] N=784)

23 Table 12
Pages in Report: 45-49

EQ1 - Surgery vs. Nonsurgical Interventions (Other Efficacy Outcomes)

Quality of Life

Short- and medium-term: ⊕◯◯◯ VERY LOW No difference **Long-term:** ◯◯◯◯ INSUFFICIENT Single study	▪ Cumulative total SF-36, 15D ▪ Improves in both groups, **no between-group differences** −Short- to medium-term (k=2,[23,33] N=96) −Long-term (k=1,[33] N=56)

Neurological Symptoms

⊕◯◯◯ VERY LOW No difference	▪ Improves in both groups, **no between-group differences** (k=2,[33,41] N=146)

Return to Work

⊕◯◯◯ VERY LOW No difference	▪ Variation in and poor validity of measures used ▪ **No between-group differences** (k=5,[22,26,33,37,41] N=835)

Measures of Global Recovery

NA	▪ Heterogenous measures, but generally mirror pain and function measures (k=4,[22,26,32,33] N=966)

24 Table 15, 18, 20
Pages in Report: 57-58, 60, 62-63, 66-67

SQ1 - Surgery vs. Nonsurgical Interventions

Mortality

⊕⊕○○ LOW No difference	▪ No surgery-related deaths (k=5,[22,23,32,33,41] N=970) ▪ All-cause mortality rare, **no between-group differences** through 26 weeks to 10 years (k=3,[22,26,41] N=717)

Surgical Morbidity

⊕⊕○○ LOW	▪ Infrequent, dural tears most commonly reported adverse event (k=6,[22,23,32,33,37,41] N=555)

Reoperations

⊕○○○ VERY LOW	▪ Variably measured and reported, most were for recurrent symptoms ▪ Incidence 0% to 10% through 1 to 5 years (k=5,[22,23,32,33,37] N=466)

Persistent Opioid Use

○○○○ INSUFFICIENT Single study	▪ No between-group differences through 26 weeks (k=1,[41] N=90)

25

Table 26, 31, 36, 41
Pages in Report: 74-75, 77-79, 83-84, 89

CQ1 - Surgery vs. Nonsurgical Interventions (Study Characteristics)

Author (Year) Related RCT (Year) Country Quality-Time Horizon	Surgical Intervention (N randomized)	Comparator (N randomized)
Van den Hout (2008) [49] Peul (2007)[32] Netherlands Good – 52 weeks	Discectomy (141)	Conservative management (142)
Tosteson (2008)[50] Weinstein (2006)[22] [SPORT] U.S. Good – 2 years	Discectomy /microdiscectomy (245)	Conservative management (256)
Malter (1996)[44] U.S. Cost Data Fair- 10 years	Discectomy (NA)	Nonsurgical management (NA)

26

Table 44
Pages in Report: 91-93

CQ1 - Surgery vs. Nonsurgical Interventions (Findings)

Cost-effectiveness

⊕○○○ VERY LOW	▪ All studies (k=3[44,49,50]) reported higher QALYs but similar or higher costs for surgery compared to nonsurgical interventions. ▪ The mean cost per QALY gained from the payor perspective ranged from $51,156 to $83,322 in 2010 U.S. dollars.

27

Table 45
Pages in Report: 93-95

EQ1 - Study Characteristics (Comparative Effectiveness)

	Surgical Intervention	Comparator	Population/Setting/Risk of Bias
Comparative effectiveness RCTs (k=15)	• Tubular discectomy (*Arts 2011*[40]) • Trocar discectomy (*Ryang 2008*[30]) • Automated percutaneous lumbar discectomy (*Chatterjee 1995*[38]) • Percutaneous endoscopic discectomy (*Mayer 1993*[34]) • Endoscopic discectomy (*Ruetten 2008*[31]) • Microendoscopic discectomy (*Sasaoka 2006*[25], *Teli 2010*[29]) • Sequestrectomy (*Thome 2005*[28]) • Percutaneous laser disc decompression (*Brouwer 2015*[39]) • Microscopically assisted percutaneous nucleotomy (*Franke 2009*[36])	Microdiscectomy	Patients: diagnosis confirmed with imaging, failed some amount of conservative therapy in most studies, must have met specific anatomical criteria depending on procedure, mean duration of symptoms 8 to 30 weeks Countries: US (2), Germany (5), Netherlands (2), UK (1), Japan (1), Italy (1), Denmark (1), Sweden (1), Taiwan (1) Risk of Bias: high (5), some concerns (9), low (1)
	• Automated percutaneous discectomy/endoscopic percutaneous discectomy (*Haines 2002*[42]) • Video-assisted arthroscopic microdiscectomy (*Hermantin 1999*[43]) • Microendoscopic discectomy (*Huang 2005*[24], *Teli 2010*[29])	Discectomy	
	Microdiscectomy (*Henrisksen 1996*[35], *Teli 2010*[29], *Tullberg 1993*[27])	Discectomy	

28

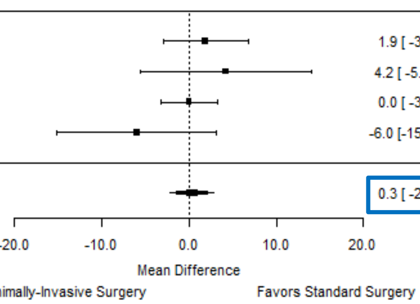
Table 5 and 6
Pages in Report: 20-24

EQ1 - MIS vs. Standard Surgery (Pain)

VAS Leg Pain (Scale 0 to 100, higher is worse pain, MID 7 to 11)

⊕⊕⊕◯ Moderate No difference	▪ Pain improves in both groups – Improves by 42.5 to 69 for MIS, 29.8 to 62 for standard surgery ▪ **<u>No between-group differences</u>** at any time point (k=5,[28,29,31,39,40] N=869) – 12 to 26 weeks pooled AMD 0.3 (95% CI, -2.2 to 2.9; N=640) – 2 years pooled AMD -0.1 (95% CI, -2.7 to 2.4; k=4; N=640; I^2=0%)

Author (year)	Sample Size	Country	Minimally-Invasive Surgery	Mean (SD)	Standard Surgery	Mean (SD)	Mean Difference [95% CI]
12 weeks to 26 weeks							
Arts (2009)	316	Netherlands	Tubular discectomy	14.6 (21.6)	Microdiscectomy	12.7 (22.3)	1.9 [-3.0, 6.8]
Brouwer (2015)	100	Netherlands	Percutaneous laser disc decompression	19.9 (27.1)	Microdiscectomy	15.7 (23.1)	4.2 [-5.7, 14.1]
Teli (2010)	142	Italy	Microendoscopic discectomy	20.0 (10.0)	Microdiscectomy	20.0 (10.0)	0.0 [-3.3, 3.3]
Thome (2005)	84	Germany	Sequestrectomy	7.0 (17.0)	Microdiscectomy	13.0 (25.0)	-6.0 [-15.1, 3.1]
RE Model for All Studies (Q = 2.87, df = 3, p = 0.41; I^2 = 0.0%)							0.3 [-2.2, 2.9]



29 Table 10, Figure G-1
Pages in Report: 36-43

EQ1 - MIS vs. Standard Surgery (Pain con't)

SF-36 Bodily Pain (0 to 100, lower is worse pain, MID 3 to 4)

Short-term: ⊕⊕◯◯ LOW No difference **Medium- and long-term:** ⊕◯◯◯ VERY LOW No difference	▪ Pain improves in both groups – Improves by 6.7 to 46.5 for MIS, 5.9 to 51.1 for standard surgery ▪ **<u>No between-group differences</u>** – Short-term (k=2,[39,40] N=443), medium- to long-term (k=4,[28,30,39,40] N=587) – Pooled AMD at 12 to 26 weeks: -3.0 (95% CI, -12.8 to 6.8; k=3;[28,39,40] N= 500, I^2=75.4%)

Sciatica Index (0 to 24, higher is worse pain, MID 2.4)

⊕⊕⊕◯ Moderate No difference	▪ Pain improves in both groups on both subscales – Improves by 4 to 8.5 for MIS, 3.2 to 8.7 for standard surgery ▪ Within-group improvements persist; **<u>no between-group differences</u>** through 2 years (k=2,[39,40] N=443)

30 Table 10
Pages in Report: 36-43

EQ1 - MIS vs. Standard Surgery (Function)

Oswestry Disability Index (0 to 100, higher scores worse function, MID 8 to11)

Medium- and long-term: ⊕○○○ VERY LOW No difference	▪ Function improves in both groups −Improves by 28 to 53 for MIS, 29 to 47 for standard surgery ▪ **No between-group differences** through 12 weeks to 2.8 years (k=4,[29,30,31,36] N=502)

Roland-Morris Disability Ques. (0 to 24, higher scores worse function, MID 2 to 5)

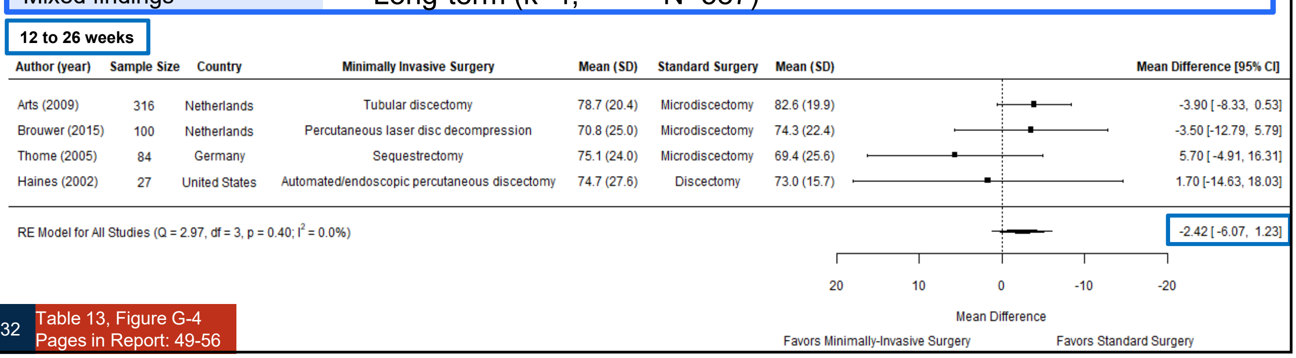
Short-term: ⊕⊕○○ LOW No difference **Medium- and long-term:** ⊕○○○ VERY LOW No difference	▪ Function improves in both groups −Improves by 4.9 to 9.7 for MIS, 2.3 to 10.6 for standard surgery ▪ **Few between-group differences** −Short-term (k=2,[39,40] N=443) −Medium- to long-term (k=3,[39,40,42] N=477)

31 Table 13
Pages in Report: 49-56

EQ1 - MIS vs. Standard Surgery (Function con't)

SF-36 Physical Functioning (0 to 100, lower is worse function, MID 3 to 4)

Short-term: ○○○○ INSUFFICIENT Mixed findings **Medium-term:** ⊕○○○ VERY LOW No difference **Long-term:** ○○○○ INSUFFICIENT Mixed findings	▪ Function improves in both groups −Improves by 27.2 to 41.8 for MIS, 2.6 to 51.9 for standard surgery ▪ **No between-group differences** −Medium-term (k=4,[28,39,40,42] N=561) ▪ **Between-group differences mixed** −Short-term (k=2,[39,40] N=443) −Long-term (k=4,[28,30,39,40] N=587)



32 Table 13, Figure G-4
Pages in Report: 49-56

EQ1 - MIS vs. Standard Surgery (Other efficacy outcomes)

Quality of Life

⊕○○○ VERY LOW No difference	▪ SF-36 Mental and Physical Component Scores ▪ Improves in both groups, **no between-group differences** (k=3,[28,29,30] N=286)

Neurological Symptoms

⊕○○○ VERY LOW No difference	▪ Improves in both groups; **no between-group differences** (k=6,[28,30,31,34,36,43] N=544)

Return to Work

⊕○○○ VERY LOW Favors MIS	▪ Variation and validity of measures used ▪ Mean duration of post-operative work disability **is lower by 3.4 to 15.2 weeks for MIS** (k=6,[28,31,34,36,38,43] N=555)

Measures of Global Recovery

NA	▪ Heterogenous measures, but **generally no between-group differences** (k=10,[24,25,28,30,34,38,39,40,42,43] N=840)

33 Table 16, 19, 21
Pages in Report: 58-59, 60-62, 63-65, 67-68

SQ1 - MIS vs. Standard Surgery

Mortality

⊕⊕○○ LOW No difference	▪ No studies reported any surgery-related deaths (k=5,[24,29,31,34,43] N=463) ▪ All-cause mortality rare, no **between-group differences** through 2 years (k=2,[31,40] N=528)

Surgical Morbidity

⊕○○○ VERY LOW No difference	▪ Heterogenous measures and reporting (k=10,[24,28,29,30, 31,34,36,39,40,43] N=1,151) ▪ **Between group-differences similar** for nearly all adverse events reported, dural tears most commonly reported adverse event

Persistent Opioid Use

○○○○ INSUFFICIENT Single study	▪ No between-group differences through 26 weeks (k=1,[43] N=60)

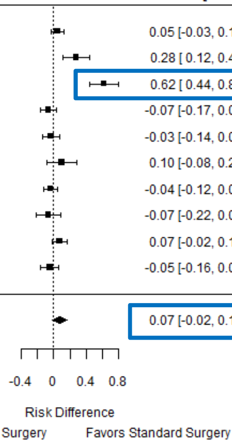
34 Table 27, 32, 42
Pages in Report: 75-76, 79-80, 89-90

SQ1 - MIS vs. Standard Surgery (con't)

Reoperations

○○○○ INSUFFICIENT Mixed findings	▪ Variably measured and ascertained, most were for recurrent symptoms ▪ Incidence ranged between 2% to 64.5% (k=10, N=1,200)

Author (year)	Length of Followup	Minimally-Invasive Surgery	N Reoperation/Total N	Standard Surgery	N Reoperation/Total N	Risk Difference [95% CI]
Arts (2009)	5y	Tubular discectomy	30/166	Microdiscectomy	21/159	0.05 [-0.03, 0.13]
Brouwer (2015)	52w	Percutaneous laser disc decompression	24/55	Microdiscectomy	9/57	0.28 [0.12, 0.44]
Chatterjee (1995)	26w	Automated percutaneous lumbar discectomy	20/31	Microdiscectomy	1/40	0.62 [0.44, 0.80]
Franke (2009)	52w	Microscopically-assisted percutaneous nucleotomy	2/52	Microdiscectomy	5/48	-0.07 [-0.17, 0.04]
Hermantin (1999)	2y	Video-assisted athroscopic microdiscectomy	1/30	Discectomy	2/30	-0.03 [-0.14, 0.08]
Mayer (1993)	2y	Percutaneous endoscopic discectomy	3/20	Microdiscectomy	1/20	0.10 [-0.08, 0.28]
Ruetten (2008)	2y	Endoscopic discectomy	7/91	Microdiscectomy	10/87	-0.04 [-0.12, 0.05]
Ryang (2008)	1.33y	Minimal access trocar microdiscectomy	2/30	Microdiscectomy	4/30	-0.07 [-0.22, 0.08]
Teli (2010)	2y	Microendoscopic discectomy	8/70	Microdiscectomy	3/72	0.07 [-0.02, 0.16]
Thome (2005)	1.5y	Sequestrectomy	2/42	Microdiscectomy	4/42	-0.05 [-0.16, 0.06]
RE Model for All Studies (Q = 64.81, df = 9, p = 0.00; I^2 = 86.1%)						0.07 [-0.02, 0.17]



RR 1.37 (95% CI, 0.74 to 2.52)

Without Chatterjee:
RD: 0.02 (95% CI, -0.04 to 0.08)
RR: 1.17 (95% CI, 0.70 to 1.97)

35 Table 37, Figure G-6
Pages in Report: 84-87

CQ1 - MIS vs. Standard Surgery (Study Characteristics)

Author (Year) Related RCT (Year) Country Quality-Time Horizon	Surgical Intervention (N randomized)	Comparator (N randomized)
Van den Akker (2011)[51] Arts (2009)[40] Netherlands Good-52 weeks	Tubular discectomy (167)	Microdiscectomy (161)
Van den Akker (2017)[52] Brouwer (2015)[39] Netherlands Good-52 weeks	Percutaneous laser disc decompression (57)	Discectomy, with laminotomy as needed (58)
Stevenson (1995)[53] Chatterjee (1995)[38] U.K. Poor-26 weeks	Automated percutaneous lumbar discectomy (31)	Microdiscectomy (40)
Teli (2010)[29] Italy NA	Microendoscopic discectomy (70)	Microdiscectomy (72) Open discectomy (70)

36 Table 44
Pages in Report: 91-93

CQ1 - MIS vs. Standard Surgery (Findings)

Cost-effectiveness

◯◯◯◯ INSUFFICIENT Mixed findings	▪ Inconsistent findings across studies –One study[51] reported higher costs and lower effectiveness (MIS is dominated) –One study[52] reported lower costs and lower effectiveness for MIS (calculated cost per QALY $-97,424). –One study[53] reported an additional cost of $3,573 per successful outcome at 26 weeks –One study[29] reported a $722 (95% CI, $551 to $892) higher surgical cost

37 Table 46
Pages in Report: 95-97

Note: all values converted to 2010 U.S. Dollars

EQ1 - Microdiscectomy vs. Discectomy (Efficacy Outcomes)

VAS Leg or Back Pain (0 to 100, higher is worse pain, MID 7 to 11)

Short-term: ◯◯◯◯ INSUFFICIENT Single study **Medium- and long-term:** ⊕◯◯◯ VERY LOW No difference	▪ Pain improves in both groups ▪ **No between-group differences** through 6 weeks (k=1,[35] N=80) ▪ **No between-group differences** through 2 years (k=2,[27,29] N=202)

Oswestry Disability Index (0 to 100, higher is worse function, MID 8 to 11)

◯◯◯◯ INSUFFICIENT Single study	▪ **No between-group differences** from 26 weeks through 2 years (k=1,[29] N=142)

38 Table 11 and 14
Pages in Report: 43-44, 56

EQ1 - Microdiscectomy vs. Discectomy (Efficacy Outcomes con't)

Quality of Life (SF-36 Mental and Physical Component Scores)

◯◯◯◯ INSUFFICIENT Single study	▪ **No between-group differences** from 26 weeks through 2 years (k=1,[29] N=142)

Return to Work

◯◯◯◯ INSUFFICIENT Single study	▪ **Similar duration** of postoperative disability (10.4 vs. 10.1 weeks) (k=1,[27] N=60)

39 Table 17 and 22
Pages in Report: 59, 65-66

SQ1 - Microdiscectomy vs. Discectomy

Mortality

◯◯◯◯ INSUFFICIENT Single study	▪ No surgery-related deaths (k=1,[29] N=142)

Surgical Morbidity

⊕◯◯◯ VERY LOW No difference	▪ Infrequent, **no between-group differences** (k=3[27,29,35] N=282)

Reoperations

⊕◯◯◯ VERY LOW No difference	▪ Incidence 3.3 to 4%, **no between-group differences** (k=2,[27,29] N=202)

40 Table 28, 33, 38
Pages in Report: 76, 80-81, 87

EQ 2 - Repeat Surgery for Recurrence (Efficacy and Safety)

Repeat lumbosacral decompression vs. spinal cord stimulation (k=1,[46] N=50)

○○○○ INSUFFICIENT Single study	▪ No pain, QOL or neurologic outcomes reported, function/disability and return to work similar differences. ▪ Reoperations: 0 vs. 3 ▪ Stable or decreased opioid use: 58% vs. 87%, P=0.025

Revision endoscopic discectomy vs. revision microdiscectomy (k=1,[47] N=100)

○○○○ INSUFFICIENT Single study	▪ Similar improvements in pain, function/disability, and neurologic symptoms ▪ Fewer surgical complications: 6% vs. 21%, P< 0.05 ▪ Shorter return to work: 4 weeks vs. 7 weeks, P<0.01 ▪ Reoperations: 2 vs. 3

41 Table 24, 28-29, 34-35, 39-40, 43
Pages in Report: 72-73, 76-77, 81-82, 87-88, 90

Clinical Practice Guideline Synthesis

- 14 CPGs or "interventional procedure guidance" documents
  - National Institute for Health and Care Excellence (UK) 2016
  - North American Spine Society 2012
  - American Pain Society 2009
  - American Society of Interventional Pain Physicians 2013
  - American College of Occupational and Environmental Medicine 2016
  - NICE interventional guidance (UK) (9 separate documents)

42 Pages in Report: 98-107

Clinical Practice Guideline Synthesis

Organization Quality Rating	Year	Recommendation	Evidence Base/ Strength of evidence
National Institute for Health and Care Excellence (U.K.) (6 out of 7)	2016	Consider spinal decompression for sciatica (includes laminectomy, foraminotomy, and/or discectomy) when nonsurgical treatment has not improved pain or function and their radiological findings are consistent with sciatica symptoms.	9 RCTs, 4 cohort studies (only evaluated surgery vs. conservative treatment) Low or very low for nearly all comparisons and outcomes (GRADE)

43 Table 48
Pages in Report: 98-107

Clinical Practice Guideline Synthesis (con't)

Organization Quality Rating	Year	Recommendation	Recommendation Rating/ Evidence Base
North American Spine Society (5 out of 7)	2012	For *patients whose symptoms are severe enough to warrant surgery:* -discectomy is suggested to provide more effective symptom relief than medical/interventional care -surgical intervention prior to 6 months is suggested, earlier surgery is associated with faster recovery	Grade: B (3 RCT, 2 PCS) Grade: B (4 unclear study designs)
		Surgical decompression provides better medium-term (1y to 4y) symptom relief compared with medical/interventional care	Grade: B (3 RCT, 1 PCS)
		Surgical decompression provides long-term (greater than four years) symptom relief	Level IV (1 RCS, 5 CS)
		Performance of sequestrectomy or aggressive discectomy is recommended for decompression	Grade: B (1 RCT, 1 PCS)
		Endoscopic and automated percutaneous discectomy may be considered	Grade: C (5 RCTs, 4 RCS, 4 PCS)
		Automated percutaneous lumbar discectomy (APLD) may achieve equivalent results to open discectomy in a select group of patients	Grade C: (3 RCTs)
		Tubular discectomy, use of fusion, surgical approach for lateral herniation, medial facetectomy, fusion for specific populations	Insufficient

Abbreviations: RCT = randomized controlled trial; RCS = retrospective cohort study; PCS = prospective cohort study; CS = case series

44 Table 48
Pages in Report: 98-107

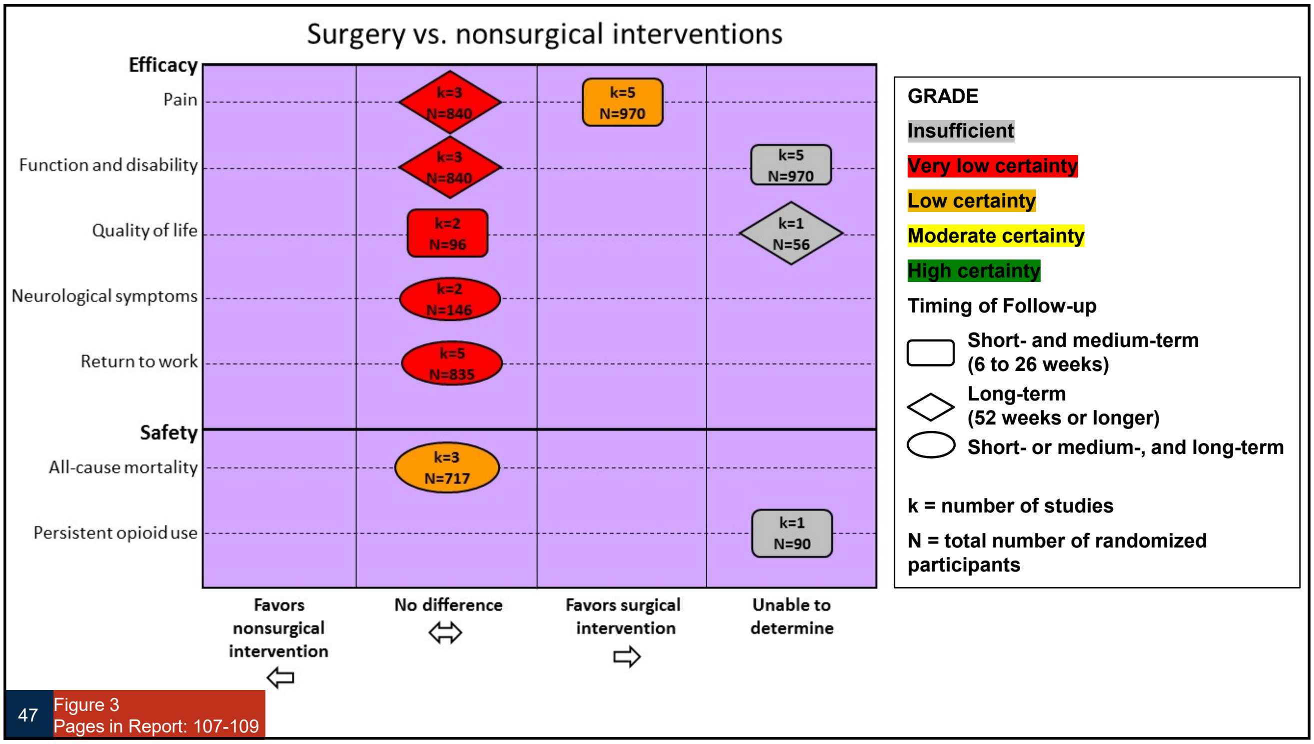
Clinical Practice Guideline Synthesis (con't)

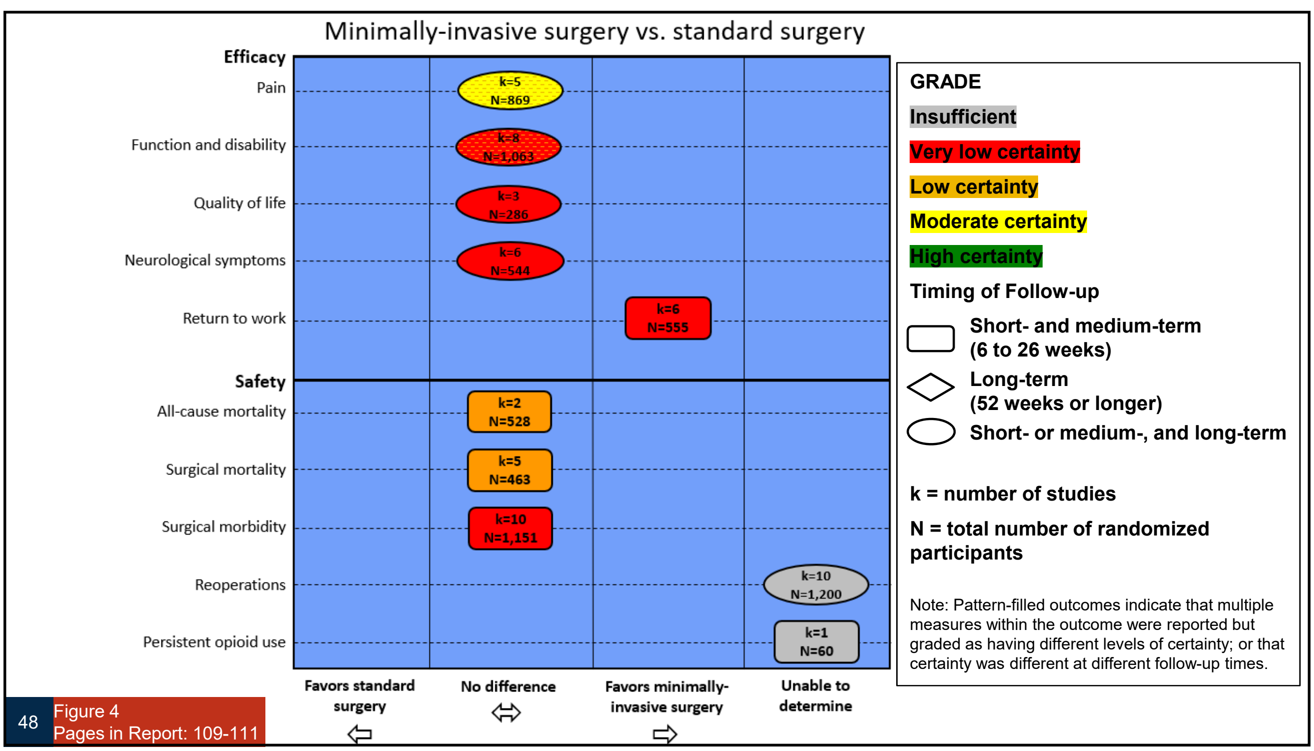
Organization Quality Rating	Year	Recommendation	Evidence Base/ Strength of evidence
American Pain Society (5 out of 7)	2009	Open discectomy or microdiscectomy for radiculopathy with prolapsed disc. - Insufficient evidence for determining superiority of open vs. micro approaches. - Insufficient evidence to evaluate alternative surgical methods, including laser- or endoscopic-assisted techniques.	4 RCTs Level B/Good Moderate net benefit for short-term outcomes (up to 12 weeks) only

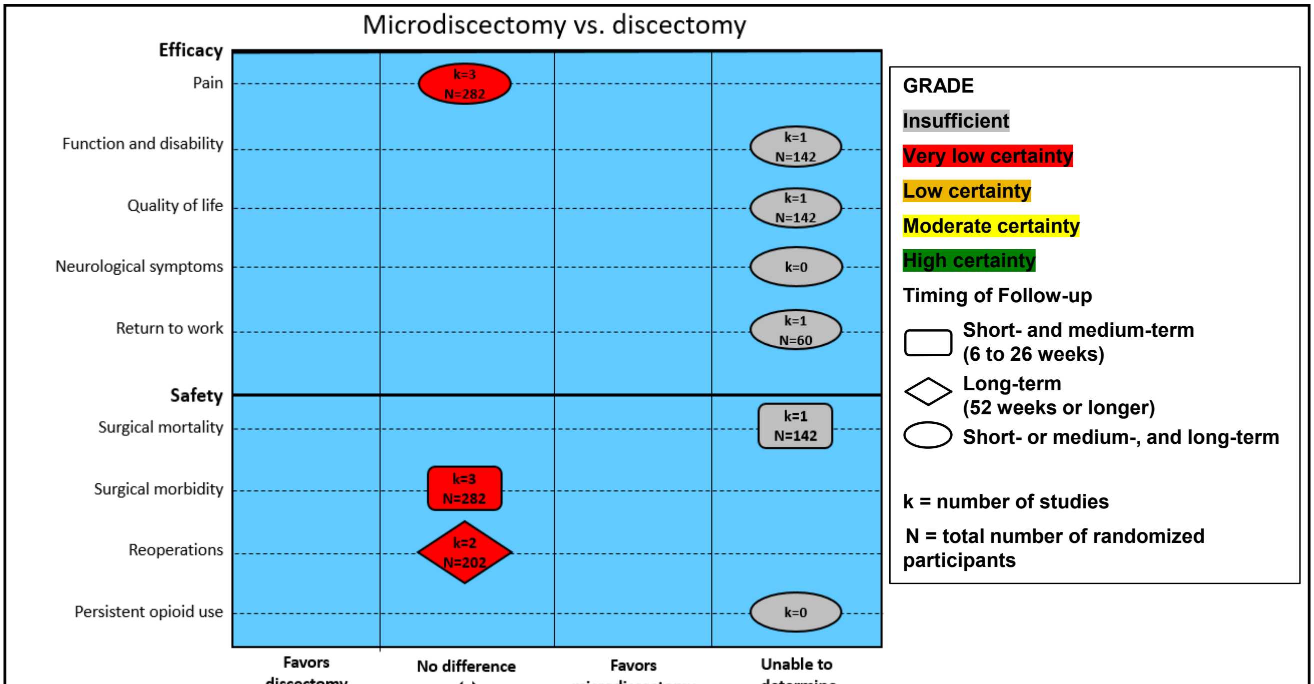
45 Table 48
Pages in Report: 98-107

Discussion

46 Pages in Report: 107-126


Surgery vs. nonsurgical interventions
Efficacy
Pain
Function and disability
Quality of life
Neurological symptoms
Return to work
Safety
All-cause mortality
Persistent opioid use
k=3 N=840
k=5 N=970
k=3 N=840
k=5 N=970
k=2 N=96
k=1 N=56
k=2 N=146
k=5 N=835
k=3 N=717
k=1 N=90
Favors nonsurgical intervention
No difference
Favors surgical intervention
Unable to determine
GRADE
Insufficient
Very low certainty
Low certainty
Moderate certainty
High certainty
Timing of Follow-up
Short- and medium-term (6 to 26 weeks)
Long-term (52 weeks or longer)
Short- or medium-, and long-term
k = number of studies
N = total number of randomized participants
47
Figure 3
Pages in Report: 107-109


Minimally-invasive surgery vs. standard surgery
Efficacy
Pain
Function and disability
Quality of life
Neurological symptoms
Return to work
Safety
All-cause mortality
Surgical mortality
Surgical morbidity
Reoperations
Persistent opioid use
k=5 N=869
k=8 N=1,063
k=3 N=286
k=6 N=544
k=6 N=555
k=2 N=528
k=5 N=463
k=10 N=1,151
k=10 N=1,200
k=1 N=60
Favors standard surgery
No difference
Favors minimally-invasive surgery
Unable to determine
GRADE
Insufficient
Very low certainty
Low certainty
Moderate certainty
High certainty
Timing of Follow-up
Short- and medium-term (6 to 26 weeks)
Long-term (52 weeks or longer)
Short- or medium-, and long-term
k = number of studies
N = total number of randomized participants
Note: Pattern-filled outcomes indicate that multiple measures within the outcome were reported but graded as having different levels of certainty; or that certainty was different at different follow-up times.
48
Figure 4
Pages in Report: 109-111



49 Figure 5
Pages in Report: 111-112

Limitations of the Evidence Base

- Nearly half of included studies were high risk of bias (poor quality).
- Studies underpowered for many outcomes of interest.
- Variation in diagnosis and severity/duration of symptoms at entry.
- Limited number of studies for any single MIS procedure.
- Variation in type, timing, and completeness in reporting outcomes.
- Applicability of older studies and RCTs to community practice.
- Limited number of U.S. cost studies.
- Limitations in AGREE guideline appraisal instrument.

50 Pages in Report: 115-118

Payer Coverage Policies

- CMS
  - No national coverage determination related to standard or microsurgical procedures
  - Non-coverage for thermal intradiscal procedures, which includes percutaneous disc decompression
- Private payers with policies cover decompressive procedures including microsurgical approaches for disc herniation with radicular symptoms.
  - Specific criteria vary by payer but often include a failed trial of conservative management for 6 to 12 weeks.
  - Most payers require imaging confirmation of nerve root compression.

Procedure	Medicare	Premera	Regence	Cigna	United	Aetna	Humana	Kaiser
Laminectomy, laminotomy, discectomy, foraminotomy	—	✓	—	—	—	✓	✓	—
Automated percutaneous lumbar disc decompression	×	×	×	×	×	✓	×	—
(Percutaneous) endoscopic discectomy	×	×	×	×	×	—	No additional reimbursement	—
(Percutaneous) laser discectomy	×	×	×	×	×	No additional reimbursement	×	—
Percutaneous nucleoplasty with coblation	×	×	×	×	×	—	—	—

Notes: ✓ = covered; × = not covered; — = no policy identified

51 Table 49 and 50
Pages in Report: 118-124

Limitations of this Health Technology Assessment

- Scope
  - English-language articles only
  - Only included efficacy outcomes reported at 4 weeks or later
  - Excluded observational studies and 'as-treated' analyses from RCTs
- Process
  - Search limited to 3 databases
  - Hand-searches for studies published prior to 2007
  - Single reviewer for title/abstract screening
- Analysis
  - Grouping of MIS procedures
    - Endoscopic procedures
    - Percutaneous procedures
    - Others: tubular or trocar discectomy, sequestrectomy

52 Page in Report: 125

Conclusions

- **Surgery** reduces pain more **compared to nonsurgical interventions** at follow-up through 26 weeks, but these findings did not persist at one year or longer. No differences in function/disability (long-term), quality of life (short-medium term), neurologic symptoms, or return to work; but evidence insufficient for quality of life (long-term), function/disability (short-medium term), and persistent opioid use.
- **Minimally-invasive surgery is comparable to microdiscectomy or discectomy** for nearly all efficacy and safety outcomes, but evidence is insufficient for reoperations and persistent opioid use.
- **Microdiscectomy and discectomy** are comparable with respect to pain, surgical morbidity, and reoperations; evidence is insufficient for all other efficacy and safety outcomes.
- The evidence is insufficient for **repeat surgery** among individuals with recurrent radiculopathy.

53 Page in Report: 126

Additional Details

54

Included Studies- Surgery vs. Nonsurgical Interventions (EQ1)

Citation	Reference
22 99 100 50	• Weinstein JN, Tosteson TD, Lurie JD, et al. Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT): a randomized trial. *Jama.* 2006;296(20):2441-2450. PMID: 17119140. doi: 10.1001/jama.296.20.2441 • Weinstein JN, Lurie JD, Tosteson TD, et al. Surgical versus nonoperative treatment for lumbar disc herniation: four-year results for the Spine Patient Outcomes Research Trial (SPORT). *Spine (Phila Pa 1976).* 2008;33(25):2789-2800. PMID: 19018250. doi: 10.1097/BRS.0b013e31818ed8f4 • Lurie JD, Tosteson TD, Tosteson AN, et al. Surgical versus nonoperative treatment for lumbar disc herniation: eight-year results for the spine patient outcomes research trial. *Spine (Phila Pa 1976).* 2014;39(1):3-16. PMID: 24153171. doi: 10.1097/BRS.0000000000000088 • Tosteson AN, Skinner JS, Tosteson TD, et al. The cost effectiveness of surgical versus nonoperative treatment for lumbar disc herniation over two years: evidence from the Spine Patient Outcomes Research Trial (SPORT). *Spine (Phila Pa 1976).* 2008;33(19):2108-2115. PMID: 18777603.
23	McMorland G, Suter E, Casha S, du Plessis SJ, Hurlbert RJ. Manipulation or microdiskectomy for sciatica? A prospective randomized clinical study. *J Manipulative Physiol Ther.* 2010;33(8):576-584. PMID: 21036279. doi: 10.1016/j.jmpt.2010.08.013
26	Weber H. Lumbar disc herniation. A controlled, prospective study with ten years of observation. *Spine (Phila Pa 1976).* 1983;8(2):131-140. PMID: 6857385.
32 97 98 49	• Peul WC, van Houwelingen HC, van den Hout WB, et al. Surgery versus prolonged conservative treatment for sciatica. *N Engl J Med.* 2007;356(22):2245-2256. PMID: 17538084. doi: 10.1056/NEJMoa064039 • Peul WC, van den Hout WB, Brand R, Thomeer RT, Koes BW. Prolonged conservative care versus early surgery in patients with sciatica caused by lumbar disc herniation: two year results of a randomised controlled trial. BMJ. 2008;336(7657):1355-1358. PMID: 18502911. doi: 10.1136/bmj.a143 • Lequin MB, Verbaan D, Jacobs WC, et al. Surgery versus prolonged conservative treatment for sciatica: 5-year results of a randomised controlled trial. *BMJ Open.* 2013;3(5). PMID: 23793663. doi: 10.1136/bmjopen-2012-002534 • van den Hout WB, Peul WC, Koes BW, Brand R, Kievit J, Thomeer RT. Prolonged conservative care versus early surgery in patients with sciatica from lumbar disc herniation: cost utility analysis alongside a randomised controlled trial. *Bmj.* 2008;336(7657):1351-1354. PMID: 18502912. doi: 10.1136/bmj.39583.709074.BE
33	Osterman H, Seitsalo S, Malmivaara A, Karppinen J. Surgery for disc herniation. A randomized controlled trial with 2-year follow-up. Paper presented at: Proceedings of the International Society for Study of the Lumbar Spine. 2003.
37	Erginousakis D, Filippiadis DK, Malagari A, et al. Comparative prospective randomized study comparing conservative treatment and percutaneous disk decompression for treatment of intervertebral disk herniation. *Radiology.* 2011;260(2):487-493. PMID: 21613439. doi: 10.1148/radiol.11101094
41	Gerszten PC, Smuck M, Rathmell JP, et al. Plasma disc decompression compared with fluoroscopy-guided transforaminal epidural steroid injections for symptomatic contained lumbar disc herniation: a prospective, randomized, controlled trial. *J Neurosurg Spine.* 2010;12(4):357-371. PMID: 20201654. doi: 10.3171/2009.10.spine09208
44	Malter AD, Larson EB, Urban N, Deyo RA. Cost-effectiveness of lumbar discectomy for the treatment of herniated intervertebral disc. *Spine (Phila Pa 1976).* 1996;21(9):1048-1054; discussion 1055. PMID: 8724089.

55

Included Studies- MIS vs. Standard Surgery (EQ1)

Citation	Reference
24	Huang TJ, Hsu RW, Li YY, Cheng CC. Less systemic cytokine response in patients following microendoscopic versus open lumbar discectomy. *J Orthop Res.* 2005;23(2):406-411. PMID: 15734255. doi: 10.1016/j.orthres.2004.08.010
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Included Studies- Microdiscectomy vs. Discectomy (EQ1)

Citation	Reference
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35	Henriksen L, Schmidt K, Eskesen V, Jantzen E. A controlled study of microsurgical versus standard lumbar discectomy. Br J Neurosurg. 1996;10(3):289-293. PMID: 8799541.

57

Included Studies- Repeat Surgery (EQ2)

Citation	Reference
46	North RB, Kidd DH, Farrokhi F, Piantadosi SA. Spinal cord stimulation versus repeated lumbosacral spine surgery for chronic pain: a randomized, controlled trial. Neurosurgery. 2005;56(1):98-106; discussion 106-107. PMID: 15617591.
47	Ruetten S, Komp M, Merk H, Godolias G. Recurrent lumbar disc herniation after conventional discectomy: a prospective, randomized study comparing full-endoscopic interlaminar and transforaminal versus microsurgical revision. J Spinal Disord Tech. 2009;22(2):122-129. PMID: 19342934. doi: 10.1097/BSD.0b013e318175ddb4

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Search Strategy and Selection Process

- Data Sources
  - Electronic search: PubMed (2007-forward), clinicaltrials.gov, Cochrane Library
  - Hand search: 40 existing systematic reviews, reference lists of pertinent articles
  - Websites: Government (FDA, NICE), Payors, Professional Societies
- Selection Process
  - English-language only
  - Title and abstracts: single reviewer screened conducted after substantial interrater reliability established on initial set of 50 titles/abstracts
  - Full text: dual independent review with one team member and the lead investigator

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Data Abstraction and Analysis

- Abstraction
  - One person abstracted data into structured template, reviewed by lead investigator for accuracy
- Risk of bias
  - Two independent assessments using ROB 2.0, QHES, and AGREE-II instruments
- Qualitative synthesis
  - By outcome and comparison (for primary research studies)
  - Tabular summary (for guideline synthesis)
- Quantitative synthesis
  - 3 or more studies with same outcome measure and compatible reporting
- Used a modified GRADE approach for assessing strength of evidence

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ROB 2.0= Cochrane risk of bias for trials; QHES= Quality of Health Economic Studies; AGREE-II = Appraisal of Guidelines for Research & Evaluation II

SOE interpretation

Grade	Definition
High	**We are very confident that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has few or no deficiencies. We believe that the findings are stable, that is, another study would not change the conclusions.
Moderate	**We are moderately confident that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has some deficiencies. We believe that the findings are likely to be stable, but some doubt remains.
Low	**We have limited confidence that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has major or numerous deficiencies (or both). We believe that additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
Very Low	**We have very limited confidence that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has numerous major deficiencies. We believe that substantial additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
Insufficient	**We have no evidence, we are unable to estimate an effect, or we have no confidence in the estimate of effect for this outcome.** No evidence is available or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

61 Table 3
Pages in Report: 12-14

Main Efficacy Outcomes Reported

Instrument	Score Range	Interpretation of Between-Group Treatment Effect	Minimally Important Difference
VAS 100 mm Pain, leg, back or general	0 to 100 Higher scores more severe	**Negative** mean difference favors intervention group	7 to 11 points
SF-36 Bodily Pain SF-36 Physical Functioning	0 to 100 (norm-based: mean 50, SD (10)) Higher scores less severe	**Positive** mean difference favors intervention group	3 to 4 points
Roland Morris Disability	1 to 24 Higher scores worse status	**Negative** mean difference favors intervention group	2 to 5 points
Oswestry Disability	0 to 100 Higher scores worse status	**Negative** mean difference favors intervention group	8 to 11 points
Sciatica Index-Bothersomeness and Frequency	0 to 24 Higher scores more severe	**Negative** mean difference favors intervention group	None established, 10% relative difference is 2.4 points

62 Table 8
Pages in Report: 27

Abbreviations

- AMD absolute mean difference
- CI confidence interval
- CS case series
- DALY disability adjusted life year
- k number of studies
- N number of participants
- MID minimally important difference
- MIS minimally-invasive surgery
- NR not reported
- NS not significant
- PCS prospective cohort study
- QALY quality-adjusted life year
- ROB risk of bias
- RCS retrospective cohort study
- RCT randomized controlled trial
- RD risk difference
- RR relative risk
- SF-36 short-form 36 survey
- SD standard deviation
- SOE strength of evidence
- VAS visual analog scale

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FINAL Key Questions and Background

Surgery for Symptomatic Lumbar Radiculopathy

Background

Radiculopathy is a clinical syndrome characterized by pain, motor weakness, and sensory disturbances in a myotomal or dermatomal distribution. When radicular symptoms are in the low back and legs, this condition is referred to as lumbar radiculopathy or sciatica. Nerve root compression is a common cause of radiculopathy and various pathological processes may be responsible, but most often it results from disc herniation or spondylosis (i.e., degenerative joint and disc disease).[1-3] Both processes can cause stenosis of the lateral recesses or neural foramina and resulting spinal nerve root compression.[1-3] Degenerative changes can also produce spondylolisthesis, central spinal canal stenosis, and facet joint hypertrophy, which may be associated with nonradicular low back pain.[1] Less common etiologies of radiculopathy include infection, inflammation, neoplasm, vascular disease, and congenital abnormalities.[1,2] Radiculopathy is a clinical diagnosis because spinal nerve root compression identified with imaging may not always be symptomatic. Thus, correlation of symptoms and physical exam with imaging is usually used to diagnose radiculopathy, with electromyography reserved for selected patients. The lifetime prevalence of lumbar radiculopathy is 3 to 5%.[1]

Lumbar radiculopathy is a heterogenous condition that may present acutely (as in the case of an acute disc herniation with chemical radiculitis) or more insidiously (as in the case of spondylosis).[1,2] Further, radiculopathy may present only with pain or with varying degrees of sensory disturbance or motor weakness.[4] The objective of treatment for radiculopathy is symptom relief. If pain or neurologic symptoms are severe or nonresponsive to conservative measures, then surgical treatment of the underlying causative mechanism may be warranted.

Policy Context

Numerous surgical and nonsurgical approaches to the management of lumbar radiculopathy have been studied and are routinely used within current clinical practice. In addition to standard open surgical techniques (e.g., discectomy with laminotomy or laminectomy as needed), minimally invasive surgical techniques that use percutaneous or endoscopic approaches are also available. This health technology assessment (HTA) will review the efficacy, safety, and cost-effectiveness of surgical interventions to treat symptomatic lumbar radiculopathy in adults to assist the State of Washington's Health Technology Clinical Committee in determining coverage for selected surgical interventions.

Scope

The proposed research questions, analytic framework, and key study selection criteria are listed in this section.

Efficacy Question 1 (EQ1). In adults with symptomatic lumbar radiculopathy, what is the effectiveness and comparative effectiveness of surgical interventions?

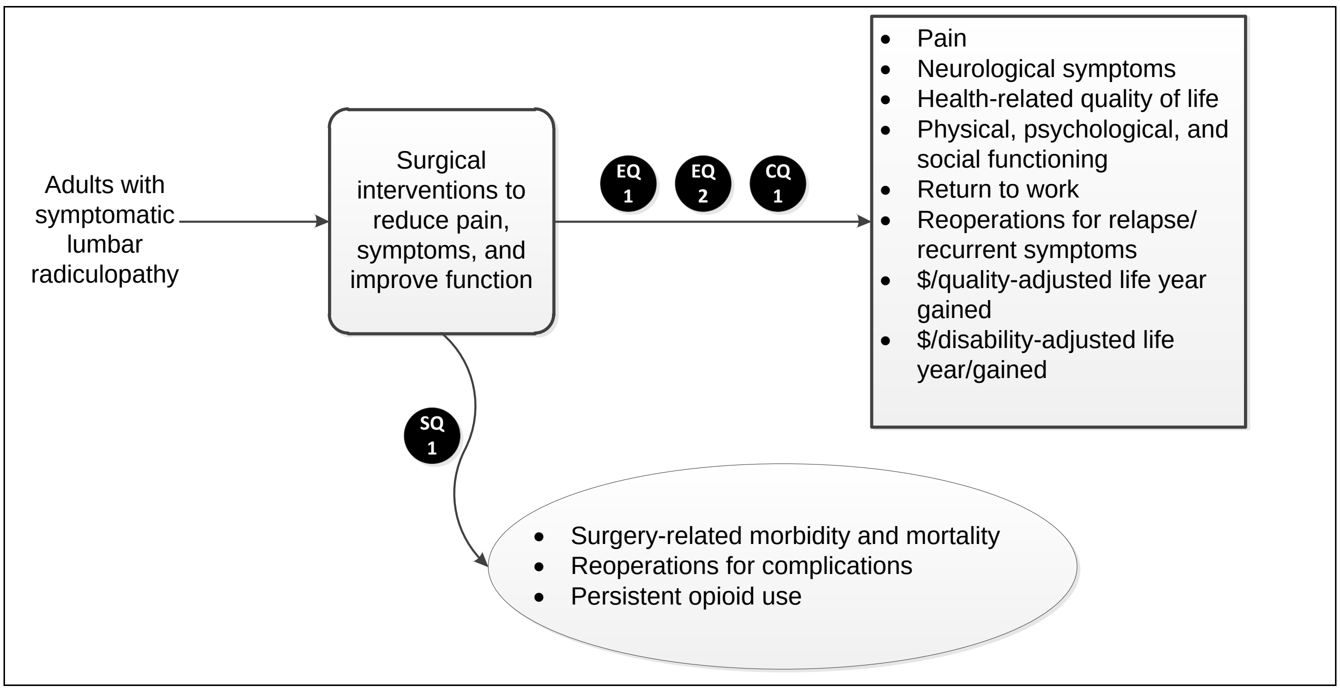
Efficacy Question 2 (EQ2). In adults with symptomatic lumbar radiculopathy, does effectiveness or comparative effectiveness of surgical interventions vary for patients who are not employed because of disability or patients who are undergoing recurrent surgery for relapse?

Safety Question 1 (SQ1). In adults with symptomatic lumbar radiculopathy, what are the adverse events associated with surgical interventions?

Cost Question 1 (CQ1). In adults with symptomatic lumbar radiculopathy, what is the cost-effectiveness of surgical interventions?

Figure 1 depicts the framework of the proposed HTA.

Figure. Analytic Framework Depicting Scope of Proposed Health Technology Assessment



Population: Adults (18 years and over) with symptomatic lumbar radiculopathy are included; adults with cauda equina syndrome, neurogenic claudication, spondylolisthesis, cervical or thoracic symptoms, traumatic or congenital structural abnormalities, or radiculopathy not related to lumbar disc herniation or spondylosis are excluded.

Intervention: The following open surgical interventions are included:

- Discectomy
- Laminectomy, laminotomy
- Foraminotomy
- Nucleotomy
- Sequestrectomy

"Micro" approaches to the above open procedures, which may involve smaller incisions, smaller areas of dissection, and use of a microscope or loupe magnification are also eligible.
Minimally invasive surgical procedures including percutaneous or endoscopic approaches to the above interventions are also eligible.

The following interventions are excluded as they are primarily designed to treat neurogenic claudication because of central spinal stenosis, spinal instability, or nonradicular low back pain.

- Spinal fusion
- Arthroplasty
- Artificial disc replacement
- Interspinous process decompression
- Minimally invasive surgical procedures designed primarily to treat discogenic low back pain or lumbar spinal stenosis

Chemonucleolysis with chymopapain is also excluded because it is a rarely used treatment for lumbar disc herniation and related radiculopathy in current practice.

Comparator: Placebo or no treatment comparators (sham surgery, expectant management); active treatment comparators including nonsurgical management (e.g., physical therapy, chiropractic treatment, epidural injection, medication) or surgical interventions listed above as eligible interventions. Studies without a comparator group, or studies that use active treatment interventions that are listed as ineligible interventions will be excluded.

Outcomes

Efficacy: Pain, neurologic symptoms, health-related quality of life, physical, psychological, and social functioning, return to work, reoperations for relapse; measures of pain, quality of life, and function must be measured using valid and reliable instruments or scales. Only outcomes reported at 4 weeks post-op or later will be included as differences in efficacy before 4 weeks may not be clinically relevant.

Safety: Surgery-related morbidity including venous thromboembolism, paralysis, new onset neurologic symptoms, dural tear, epidural hematoma, surgical mortality, reoperations for complications, persistent opioid use

Cost/Cost-Effectiveness: cost per quality-adjusted life years gained, cost per disability-adjusted life years gained

Setting: Inpatient or outpatient settings in countries categorized as "very high" on United National Human Development Index

Time Period: No restriction on included studies; however, search strategy will use existing systematic reviews to identify potentially relevant studies published prior to 2007.

Other Criteria

Only studies published in English will be included.

For all efficacy and safety research questions, only controlled clinical trials, randomized clinical trials, and systematic reviews of controlled or randomized clinical trials will be included. For active treatment comparisons, only randomized clinical trials or systematic reviews of randomized clinical trials will be included. For cost-effectiveness research question, we will include cost-effectiveness, cost-utility, or cost-benefit analyses performed from payor or societal perspectives.

Studies will be included regardless of risk of bias, however; we will only include studies with a high risk of bias rating in quantitative analysis if fewer than 3 studies are available.

References

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2. Hsu PS, Armon C, Levin K. Acute lumosacral radiculopathy: Pathophysiology, clinical features, and diagnosis. Waltham, MA: UpToDate Inc.; 2017.
3. Genevay S, Atlas SJ. Lumbar Spinal Stenosis. Best practice & research. Clinical rheumatology. 2010;24(2):253-65. doi: 10.1016/j.berh.2009.11.001
4. Levin K, S. HP, C. A. Acute lumbosacral radiculopathy: Treatment and prognosis. Waltham, MA: UpToDate Inc.; 2017.

Public comment and response

See ***Draft Key Questions: Public Comment & Response*** document published separately.

HTCC Coverage and Reimbursement Determination
Analytic Tool

HTA's goal is to achieve *better health care outcomes* for enrollees and beneficiaries of state programs by paying for proven health *technologies that work*.

To find best outcomes and value for the state and the patient, the HTA program focuses on three questions:

1. Is it safe?
2. Is it effective?
3. Does it provide value (improve health outcome)?

The principles HTCC uses to review evidence and make determinations are:

Principle One: Determinations are evidence-based

HTCC requires scientific evidence that a health technology is safe, effective and cost-effective[1] as expressed by the following standards[2]:

- Persons will experience better health outcomes than if the health technology was not covered and that the benefits outweigh the harms.
- The HTCC emphasizes evidence that directly links the technology with health outcomes. Indirect evidence may be sufficient if it supports the principal links in the analytic framework.
- Although the HTCC acknowledges that subjective judgments do enter into the evaluation of evidence and the weighing of benefits and harms, its recommendations are not based largely on opinion.
- The HTCC is explicit about the scientific evidence relied upon for its determinations.

Principle Two: Determinations result in health benefit

The outcomes critical to HTCC in making coverage and reimbursement determinations are health benefits and harms[3]:

- In considering potential benefits, the HTCC focuses on absolute reductions in the risk of outcomes that people can feel or care about.
- In considering potential harms, the HTCC examines harms of all types, including physical, psychological, and non-medical harms that may occur sooner or later as a result of the use of the technology.
- Where possible, the HTCC considers the feasibility of future widespread implementation of the technology in making recommendations.
- The HTCC generally takes a population perspective in weighing the magnitude of benefits against the magnitude of harms. In some situations, it may make a determination for a technology with a large potential benefit for a small proportion of the population.

[1] Based on Legislative mandate: See RCW 70.14.100(2).

[2] The principles and standards are based on USPSTF Principles at: http://www.ahrq.gov/clinic/ajpmsuppl/harris3.htm

[3] The principles and standards are based on USPSTF Principles at: http://www.ahrq.gov/clinic/ajpmsuppl/harris3.htm

- In assessing net benefits, the HTCC subjectively estimates the indicated population's value for each benefit and harm. When the HTCC judges that the balance of benefits and harms is likely to vary substantially within the population, coverage or reimbursement determinations may be more selective based on the variation.
- The HTCC considers the economic costs of the health technology in making determinations, but costs are the lowest priority.

Using evidence as the basis for a coverage decision

Arrive at the coverage decision by identifying for Safety, Effectiveness, and Cost whether (1) evidence is available, (2) the confidence in the evidence, and (3) applicability to decision.

1. *Availability of evidence:*

Committee members identify the factors, often referred to as outcomes of interest, that are at issue around safety, effectiveness, and cost. Those deemed key factors are ones that impact the question of whether the particular technology improves health outcomes. Committee members then identify whether and what evidence is available related to each of the key factors.

2. *Sufficiency of the evidence:*

Committee members discuss and assess the evidence available and its relevance to the key factors by discussion of the type, quality, and relevance of the evidence[4] using characteristics such as:

- Type of evidence as reported in the technology assessment or other evidence presented to committee (randomized trials, observational studies, case series, expert opinion);
- The amount of evidence (sparse to many number of evidence or events or individuals studied);
- Consistency of evidence (results vary or largely similar);
- Recency (timeliness of information);
- Directness of evidence (link between technology and outcome);
- Relevance of evidence (applicability to agency program and clients);
- Bias (likelihood of conflict of interest or lack of safeguards).

Sufficiency or insufficiency of the evidence is a judgment of each clinical committee member and correlates closely to the GRADE confidence decision.

Not Confident	Confident
Appreciable uncertainty exists. Further information is needed or further information is likely to change confidence.	Very certain of evidentiary support. Further information is unlikely to change confidence

[4] Based on GRADE recommendation: http://www.gradeworkinggroup.org/FAQ/index.htm

3. Factors for Consideration - Importance

At the end of discussion a vote is taken on whether sufficient evidence exists regarding the technology's safety, effectiveness, and cost. The committee must weigh the degree of importance that each particular key factor and the evidence that supports it has to the policy and coverage decision. Valuing the level of importance is factor or outcome specific but most often include, for areas of safety, effectiveness, and cost:

- Risk of event occurring;
- The degree of harm associated with risk;
- The number of risks; the burden of the condition;
- Burden untreated or treated with alternatives;
- The importance of the outcome (e.g. treatment prevents death vs. relief of symptom);
- The degree of effect (e.g. relief of all, none, or some symptom, duration, etc.);
- Value variation based on patient preference.

Clinical committee findings and decisions

Efficacy considerations

- What is the evidence that use of the technology results in more beneficial, important health outcomes? Consider:
  - Direct outcome or surrogate measure
  - Short term or long term effect
  - Magnitude of effect
  - Impact on pain, functional restoration, quality of life
  - Disease management
- What is the evidence confirming that use of the technology results in a more beneficial outcome, compared to no treatment or placebo treatment?
- What is the evidence confirming that use of the technology results in a more beneficial outcome, compared to alternative treatment?
- What is the evidence of the magnitude of the benefit or the incremental value?
- Does the scientific evidence confirm that use of the technology can effectively replace other technologies or is this additive?
- For diagnostic tests, what is the evidence of a diagnostic tests' accuracy?
  - Does the use of the technology more accurately identify both those with the condition being evaluated and those without the condition being evaluated?
- Does the use of the technology result in better sensitivity and better specificity?
- Is there a tradeoff in sensitivity and specificity that on balance the diagnostic technology is thought to be more accurate than current diagnostic testing?
- Does use of the test change treatment choices?

Health Technology Evidence Identification

Safety

- What is the evidence of the effect of using the technology on significant morbidity?
  - Frequent adverse effect on health, but unlikely to result in lasting harm or be life-threatening, or;
  - Adverse effect on health that can result in lasting harm or can be life-threatening?
- Other morbidity concerns?
- Short term or direct complication versus long term complications?
- What is the evidence of using the technology on mortality – does it result in fewer adverse non-fatal outcomes?

Cost impact

- Do the cost analyses show that use of the new technology will result in costs that are greater, equivalent or lower than management without use of the technology?

Overall

- What is the evidence about alternatives and comparisons to the alternatives?
- Does scientific evidence confirm that use of the technology results in better health outcomes than management without use of the technology?

Next step: Cover or no cover

If not covered, or covered unconditionally, the chair will instruct staff to write a proposed findings and decision document for review and final adoption at the following meeting.

Next step: Cover with conditions

If covered with conditions, the committee will continue discussion.

1) Does the committee have enough information to identify conditions or criteria?
   - Refer to evidence identification document and discussion.
   - Chair will facilitate discussion, and if enough members agree, conditions and/or criteria will be identified and listed.
   - Chair will instruct staff to write a proposed findings and decision document for review and final adoption at next meeting.
2) If not enough or appropriate information, then Chair will facilitate a discussion on the following:
   - What are the known conditions/criteria and evidence state
   - What issues need to be addressed and evidence state

The chair will delegate investigation and return to group based on information and issues identified. Information known but not available or assembled can be gathered by staff ; additional clinical questions may need further research by evidence center or may need ad hoc advisory group; information on agency utilization, similar coverage decisions may need agency or other health plan input; information on current practice in community or beneficiary preference may need further public input. Delegation should include specific instructions on the task, assignment or issue; include a time frame; provide direction on membership or input if a group is to be convened.

Clinical committee evidence votes

First voting question

The HTCC has reviewed and considered the technology assessment and information provided by the administrator, reports and/or testimony from an advisory group, and submissions or comments from the public. The committee has given greatest weight to the evidence it determined, based on objective factors, to be the most valid and reliable.

Discussion document: What are the key factors and health outcomes and what evidence is there? (Applies to the population in the PICO for this review)

Safety outcomes	Importance of outcome	Safety evidence/ confidence in evidence
Mortality		
Surgical morbidity		
Reoperations		
Persistent opioid use		

Efficacy –effectiveness outcomes	Importance of outcome	Efficacy / Effectiveness evidence
Pain		
Function/ disability		
Quality of life		
Neurological symptoms		
Return to work		

Cost outcomes	Importance of outcome	Cost evidence
Cost effectiveness		
Direct costs		

Special population / Considerations outcomes	Importance of outcome	Special populations/ Considerations evidence
Employment status		

Health Technology Evidence Identification

For safety:

Is there sufficient evidence that the technology is safe for the indications considered?

Unproven (no)	Less (yes)	Equivalent (yes)	More in some (yes)	More in all (yes)

For efficacy/ effectiveness:

Is there sufficient evidence that the technology has a meaningful impact on patients and patient care?

Unproven (no)	Less (yes)	Equivalent (yes)	More in some (yes)	More in all (yes)

For cost outcomes/ cost-effectiveness:

Is there sufficient evidence that the technology is cost-effective for the indications considered?

Unproven (no)	Less (yes)	Equivalent (yes)	More in some (yes)	More in all (yes)

Health Technology Evidence Identification

Discussion

Based on the evidence vote, the committee may be ready to take a vote on coverage or further discussion may be warranted to understand the differences of opinions or to discuss the implications of the vote on a final coverage decision.

- Evidence is insufficient to make a conclusion about whether the health technology is safe, efficacious, and cost-effective;
- Evidence is sufficient to conclude that the health technology is unsafe, ineffectual, or not cost-effective
- Evidence is sufficient to conclude that the health technology is safe, efficacious, and cost-effective for all indicated conditions;
- Evidence is sufficient to conclude that the health technology is safe, efficacious, and cost-effective for some conditions or in some situations

A straw vote may be taken to determine whether, and in what area, further discussion is necessary.

Second Vote

Based on the evidence about the technologies' safety, efficacy, and cost-effectiveness, it is

_____Not covered _____ Covered unconditionally _____ Covered under certain conditions

Discussion item

Is the determination consistent with identified Medicare decisions and expert guidelines, and if not, what evidence is relied upon.

Next step: proposed findings and decision and public comment

At the next public meeting the committee will review the proposed findings and decision and consider any public comments as appropriate prior to a vote for final adoption of the determination.

1) Based on public comment was evidence overlooked in the process that should be considered?
2) Does the proposed findings and decision document clearly convey the intended coverage determination based on review and consideration of the evidence?

Next step: final determination

Following review of the proposed findings and decision document and public comments:

Final vote

Does the committee approve the Findings and Decisions document with any changes noted in discussion?

If yes, the process is concluded.

If no, or an unclear (i.e., tie) outcome chair will lead discussion to determine next steps.

Medicare coverage and guidelines
[From page 118 of the Final Evidence Report]

The Centers for Medicare and Medicaid Services (CMS) does not have a national coverage determination related to open standard or microsurgical decompressive procedures (i.e., discectomy, microdiscectomy, foraminotomy, laminectomy/otomy).

[Guidelines from Pages 99-106 of the Final Evidence Report]

Organization *Guideline Title (Year)* Guideline Quality[a]	Recommendation[b]	Evidence Base	Rating/Strength of Evidence Narrative Assessment
National Institute for Health and Care Excellence (United Kingdom) *Low back pain and sciatica in over 16s: assessment and management-Invasive treatments (2016)*[45] Quality Rating: 6 out of 7	Consider spinal decompression for sciatica (includes laminectomy, foraminotomy, and/or discectomy) when nonsurgical treatment has not improved pain or function and their radiological findings are consistent with sciatica symptoms.	9 RCTs comparing surgery to nonsurgical treatment including epidural steroids, analgesics and anti-inflammatory medication, physical therapy[c] 4 cohort studies comparing decompression to fusion or conservative treatment	Low or very low for nearly all comparisons and outcomes[d] Sciatic symptoms tend to improve naturally with time without treatment, but earlier symptom resolution with surgical intervention should be an option for people.
North American Spine Society *Clinical Guidelines for Diagnosis and Treatment of Lumbar Disc Herniation with Radiculopathy (2012)*[57] Quality Rating: 5 out of 7	Discectomy is suggested to provide more effective symptom relief than medical/interventional care for patients with lumbar disc herniation with radiculopathy whose symptoms warrant surgical intervention. In patients with less severe symptoms, surgery or medical/interventional care appear to be effective for both short- and long-term relief.	3 RCTs 2 prospective comparative cohort studies	Grade: B[e]
	Surgical intervention prior to 6 months is suggested in patients with symptomatic lumbar disc herniation whose symptoms are severe enough to warrant surgery. Earlier surgery (within 6 months to 1 year) is associated with faster recovery and improved long-term outcomes.	4 studies (unclear study design)	Grade: B[e]
	The performance of surgical decompression is suggested to provide better medium-term (1 to 4 years) symptom relief as compared with medical/interventional management of patients with radiculopathy from lumbar disc herniation whose symptoms are severe enough to warrant surgery.	3 RCTs 1 prospective comparative cohort study	Grade: B[e]
	Surgical decompression provides long-term (greater than four years) symptom relief for patients with radiculopathy from lumbar disc herniation whose symptoms warrant surgery. It should be noted that a substantial portion (23-28%) of patients will have chronic back or leg pain.	1 retrospective comparative cohort study 5 retrospective case series	f Evidence: IV[e]

(continued)

Table 48. Clinical practice guidelines related to lumbar radiculopathy or herniated intervertebral lumbar disc (continued)

Organization *Guideline Title (Year)* Guideline Quality[a]	Recommendation[b]	Evidence Base	Rating/Strength of Evidence Narrative Assessment
North American Spine Society (continued)	When surgery is indicated, performance of sequestrectomy or aggressive discectomy is recommended for decompression in patients with lumbar disc herniation with radiculopathy since there is no difference in rates of reherniation.	1 RCT 1 prospective comparative cohort study	Grade: B[e]
	Use of an operative microscope is suggested to obtain comparable outcomes to open discectomy for patients with lumbar disc herniation with radiculopathy whose symptoms warrant surgery.	2 RCTs	Grade: B[e]
	Endoscopic percutaneous discectomy is suggested for carefully selected patients to reduce early postoperative disability and reduce opioid use compared with open discectomy in the treatment of patients with lumbar disc herniation with radiculopathy.	3 RCTs	Grade: B[e]
	Endoscopic percutaneous discectomy may be considered for the treatment of lumbar disc herniation with radiculopathy.	3 RCTs 4 retrospective case series	Grade: C[e]
	Automated percutaneous discectomy may be considered for the treatment of lumbar disc herniation with radiculopathy.	2 RCTs 4 prospective case series	Grade: C[e]
	In a select group of patients automated percutaneous lumbar discectomy (APLD) may achieve equivalent results to open discectomy, however, this equivalence is not felt to be generalizable to all patients with lumbar disc herniation with radiculopathy whose symptoms warrant surgery.	3 RCTs	Level of Evidence: II/III[e]
	There is insufficient evidence to make a recommendation for or against the following: Urgent surgery for patients with motor deficits Use of spinal manipulation as an alternative to discectomy The specific surgical approach for far lateral disc herniation Use of tubular discectomy compared with open discectomy Use of medial facetectomy with discectomy Use of fusion for specific patient populations with lumbar disc herniation and radiculopathy	--	Grade: I[e]

(continued)

Table 48. Clinical practice guidelines related to lumbar radiculopathy or herniated intervertebral lumbar disc (continued)

Organization *Guideline Title (Year)* Guideline Quality[a]	Recommendation[b]	Evidence Base	Rating/Strength of Evidence Narrative Assessment
North American Spine Society (continued)	Use of percutaneous electrothermal disc decompression Use of intradiscal high-pressure saline injection Use of automated percutaneous discectomy compared with open discectomy Use of plasma disc decompression/nucleoplasty Use of plasma disc decompression as compared with transforaminal epidural steroid injections in patients with lumbar disc herniation who have previously failed transforaminal epidural steroid injection therapy		
American Pain Society *Interventional Therapies, Surgery, and Interdisciplinary Rehabilitation for Low Back Pain (2009)*[55] Quality Rating: 5 out of 7	Open discectomy or microdiscectomy for radiculopathy with prolapsed disc.	4 RCTs comparing surgery to conservative management	Level B/Good[f] Moderate net benefit for short-term outcomes (up to 12w) only
	Insufficient evidence for determining superiority of open vs. micro approaches.		
	Insufficient evidence to evaluate alternative surgical methods, including laser- or endoscopic-assisted techniques."		
American Society of Interventional Pain Physicians *An Update of Comprehensive Evidence-Based Guidelines for Interventional Techniques in Chronic Spinal Pain (2013)*[21,56] Quality Rating: 4 out of 7	For lumbar disc prolapse, protrusion, and extrusion: automated percutaneous lumbar decompression (APLD), percutaneous lumbar disc decompression (PLDD), and mechanical decompression with nucleoplasty are recommended in select cases.	19 observational studies for APLD. 15 observational studies for laser-assisted PLDD 1 SR of 3 observational studies PLDD with DeKompressor. 1 RCT and 14 observational studies for nucleoplasty.	The evidence is limited for APLD, PLDD, and percutaneous disc decompression with DeKompressor. The evidence is limited to fair for mechanical lumbar disc decompression with nucleoplasty.

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Table 48. Clinical practice guidelines related to lumbar radiculopathy or herniated intervertebral lumbar disc (continued)

Organization *Guideline Title (Year)* Guideline Quality[a]	Recommendation[b]	Evidence Base	Rating/Strength of Evidence Narrative Assessment
American College of Occupational and Environmental Medicine *Low back disorders. In occupational medicine practice guidelines: evaluation and management of common health problems and functional recovery in workers (2016)*[54] Quality Rating: Unknown[g]	Patients with evidence of specific nerve root compromise confirmed by appropriate imaging studies may be expected to potentially benefit from surgery. Quality evidence indicates that patient outcomes are not adversely affected by delaying nonemergent surgery for weeks or a few months and continued conservative care is encouraged in patients with stable or improving deficits who desire to avoid surgery. However, patients with either moderate to severe neurological deficits that are not improving or trending to improvement at 4 to 6 weeks may benefit from earlier surgical intervention. Those with progressive neurological deficit(s) are believed to have indications for immediate surgery. Those with severe deficits that do not rapidly improve are also candidates for earlier testing and referrals.	Unknown[g]	Unknown[g]
National Institute for Health and Care Excellence (United Kingdom) *Percutaneous transforaminal endoscopic lumbar discectomy for sciatica: Interventional procedures guidance [IPG 556] (2016)*[58] Quality Rating: 2 out of 7	Current evidence on the safety and efficacy of percutaneous transforaminal endoscopic lumbar discectomy for sciatica is adequate to support the use of this procedure provided that standard arrangements are in place for clinical governance, consent and audit. Percutaneous transforaminal endoscopic lumbar discectomy for sciatica is a procedure that needs particular experience. Surgeons should acquire the necessary expertise through specific training and mentoring. It should only be done by surgeons who do the procedure regularly.	1 SR of observational studies 1 retrospective comparative cohort study 2 prospective case series 5 retrospective case series	None provided

(continued)

Table 48. Clinical practice guidelines related to lumbar radiculopathy or herniated intervertebral lumbar disc (continued)

Organization *Guideline Title (Year)* Guideline Quality[a]	Recommendation[b]	Evidence Base	Rating/Strength of Evidence Narrative Assessment
National Institute for Health and Care Excellence (United Kingdom) *Percutaneous interlaminar endoscopic lumbar discectomy for sciatica: Interventional procedures guidance[IPG555](2016)*[59] Quality Rating: 2 out of 7	Current evidence on the safety and efficacy of percutaneous interlaminar endoscopic lumbar discectomy for sciatica is adequate to support the use of this procedure provided that standard arrangements are in place for clinical governance, consent and audit. Percutaneous interlaminar endoscopic lumbar discectomy for sciatica is a procedure that needs particular experience. Surgeons should acquire the necessary expertise through specific training and mentoring. It should only be done by surgeons who do the procedure regularly.	2 RCTs 2 retrospective comparative cohort studies 4 retrospective case series	None provided
National Institute for Health and Care Excellence (United Kingdom) *Percutaneous coblation of the intervertebral disc for low back pain and sciatica Interventional procedures guidance[IPG543](2016)*[60] Quality Rating: 2 out of 7	Current evidence on percutaneous coblation of the intervertebral disc for low back pain and sciatica raises no major safety concerns. The evidence on efficacy is adequate and includes large numbers of patients with appropriate follow-up periods. Therefore, this procedure may be used provided that normal arrangements are in place for clinical governance, consent and audit. As part of the consent process, patients should be informed that there is a range of treatment options available to them and that further procedures may be needed.	1 SR 2 RCTs 1 case series	None provided
National Institute for Health and Care Excellence (United Kingdom) Percutaneous electrothermal treatment of the intervertebral disc annulus for low back pain and sciatica Interventional procedures guidance[IPG544](2016)[61] Quality Rating: 2 out of 7	Current evidence on percutaneous electrothermal treatment of the intervertebral disc annulus for low back pain and sciatica raises no major safety concerns. The evidence on efficacy is inconsistent and of poor quality. Therefore, this procedure should only be used with special arrangements for clinical governance, consent and audit or research.	1 SR 1 RCT 1 Cohort study	None provided

(continued)

Table 48. Clinical practice guidelines related to lumbar radiculopathy or herniated intervertebral lumbar disc (continued)

Organization *Guideline Title (Year)* Guideline Quality[a]	Recommendation[b]	Evidence Base	Rating/Strength of Evidence Narrative Assessment
National Institute for Health and Care Excellence (United Kingdom) *Percutaneous intradiscal radiofrequency treatment of the intervertebral disc nucleus for low back pain. Interventional procedures guidance[IPG545] (2016)*[62] Quality Rating: 2 out of 7	Current evidence on percutaneous intradiscal radiofrequency treatment of the intervertebral disc nucleus for low back pain raises no major safety concerns. The evidence on its efficacy is limited in quantity and quality. Therefore, this procedure should only be used with special arrangements for clinical governance, consent and audit or research.	1 RCT 1 nonrandomized CT 2 case series	None provided
National Institute for Health and Care Excellence (United Kingdom) *Epiduroscopic lumbar discectomy through the sacral hiatus for sciatica Interventional procedures guidance[IPG570] (2016)*[63] Quality Rating: 2 out of 7	Current evidence on the safety and efficacy of epiduroscopic lumbar discectomy through the sacral hiatus for sciatica is limited in quantity and quality. Therefore, this procedure should only be used in the context of research.	1 Cohort study	None provided
National Institute for Health and Care Excellence (United Kingdom) *Percutaneous intradiscal laser ablation in the lumbar spine. Interventional procedures guidance[IPG357] (2010)*[64] Quality Rating: 2 out of 7	Current evidence on the safety and efficacy of percutaneous intradiscal laser ablation in the lumbar spine is adequate to support the use of this procedure provided that normal arrangements are in place for clinical governance, consent and audit. Patients selected for the procedure should be limited to those with severe pain refractory to conservative treatment, in whom imaging studies show bulging of an intact disc, and who do not have neurological deficit requiring surgical decompression.	1 RCT 2 Cohort studies 2 Case series	None provided

(continued)

Table 48. Clinical practice guidelines related to lumbar radiculopathy or herniated intervertebral lumbar disc (continued)

Organization *Guideline Title (Year)* Guideline Quality[a]	Recommendation[b]	Evidence Base	Rating/Strength of Evidence Narrative Assessment
National Institute for Health and Care Excellence (United Kingdom) *Automated percutaneous mechanical lumbar discectomy: Interventional procedures guidance[IPG141])(2005)*[65] Quality Rating: 2 out of 7	Current evidence suggests that there are no major safety concerns associated with automated percutaneous mechanical lumbar discectomy. There is limited evidence of efficacy based on uncontrolled case series of heterogeneous groups of patients, but evidence from small randomized controlled trials shows conflicting results. In view of the uncertainties about the efficacy of the procedure, it should not be used without special arrangements for consent and for audit or research. Clinicians wishing to undertake automated percutaneous mechanical lumbar discectomy should take the following actions. Inform the clinical governance leads in their Trusts. Ensure that patients understand the uncertainty about the procedure's efficacy and provide them with clear written information. In addition, use of the Institute's information for the public is recommended. Audit and review clinical outcomes of all patients having automated mechanical percutaneous lumbar discectomy.	3 RCTs 5 case series	None provided
National Institute for Health and Care Excellence (United Kingdom) *Endoscopic laser foraminoplasty. Interventional procedures guidance[IPG31] (2003)*[66] Quality Rating: 2 out of 7	Current evidence of the safety and efficacy of endoscopic laser foraminoplasty does not appear adequate to support the use of this procedure without special arrangements for consent and for audit or research. Clinicians wishing to undertake endoscopic laser foraminoplasty should inform the clinical governance leads in their Trusts. They should ensure that patients offered the procedure understand the uncertainty about its safety and efficacy and should provide them with clear written information. Use of the Institute's information for the public is recommended. Clinicians should ensure that appropriate arrangements are in place for audit or research. Further research into safety and efficacy outcomes will be useful in reducing the current uncertainty. NICE is not undertaking further investigation at present.	3 Cohort studies 2 Case series	None provided

[a] We assessed the quality of guideline using the Appraisal of Guidelines For Research & Evaluation II (AGREE II) Instrument, version 2017.[21] The lowest quality score possible is 1, the highest possible quality score is 7.

[b] Only recommendations from the guideline pertinent to surgical interventions for lumbar radiculopathy are summarized.

[c] One included trial was for treatment of sciatica with spinal stenosis, the rest were for treatment of lumbar radiculopathy

[d] Based on GRADE.

[e] Level 1=high quality RCTs or SRs of RCTs; Level II=lesser quality RCTs, prospective comparative studies, SRs that include Level II studies; Level III=Case control or retrospective cohort studies, SRs of Level III studies, Level 4=case series; Level 5= Expert Opinion, Grade A=Good evidence (Level 1 studies with consistent findings); Grade B=Fair evidence (Level II or III studies with consistent findings), Grade C=Poor evidence (Level IV or V studies); Grade I=insufficient or conflicting evidence not allowing a recommendation

[f] One included trial was for treatment of sciatica with spinal stenosis, the rest were for treatment of lumbar radiculopathy

[g] The complete guideline is not publicly accessible; thus, a full quality appraisal and summary of the evidence base and strength of evidence ratings were not possible.

Abbreviations: RCT = randomized controlled trial; SR = systematic review; CT = controlled trial; w = week(s); y = year(s); APLD = automated percutaneous lumbar decompression; PLDD = percutaneous lumbar disc decompression.