**Supplemental Digital Material: Treatment of cervical ASP**

**Level of Evidence table**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Methodological principle** | **Hilibrand (1997)** | **Gause (2008)** | **Matsumoto (2006)** | **Baba**  **(1994)** | **Phillips (2009)** |
| Study design |  |  |  |  |  |
| Randomized controlled trial |  |  |  |  |  |
| Cohort study | + |  |  |  |  |
| Case-series |  | +\* | +† | + | +‡ |
| Statement of concealed allocation\* |  |  |  |  |  |
| Intent-to-treat\* |  |  |  |  |  |
| Independent or blind assessment |  |  |  |  |  |
| Complete follow-up of ≥85% |  |  |  |  |  |
| Adequate sample size |  |  |  |  |  |
| Controlling for possible confounding |  | + |  |  |  |
| **Evidence Class** | III | IV | IV | IV | IV |

\*Treated as a case series due to small size of the comparative group.

†A case series for purposes of this report; the comparison group has too few observations for analysis in this report.

‡Study compares ADR as treatment next to previous fusion with primary treatment; only the adjacent segment treatment is considered in this report.

**Strength of evidence summary**

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| --- | --- | --- | --- | --- | --- |
| Baseline quality:  HIGH = majority of article Level I/II.  LOW = majority of articles Level III/IV.  UPGRADE:  Large magnitude of effect (1 or 2 levels); dose response gradient (1 level)  DOWNGRADE:  Inconsistency of results (1 or 2 levels); indirectness of evidence (1 or 2 levels); imprecision of effect estimates (1 or 2 levels) | | | | | |
|  | **Strength of evidence** | **Conclusions/Comments** | **Baseline** | **UPGRADE (levels)** | **DOWN-GRADE**  **(levels)** |
| **Question 1: What is the comparative effectiveness and safety of operative versus non-operative treatments for cervicalCASP** | | | | | |
| Operative vs. non-operative treatment | INSUFFICIENT | No studies identified | INSUFFICIENT | NO | NO |
| **Question 2: Describe the outcomes of surgical treatment of clinical adjacent segment pathology (CASP).** | | | | | |
| Surgical treatment | INSUFFICIENT | Retrospective case series (LoE IV) described favorable outcomes after laminoplasty (2 studies) and fusion with ACDF or corpectomy (1 study).  A prospective study compared VAS pain scores and NDI among 26 patients who received disc arthroplasty for CASP compared with 126 patients who underwent primary disc arthroplasty. Similar outcomes were reported for both groups, but large standard deviations are noted. | INSUFFICIENT | NO | NO |
| Risk factors | INSUFFICIENT | The location of fusion with respect to CASP was a marginally significant factor in one study, with higher rates of pseudoarthrosis for fusions caudal to the CASP. | INSUFFICIENT | NO | NO |

**Evidence table for the treatment of cervical ASD:**

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| --- | --- | --- | --- | --- | --- | --- |
| Author (year)  Study type (LoE) | Demographics | Definition ASD | Treatment | | Outcomes | |
| Key question 1: | | | Operative | Nonoperative | Outcomes | Statistical |
| (no comparative studies found) | | | | | |  |
| Key question 2: | | | Operative | Operative |  |  |
| Hilibrand (1997)  Retrospective cohort | N = 38  Previous fusion a mean of 68 month (24-183 months) prior  f/u: “regular intervals” | New radiculopathy in a distribution referable to a segment adjacent to a prior anterior cervical fusion, and radiographic evidence of segmental degeneration with compression of nerve roots, spinal cord, or both | Discectomy with interbody grafting n = 24  1-level: n = 11  Multi-level: n = 13 | Corpectomy with strut grafting n = 14 | Solid arthrodesis:  Discectomy: n = 15/24 (62.5%)  Corpectomy: n = 14/14 (100%) | P = 0.01 |
| Solid arthrodesis: single-level procedure: n = 7/11, 64%)  multi-level procedure: n = 8/13, 62%) | P = 1.0 |
| Clinical outcomes: Discectomy: n = 9/24 excellent, 11/24 good, 4/24 fair  Corpectomy: n = 7/14 excellent, 5/14 good, 2/14 fair | P = 0.55 |
| Clinical outcomes:  Solid arthrodesis: good or excellent outcomes in n = 26/29  Pseudarthrosis: good or excellent outcomes in n = 6/9 | P = 0.13 |
| Gause (2008) | N = 56  Mean age: 53 years (31-76)  Previous surgery: mean 86 months (12-300 months) prior  f/u: minimum 6 months; mean 22 months (6-70); % NR | Degenerative cervical stenosis with radicular and/or myelopathic symptoms consistent with radiographic level of segmental degeneration | Anterior cervical discectomy and fusion (ACDF) n = 49  1-level: n = 38  2-level: n = 10  3-level: n = 1 | Anterior cervical corpectomy and fusion (ACCF) n = 7  3-level: n = 4  4-level: n = 3 | Solid arthrodesis:  ACDF: n = 40/49 (82%)  ACCF: n = 7/7 (100%)  Solid arthrodesis: cranial to previous fusion: n = 25/28 (89%)  caudal to previous fusion: n = 12/16 (75%)  both cranial and caudal to previous fusion: n = 1/3 (33%)  P = 0.05  Analyzes risk factors also; previous number of levels treated, current number of levels treated, interaction between previous levels fused and current number levels fused; smoking, | Chi-square test for potential predictors and fusion |
| Key question 3: | | | Treatment (case series) | | Outcomes | |
| Matsumoto (2006)  Matched cohort study; the reoperated cohort are of interest for this report. | N = 31  Male: 26/31  Mean age: 60 years (39-83)  Previous ACDF, mean 12 years 3 months (1 year 4 mo to 36 year 11 mo) prior  f/u: 45 months (25-60)  Matched cohort:  N = 31  Male: 26/31  Mean age: 58 years (42-77)  *No previous surgery* also ELAP | “cervical myelopathy resulting from adjacent segment disease”; further definition not provided. | Open door laminoplasty | | JOA scores:  Preoperative: 9.2 ± 2.6 (4-14)  Postoperative: 11.9 ± 2.8 (6-15)  Recovery rate (JOA score at f/u - preoperative JOA score)/(17 - preoperative JOA score) x 100 (%): 37.1 ± 22.4 (0-81)  Clinical outcome (based on recovery rate): n = 1 excellent, n = 11 good, n = 11 fair, n = 8 poor  recovery rates according to diagnosis before ACDF in group A: 41.1 ± 21.5% in cases with soft disc herniation, 35.9 ± 23.0% in cases of spondylotic myelopathy, and 20.8 ± 29.4% in cases of spine injury (*P* = 0.48, ANOVA).  Radiological results:  Mean angular motion at adjacent levels:  Preoperative: 10.5° ± 5.6°  Postoperative: 7.0° ± 6.6°  P = 0.008, paired t test | |
| Baba (1994) | N = 18  Male: 11/18  Mean age: 50 years (40 – 63)  Previous ACDF, mean 7.8 years (1 – 33) prior  f/u: 34 months (16-54) | NR | Laminoplasty | | JOA scores:  NR  Clinical outcome (based on improvement rate): n = 4 excellent, n = 6 good, n = 4 fair, n = 4 poor  Improvement rate according to diagnosis: 57% in cases with both SCS and dynamic SCS, 10.7% in cases with mild swan-neck deformity with anterior spondylolisthesis of C2 on C3. | |
| Phillips (2009) | N = 126 primary and N = 26 previous “adjacent level” fusion surgeries  Primary:  Male: 70/126  Mean age: 44.4 years  Previous:  Male: 10/26  Mean age: 46.4 years | NR | Cervical disc replacement (PCM disc) | | NDI scores:  Primary Preoperative: 28.1 ± 7.3  Primary 52 week Postoperative: 10.8 ± 10.5  Previous Preoperative: 28.2 ± 7.5  Previous 52 week Postoperative: 11.7 ± 10.5  Neck VAS scores:  Primary Preoperative: 68.5 ± 23.1  Primary 52 week Postoperative: 25.8 ± 25.8  Previous Preoperative: 72.0 ± 16.4  Previous 52 week Postoperative: 28.4 ± 29.6  Arm VAS scores:  Primary Preoperative: 71.3 ± 19.8  Primary 52 week Postoperative: 27.2 ± 30.2  Previous Preoperative: 78.2 ± 17.2  Previous 52 week Postoperative: 31.0 ± 34.3  P = 0.001 for all groups/scores  Radiological results:  Intervertebral levels grouped difference between primary and adjacent-to-fusion groups P = 0.23  12 month f/u increase in motion in adjacent-to-fusion group P = 0.037  Change in intervertebral rotation between primary and adjacent-to-fusion groups: P = 0.57  Change in intervertebral rotation between levels implanted: P = 0.018  12 month f/u amount of intervertebral translation at PCM level between primary and adjacent-to-fusion groups P = 0.02  12 month f/u amount of intervertebral translation at PCM level between levels P = 0.002 | |

Inclusion/exclusion criteria:

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| --- | --- | --- | --- |
| Author (year)  Study type (LoE) | Inclusion | Exclusion | Purpose |
| Key question 1: |  |  |  |
| (no comparative studies found) | | | |
| Key question 2: |  |  |  |
| Hilibrand (1997)  Retrospective cohort | Prior anterior cervical compressive procedures with arthrodesis  Failure of prior intervention to relieve symptoms with a cervical orthosis, physical therapy, and anti-inflammatory medication; persistent radiculopathy with or without neurologic deficit, or evidence of myelopathy on physical exam with spinal cord compression on neuroradiologic imaging | NR | “To determine the clinical and radiographic success of discectomy with interbody grafting and corpectomy with strut grafting in the treatment of adjacent segment disease of the cervical spine.” |
| Gause (2008) | Patients consecutively treated for degenerative cervical stenosis adjacent to a previously anterior fused segment  Radicular and/or myelopathic symptoms consistent with radiographic level of segmental degeneration  Failure of nonoperative treatment including analgesic and physical therapy | Acute trauma, instability, previous or current posterior procedures, short f/u of only 3 weeks | “To determine the fusion rate when arthrodesis is performed in the setting of junctional stenosis using iliac crest autograft and instrumentation.” |
| Key question 3: |  |  |  |
| Matsumoto (2006) | History of previous ACDF, including 2 with previous reoperation for ASD  Reasons for ACDF: disc herniation, spondylotic myelopathy, spinal injury  Adjacent lesions included spondylosis, disc herniation; in superior segment (n = 21) or inferior segment (n = 10) | NR | “To evaluate the effectiveness of laminoplasty for cervical myelopathy resulting from adjacent-segment disease.” |
| Baba (1994) | Recursion of symptoms of spondyloticmyeloradiculopathy  Previous ACDF | NR | “To assess the adverse effects of the original procedure on the adjacent intervertebral segments.” |
| Phillips (2009) | Age 18–65 yr  Diagnosis of radiculopathy or myelopathy of the cervical spine  Symptomatic at only 1 level from C3–C4–C7–T1  Radiographically determined pathology at level to be treated correlating to primary symptoms  Neck disability index score 30% (15/50)  Unresponsive to nonoperative treatment for 6 wk, or presence  of progressive nerve root/spinal cord compression in the face of conservative treatment. | Surgery site or active systemic infection.  Prior attempted or completed cervical spine surgery, except laminoforaminotomy or a successful single-level anterior cervical fusion.  Previous trauma to the C3–T1 levels resulting in significant bony or  discoligamentous cervical spine injury.  Axial neck pain in the absence of other symptoms of radiculopathy or myelopathy.  Radiographic confirmation of severe facet joint disease or degeneration.  Osteoporosis or any other metabolic bone disease.  Severe diabetes mellitus  Symptomatic DDD or significant cervical spondylosis at 2 or more levels;  Marked cervical instability on resting lateral or flexion/extension radiographs.  Known or suspected allergy to implant materials.  Severe myelopathy  Congenital canal stenosis with a canal diameter of 10 mm.  Kyphotic segmental angulation of greater than 11° at treatment or adjacent levels.  Autoimmune disorders that impact the musculoskeletal system.  Congenital bony and/or spinal cord abnormalities that affect spinal stability.  Spinal axis disease (thoracic or lumbar) or other degenerative joint disease to the extent that surgical consideration is likely anticipated within 6 mo after the  cervical randomized procedure.  Previous spine surgery within the 6 mo preceding the cervical randomized procedure.  Currently experiencing acute episode of major mental illness or manifesting physical symptoms without a diagnosable medical condition to account for the symptoms.  Current or recent history of substance abuse (drug or alcohol).  Morbid obesity, defined as body mass index (“BMI”) >40 or more than 100 lbs. over ideal body weight.  Currently using, or planning to use, bone growth stimulators in the cervical spine.  Currently pursuing personal litigation. | “To evaluate outcomes of cervical disc replacement performed adjacent to a prior cervical fusion.” |