

Hybrid Surgery versus Three-Level ACDF: A Systematic Review and Meta-Analysis of Clinical and Radiological Outcomes

Chinedu Egu¹, Neel Badhe², Hussein Akit³, Rebecca Aida Hakim⁴, Elie Najjar⁵, Balaji Purushothaman¹

¹Department of Trauma and Orthopaedics, South Tyneside and Sunderland Royal Hospital NHS Foundation Trust, UK ²School of Medicine, Cambridge University, Cambridge, UK ³Faculty of Medicine, University of Balamand, Beirut, Lebanon ⁴Department of Trauma and Orthopaedics, West Middlesex Hospital, Chelsea and Westminster NHS Trust, London, UK ⁵Centre for Spinal Studies and Surgery, Queen's Medical Centre, Nottingham, UK

INTRODUCTION

Degenerative cervical spine disease is a major cause of neck pain, radiculopathy, and myelopathy, often requiring surgical intervention (1,2).

Anterior cervical discectomy and fusion (ACDF) is the standard treatment for multilevel disease but eliminates motion and may accelerate adjacent segment degeneration (ASD) (3-5).

Cervical disc arthroplasty (CDA) preserves motion at one- and two-levels (6-8) but is less feasible for three-level pathology.

Hybrid surgery (HS) combines both approaches, offering a motion-preserving alternative (9-11). However, evidence directly comparing three-level HS with three-level ACDF remains limited.

OBJECTIVE

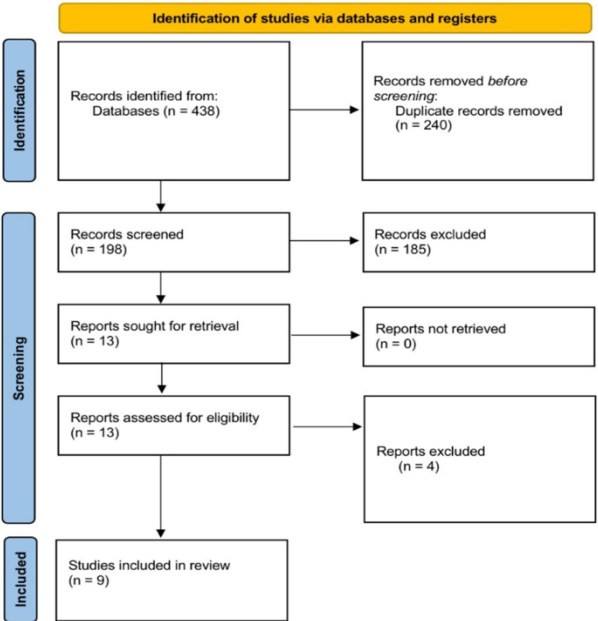
To compare clinical, radiological, and perioperative outcomes of three-level hybrid surgery (HS) versus three-level ACDF, and to assess differences between hybrid subtypes (Type 1: 1CDA+2ACDF vs Type 2: 2CDA+1ACDF).

METHODOLOGY

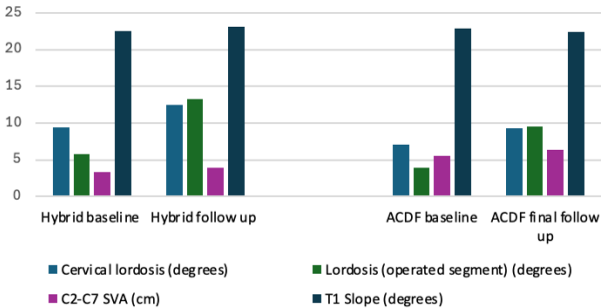
A systematic review and meta-analysis were conducted following PRISMA guidelines (12). Searches of PubMed, Embase, Cochrane CENTRAL, Scopus, and Web of Science (to June 2025) identified studies comparing three-level hybrid surgery (HS) and anterior cervical discectomy and fusion (ACDF).

Clinical, radiological, and perioperative outcomes were pooled using random-effects models. Study quality was appraised using the NIH Quality Assessment Tool (13).

RESULTS



Radiological outcomes at baseline and follow up



DISCUSSION

HS and ACDF provide comparable clinical improvements for three-level cervical disease. HS preserves motion and restores segmental lordosis more effectively, consistent with reported biomechanical and clinical advantages of motion-preserving constructs (9-11,14).

ACDF demonstrates higher instrumentation failure, whereas HS has higher heterotopic ossification patterns aligning with longer-term CDA evidence (6-8,15).

Current evidence is limited by retrospective study design and mid-term follow-up; long-term prospective studies are needed.

REFERENCES

1.Pajer R, Kyvik KO, Hartvigsen J. The prevalence of neck pain in the world population: a systematic critical review of the literature. *Eur Spine J*. 2006;15(6):634-648. doi:10.1007/s00586-004-0864-4 2.Ying D, Probst M, De R, Buchholz R. The epidemiology of neck pain. *Best Pract Res Clin Rheumatol*. 2010;24(6):785-792. doi:10.1016/j.bpr.2010.10.019 3.Dinh GW, Robinson RW. The treatment of certain cervical spine disorders by anterior removal of the intervertebral disc and interbody fusion. *J Bone Joint Surg Am*. 1958;40(2):557-574. 4.Vincent AD, Gervin GD, Poulos MA, Jones PW, Boshuisen HC. Radiography and myelography at segments adjacent to the site of a previous anterior cervical arthrodesis. *J Bone Joint Surg Am*. 1998;80(14):1592-8. doi:10.2106/00006123-19980400000005 5.Giles JC, Humphrey SC, Liu TH, et al. Biomechanical study on the effect of cervical spine fusion on adjacent cervical motion preservation and segmental motion. *Spine (Phila Pa 1976)*. 2002;27(22):2453-2464. doi:10.1097/SPS.0000000000000000 6.Murphy PG, Burke JK, Hall RW, Zdebka TA. Clinical and radiographic analysis of cervical disc arthroplasty compared with allograft fusion: a randomized controlled clinical trial. *J Neurosurg Spine*. 2010;23(1):188-200. doi:10.3171/2009.3.SPINE.1987 7.Cole TJ, Bellizzi K, Flegal DM, Cole T. A global standard definition for child overweight and obesity worldwide: International Survey (BMC Public Health 2004). 8.Lewyke T, Birkner JK, et al. Two-level cervical disc arthroplasty versus anterior cervical discectomy and fusion: 10-year outcomes of a prospective, randomized trial. *J Neurosurg Spine*. 2013;29(1):55-61. doi:10.3171/2012.1.SPINE.12106 9.Parkash AP, New KD. Multilevel cervical arthroplasty: current evidence. A systematic review. *Neurosurg Focus*. 2017;42(2):E6. doi:10.3171/2016.10.FOCUS.1638 10.Pang JC, Wu MF, Yu G, et al. Comparison of sagittal parameters for anterior cervical discectomy and fusion, hybrid surgery, and total disc replacement for three levels of cervical spondylosis. *Clin Neurol Neurosurg*. 2018;168:140-148. doi:10.1016/j.clineuro.2018.03.011 11.Wang H, Huang K, Wang Y, Wang X, Ding C, Peng Y. In cervical disc replacement, variable 3-level hybrid surgery compared with 3-level anterior cervical discectomy and fusion? *World Neurology*. 2021;16(1):1-10. doi:10.1016/j.wneu.2020.10.017 12.Pagani MJ, McArthur JE, Bousquet PH, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMC Med*. 2021;19(1):201. doi:10.1186/s12916-021-01967-6 13.National Institutes of Health. Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies. NIH/NIH. 2014. 14.Fu S, Liang Y, Wang J, Yu Z, Zhu Z, Li H. Cervical spine balance of multilevel total disc replacement, hybrid surgery and anterior cervical discectomy and fusion with long-term follow-up. *Spine (Phila Pa 1976)*. 2024;49(16):E89-E94. doi:10.1097/BRS.000000000000474 15.Ding L, Ju Z, Chen X, et al. The change of adjacent segment after cervical disc arthroplasty compared with anterior cervical discectomy and fusion: a meta-analysis of randomized controlled trial. *Spine J*. 2017;27(10):1549-1558. doi:10.1016/j.spinee.2017.06.010