Feasibility of 1, 2, 3 and 4 level Cervical Viscoelastic Total Disc Replacement In An Emerging Country: A Pilot Study

Kingsley R Chin MD[1,2,3,4,5]
Vito Lore, P.E[6]
Roger D Sung MD[7]
Jeffrey R Carlson MD[8]
Mark W McFarland DO[8]
Erik Spayde MD[9]
William M Costigan MD[10]
Hope Estevez HS[1,5]
Marilyn Speid HS[1,5]
Chukwunonso C Ilogu, MD[1,5]
Jason A Seale, MBBS[1,5]

[1]Less Exposure Spine Surgery Institute (LESS Institute aka LESS Clinic), Fort Lauderdale, Florida, USA; [2]LESS Institute of Jamaica, Kingston, St. Andrew, Jamaica, West Indies; [3]Department of Orthopedics, Herbert Wertheim College of Medicine at Florida International University, Miami, Florida, USA; [4]Faculty of Science and Sports, University of Technology, Kingston, St. Andrew, Jamaica; [5]Less Exposure Spine Surgery (LESS) Society 501©(3), Fort Lauderdale, Florida, USA; [6]LESSpine, Burlington, MA, USA; [7]Colorado Springs Orthopaedic Group, Colorado Springs, CO, USA; [8]Orthopaedic and Spine Center, Newport News, VA, USA; [9]St. Charles Spine Institute, Thousand Oaks, CA, USA; [10]Congress Orthopaedic Associates, Pasadena, CA, USA.

Corresponding Author:
Kingsley R. Chin, MD, MBA
Less Exposure Surgery Specialists Institute (LESS Institute aka LESS Clinic),
6550 N Federal Hwy, Suite 510, Fort Lauderdale, Florida, 33308.
Email: kingsleychin@thelessinstitute.com

Keywords: AxioMed® viscoelastic disc replacement; Degenerative disc disease (DDD); Cervical spine; Total disc replacement (TDR); Multi-level.

Abstract word count: 255
Text word count: 2301
Number of references: 35
Number of tables and/or figures: 1 Table and 4 Figures
Number of videos: 1

Structured Abstract:

Objective:

To evaluate the feasibility and preliminary two-year postoperative outcomes of cervical viscoelastic total disc replacement (cVTDR) across 1 to 4 levels in an emerging country. This study aims to address the limitations of traditional anterior cervical discectomy and fusion (ACDF), including technical complexity, higher complication risks, greater inventory requirements, and limited infrastructure in resource-constrained settings, and highlight cVTDR as a simplified and effective alternative.

Methods:

A prospective pilot study was conducted on six patients (mean age 50.67 years; five females, one male) diagnosed with cervical degenerative disc disease. Fourteen AxioMed® Freedom Cervical Discs were implanted across single to four levels (C3–C7). Outcome measures included the Neck Disability Index (NDI), Visual Analog Scale (VAS) for pain, range of motion (ROM) assessments, intraoperative blood loss, and radiographic evaluations. Results were compared with single- and two-level cVTDR historical data.

Results:

Patients demonstrated significant clinical improvements, with mean NDI scores decreasing from 67.33 to 16 and VAS scores from 9.5 to 1.83 at the two-year follow-up. ROM was preserved across all treated segments, with no reported complications, revisions, readmissions, adjacent segment disease, heterotopic ossification, or device failures.

Conclusions:

Cervical VTDR is a feasible and effective non-fusion alternative for managing cervical degenerative disc disease across 1 to 4 levels, offering a simplified solution to the challenges faced in emerging countries. Its streamlined design minimizes technical demands, reduces inventory needs, and avoids complications associated with ACDF, making it a reliable choice in resource-constrained healthcare systems. Further research with larger samples and extended follow-up will help confirm these promising findings.

Introduction

Cervical degenerative disc disease is a major cause of disability worldwide, often necessitating surgical intervention when conservative treatments fail. Anterior cervical discectomy and fusion (ACDF) remains the standard treatment for symptomatic cervical disc degeneration, myelopathy, and radiculopathy[1]. While effective, ACDF alters spinal biomechanics, increasing intradiscal pressure and abnormal motion at adjacent levels (4), contributing to adjacent segment disease (ASD) in up to 92% of patients within five years, with an annual incidence of 2.9%[2-4].

Multi-level ACDF with plate fixation have better outcomes, however the fusion rates decline as the number of levels increases, leading to the increased need for revision surgeries [5,6]. Longer operative times, greater technical complexity, and the need for posterior instrumentation further elevate complication risks [7]. Additionally, bone graft substitutes such as demineralized bone matrix, hydroxyapatite, and beta-tricalcium phosphate introduce potential complications, even in single- and two-level ACDF[8]. These limitations have driven the development of motion-preserving alternatives to mitigate the biomechanical drawbacks of fusion.

Cervical total disc replacement (TDR) was introduced in the 1990s as an alternative to ACDF, preserving segmental motion and eliminating the need for plates, screws, interbody cages, and bone grafts [9]. Traditional articulating TDRs (ATDRs), modeled after hip and knee replacements, restore motion using ball-and-socket designs. These early TDRs demonstrated clinical utility in the literature, establishing non-inferiority to ACDF[10-14].

However, the intervertebral disc is not naturally articulating; it is viscoelastic, allowing for multidirectional movement and shock absorption. Consequently, ATDRs have been associated with complications such as osteolysis, heterotopic ossification (HO), device migration, and loss of sagittal balance [15-17]. These limitations have necessitated further advancements in disc replacement technology.

Viscoelastic total disc replacement (VTDR) was developed as the next generation of TDR to better replicate the biomechanics of a healthy disc. Unlike ATDRs, AxioMed® VTDR features a single-piece viscoelastic design that provides natural shock absorption, six degrees of motion, and lordotic alignment[18,19]. A post-market analysis (PMA) European demonstrated significant improvements in Neck Disability Index (NDI), Visual Analog Scale (VAS) scores, and neurological function over two years in single- and two-level cervical VTDR (cVTDR) patients, with no device failures, explantations, or radiographic evidence of heterotopic ossification or osteolysis[20]. However, the feasibility and outcomes of multi-level applications remain unexamined.

This evaluation is particularly relevant in emerging countries, where motion-preserving spine surgery remains underexplored. Complex spinal procedures such as multi-level ACDF require specialized expertise, advanced instrumentation, and robust healthcare infrastructure, all of which are often limited in resource-constrained settings. Additionally, revision surgeries for ASD, nonunion, or hardware failure further complicate long-term treatment planning. A motion-preserving solution that reduces surgical complexity, inventory demands, and sterilization requirements could be highly beneficial.

Most TDR research has focused on single- and two-level applications, leaving outcomes at three and four levels largely unexamined, despite promising results in a recent four-level cervical disc arthroplasty study[21]. A critical gap remains in assessing the feasibility, safety, and clinical effectiveness of VTDR in multi-level applications, particularly in resource-limited settings. The objective of this pilot study was to assess the feasibility of 1-, 2-, 3-, and 4-level cervical VTDR in Jamaica, an emerging country, over a two-year follow-up period and determine whether its results align with previously published single- and two-level data.

Materials and Methods

Study Design

This prospective cohort pilot study enrolled six consecutive patients in 2017 from a single center in Jamaica who underwent cVTDR with the AxioMed® Freedom Cervical Disc (FCD) across multiple levels. All surgeries were performed by an experienced orthopedic spine surgeon, assisted by a neurosurgeon, at a single hospital facility. Written informed consent was obtained from all participants before enrollment. As an early feasibility study, the small sample size was intended to provide preliminary insights into the safety and clinical outcomes of multilevel cVTDR in a resource-limited setting.

Inclusion and Exclusion Criteria

Candidates were considered for surgery only after a minimum of six weeks of failed conservative treatment. Indications for cVTDR surgery included symptomatic cervical

degenerative disc disease with radiculopathy, herniated cervical disc(s) with mild facet signal changes suggestive of degeneration. Exclusion criteria included malignancy, infection and unstable chronic medical conditions.

Assessment Parameters

Comprehensive clinical and radiographic assessments were conducted pre- and postoperatively. Clinical evaluation included the Neck Disability Index (NDI) and Visual Analog Scale (VAS) for pain to assess functional improvement and pain relief. Radiographic assessments focused on device positioning, postoperative complications, and the need for revision surgeries.

Surgical Technique

Patients were positioned supine under general anesthesia. Using an anterior cervical approach, a horizontal midline incision was used to access the surgical level(s). A total discectomy was performed using a high-speed burr and curettes. The posterior longitudinal ligament was preserved whenever possible to maintain segmental stability. The endplates were prepared without keel cuts, and an implant trial was used to determine the appropriate width and height. Due to inventory constraints, only 8-degree cVTDR implants were available, and the closest fitting size was selected for each patient. Higher degree lordosis was not indicated due to lack of substantial kyphosis. The selected disc was then inserted midline in the prepared disc space. For multilevel cases, the same technique was repeated at each affected level.

Statistics

Statistical analyses were executed utilizing Visual Studio (VS) Code (version 1.83.2), the Anaconda3 (Python 3.11.4) kernel within VS Code, and a comprehensive suite of packages, including 'pandas,' 'numpy,' 'datetime,' 'matplotlib,' 'altair,' 'seaborn,' 'statsmodels,' 'math,' 'pingouin,' and 'scipy.' The Mann-Whitney U test was used to compare VAS and NDI scores between this cohort and previously published single- and two-level VTDR outcomes by Chin et al.[20] , as it is a non-parametric method suitable for comparing two independent groups without assuming normal distribution. Cohen's d was calculated to measure the effect size, indicating the magnitude of differences in pain and disability outcomes.

Results

The study cohort consisted of six patients, five of whom were female, with a mean age of 50.7 years (SD 14.1). The mean weight was 153.5 pounds (SD 21.9), and the average BMI was 24.7 (SD 6.1). A total of 14 cVTDRs were implanted at cervical levels C3 through C7 (Table 1). Two patients received single-level cVTDR at C5-6 (Figure 1), one patient underwent a two-level cVTDR at C4-5 and C5-6 (Figure 2), two patients received three-level cVTDR at C4-5, C5-6, and C6-7 (Figure 3), and one patient underwent a four-level cVTDR from C3 to C7, which included treatment for significant ossification of the posterior longitudinal ligament (OPLL) (Figure 4). The mean blood loss was 41.7 cc (SD 12.9), and all patients were discharged within 48 hours post-operation with immediate clinical

improvement. No intraoperative or postoperative complications, including infections, hematomas, or neurological deficits, were reported.

Significant postoperative improvements were observed across all outcome measures. Preoperative VAS scores decreased from a mean of 9.5 to 1.83 postoperatively, reflecting an 80.7% reduction ($p = 0.013$). Similarly, NDI scores improved from 67.3% preoperatively to 16% postoperatively, representing a 76.2% improvement ($p < 0.001$). Comparatively, in Chin et al.[20] reference cohort, VAS scores improved from 63 mm to 15 mm (76.2% reduction, $p < 0.001$), and NDI scores improved from 48% to 4% (91.7% improvement, $p < 0.001$). Over the two-year follow-up period, no revision surgeries, readmissions or device failures were reported in either group.

Radiographically, all VTDR implants remained stable at the two-year follow-up. One implant in a single-level VTDR patient showed slight postoperative misplacement following a motor vehicle accident but remained stable over time (Figure 1). No radiographic evidence of HO was observed based on the McAfee classification[22].

Statistical analysis

The analysis revealed significant pain relief and functional improvement in both the study and reference cohorts. Postoperative VAS scores were significantly lower in the study cohort compared to the reference cohort ($U = 1.0$, $p = 0.048$, $r = 0.68$). Similar statistical significance was observed for NDI scores ($U = 10.0$, $p = 0.048$, $r = 0.68$), indicating comparable clinical outcomes between the two groups.

Cohen's d was calculated to assess the effect size of observed improvements. The effect size for VAS was large (d = 4.68 for the study cohort and d = 3.56 for the reference cohort), indicating a substantial reduction in pain for both groups. Similarly, the effect size for NDI was large (d = 3.76 for the study cohort and d = 4.79 for the reference cohort), demonstrating significant reductions in disability. These effect sizes confirm that the observed improvements were both statistically significant and clinically meaningful.

Discussion

This study evaluated the feasibility of cervical viscoelastic total disc replacement across single and multi-level applications over a two-year period in an emerging country. It aimed to expand current knowledge on VTDR's performance across multiple levels, an area with limited published data, and to explore its potential as an alternative to ACDF, which is associated with high risks of ASD due to its impact on cervical motion.

Key Findings

cVTDR demonstrated substantial improvements in clinical outcomes, with reductions of 80.7% in VAS scores and 76.2% in NDI scores, indicating significant pain relief and functional improvement. No complications, revisions, or device failures were reported over the follow-up period, underscoring the device's safety and reliability in the study cohort. These results align with prior study by Chin et al. [20] that showed similar improvements in NDI and VAS scores, supporting the consistency of the implant's clinical efficacy.

Additionally, radiographic assessments showed stable implant positioning, with no HO, osteolysis, or device migration, further suggesting the device's durability.

Comparison with Similar Research

Sheng et al. [23] conducted a systematic review and meta-analysis examining the risks of HO and fusion following cervical articulating TDR. Analyzing eleven studies with at least 10 years of follow-up, involving 1140 patients, they found that the overall incidence of HO was 70% at 10 years, 60% at five to six years, and 50% at one to two years postoperatively. Specifically, the incidence of severe HO (grades 3 or 4) was 37%, while mild HO (grades 1 or 2) was 30% at the 10-year follow-up.

Risk factors for HO include a high degree of ossification before surgery[24], insufficient endplate coverage of the prosthesis [25-27], intervertebral space height change before and after surgery ≥ 1.8 mm[25], excessive intervertebral space distraction [28] and disk space angle change during operation > 5 degrees [29] may lead to higher incidences of HO. The above patient characteristics and surgical details may vary between studies. ProDisc-C (Centinel Spine, West Chester, PA, USA) had the highest pooled overall HO rate (86%) at 10 years of follow-up. Bryan (64%) and Prestige LP (62%) prostheses had a lower pooled overall HO rate.

Three critical factors contributing to the low incidence of HO and complications were identified. First, a proper surgical technique, which avoids excessive burring of the endplates, likely reduced the risk of fusion [30,31]. Second, the cVTDR's non-articulating design does not rely on perfect centralization for effective functioning, reducing the likelihood of abnormal kinematics seen in earlier devices that required precise placement [32,33]. Third, minimizing

dead space in the disc cavity through proper implant sizing further mitigated the risk of HO, as evidenced by the absence of complications even in cases where slightly undersized implants were used [15,34].

Limitations

This study has several limitations. The small sample size limits the generalizability of findings to larger populations, and the single-center nature of the study may restrict applicability across different clinical settings. A two-year follow-up, while informative, is not sufficient for assessing long-term complications such as late-onset HO or implant wear. The absence of a control group or direct comparison with ACDF limits the ability to comprehensively evaluate cVTDR's advantages over fusion. Furthermore, no economic assessment was conducted, leaving questions regarding cost-effectiveness, particularly in resource-limited settings.

Clinical Relevance

The results of this study are promising for the application of cVTDR as a non-fusion alternative in managing cervical DDD, particularly across multiple levels. The absence of complications and revision surgeries suggests that cVTDR may reduce the need for reoperations, providing a cost-effective option that also preserves cervical motion. The cost of the implant will be determined by market forces, but the cost of inventory, transportation, and osteobiologics is expected to be higher for fusion compared to the AxioMed® disc, which comes sterile-packed with a compact instrument kit containing mostly an inserter and trials. Additionally, the average cost of readmission for ACDF is approximately $25,000[35], further

emphasizing the potential cost savings with cVTDR. Its viscoelastic, non-articulating design simplifies the implantation process, which could be beneficial in diverse clinical settings, including those where specialized surgical expertise may be limited. The favorable radiographic outcomes observed even in multi-level cases support cVTDR's reliability as a solution for managing cervical disc disease without the risks associated with fusion.

Implications for Further Research

Larger, multi-center studies are essential to confirm these findings and evaluate cVTDR's performance across varied clinical settings. Extended follow-up periods are necessary to fully assess the device's durability and to monitor for late-onset complications, such as HO or implant failure. Comparative studies with ACDF and other TDR systems would provide a more comprehensive understanding of the device's relative advantages. Additionally, future research should include economic analyses to determine cost-effectiveness, especially in low- and middle-income settings where healthcare budgets may be constrained.

Conclusion

Cervical viscoelastic total disc replacement showed significant clinical improvements and radiographic stability across 1 to 4 cervical levels over two years, with reduced pain and disability scores and no complications or revisions. These results align with previous single- and two-level studies, highlighting cVTDR as a reliable, motion-preserving alternative to fusion, especially in multi-level cases. Conducted in Jamaica, an emerging country, this pilot study demonstrates cVTDR's feasibility in resource-constrained settings, where reduced

inventory needs and simplified procedures are particularly beneficial. Consistent outcomes across multiple surgeons indicate reproducibility and support broader clinical use. The potential cost savings, including reduced reoperations, readmissions and lower inventory demands, further emphasize cVTDR's value. This study offers preliminary evidence of cVTDR's effectiveness, warranting further research to confirm long-term safety, efficacy, and cost-efficiency in diverse clinical environments.

References:

1. Peng J, Li S, Lin X, et al. Anterior cervical discectomy and fusion without plate (ACDFWP) versus anterior cervical disc arthroplasty (ACDA) for cervical spondylosis: A meta-analysis and literature review. *Intractable Rare Dis Res*. Aug 2022;11(3):105-112. doi:10.5582/irdr.2022.01080

2. Hilibrand AS, Carlson GD, Palumbo MA, Jones PK, Bohlman HH. Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis. *J Bone Joint Surg Am*. Apr 1999;81(4):519-28. doi:10.2106/00004623-199904000-00009

3. Goffin J, Geusens E, Vantomme N, et al. Long-term follow-up after interbody fusion of the cervical spine. *J Spinal Disord Tech*. Apr 2004;17(2):79-85. doi:10.1097/00024720-200404000-00001

4. Dmitriev AE, Cunningham BW, Hu N, Sell G, Vigna F, McAfee PC. Adjacent level intradiscal pressure and segmental kinematics following a cervical total disc arthroplasty: an

in vitro human cadaveric model. *Spine*. May 15 2005;30(10):1165-72. doi:10.1097/01.brs.0000162441.23824.95

5. Wang JC, McDonough PW, Endow KK, Delamarter RB. Increased fusion rates with cervical plating for two-level anterior cervical discectomy and fusion. *Spine*. Jan 2000;25(1):41-5. doi:10.1097/00007632-200001010-00009

6. Wang JC, McDonough PW, Kanim LE, Endow KK, Delamarter RB. Increased fusion rates with cervical plating for three-level anterior cervical discectomy and fusion. *Spine*. Mar 15 2001;26(6):643-6; discussion 646-7. doi:10.1097/00007632-200103150-00015

7. Wang T, Long Y, Guo J, Hou Z. Comparison between 3-level and 4level anterior cervical discectomy and fusion in the treatment of cervical spondylotic myelopathy: A meta-analysis. *Heliyon*. Nov 2023;9(11):e21595. doi:10.1016/j.heliyon.2023.e21595

8. Cabrera JP, Muthu S, Mesregah MK, et al. Complications With Demineralized Bone Matrix, Hydroxyapatite and Beta-Tricalcium Phosphate in Single and Two-Level Anterior Cervical Discectomy and Fusion Surgery. *Global Spine J*. Feb 2024;14(2_suppl):78S-85S. doi:10.1177/21925682231157320

9. Wellington IJ, Kia C, Coskun E, et al. Cervical and Lumbar Disc Arthroplasty: A Review of Current Implant Design and Outcomes. *Bioengineering (Basel)*. May 23 2022;9(5)doi:10.3390/bioengineering9050227

10. Hisey MS, Bae HW, Davis R, et al. Multi-center, prospective, randomized, controlled investigational device exemption clinical trial comparing Mobi-C Cervical Artificial Disc to

anterior discectomy and fusion in the treatment of symptomatic degenerative disc disease in the cervical spine. *Int J Spine Surg*. 2014;8doi:10.14444/1007

11. Hisey MS, Zigler JE, Jackson R, et al. Prospective, Randomized Comparison of One-level Mobi-C Cervical Total Disc Replacement vs. Anterior Cervical Discectomy and Fusion: Results at 5-year Follow-up. *Int J Spine Surg*. 2016;10:10. doi:10.14444/3010

12. Radcliff K, Davis RJ, Hisey MS, et al. Long-term Evaluation of Cervical Disc Arthroplasty with the Mobi-C(c) Cervical Disc: A Randomized, Prospective, Multicenter Clinical Trial with Seven-Year Follow-up. *Int J Spine Surg*. 2017;11(4):31. doi:10.14444/4031

13. Delamarter RB, Murrey D, Janssen ME, et al. Results at 24 months from the prospective, randomized, multicenter Investigational Device Exemption trial of ProDisc-C versus anterior cervical discectomy and fusion with 4-year follow-up and continued access patients. *SAS J*. 2010;4(4):122-8. doi:10.1016/j.esas.2010.09.001

14. Gornet MF, Lanman TH, Burkus JK, et al. Cervical disc arthroplasty with the Prestige LP disc versus anterior cervical discectomy and fusion, at 2 levels: results of a prospective, multicenter randomized controlled clinical trial at 24 months. *Journal of neurosurgery Spine*. Jun 2017;26(6):653-667. doi:10.3171/2016.10.SPINE16264

15. Hackel S, Gaff J, Pabbruwe M, et al. Heterotopic ossification, osteolysis and implant failure following cervical total disc replacement with the M6-C artificial disc. *Eur Spine J*. Mar 2024;33(3):1292-1299. doi:10.1007/s00586-024-08129-5

16. Mehren C, Suchomel P, Grochulla F, et al. Heterotopic ossification in total cervical artificial disc replacement. *Spine*. Nov 15 2006;31(24):2802-6. doi:10.1097/01.brs.0000245852.70594.d5

17. Leung C, Casey AT, Goffin J, et al. Clinical significance of heterotopic ossification in cervical disc replacement: a prospective multicenter clinical trial. *Neurosurgery*. Oct 2005;57(4):759-63; discussion 759-63. doi:10.1093/neurosurgery/57.4.759

18. Jacobs CAM, Siepe CJ, Ito K. Viscoelastic cervical total disc replacement devices: Design concepts. *The spine journal : official journal of the North American Spine Society*. Dec 2020;20(12):1911-1924. doi:10.1016/j.spinee.2020.08.007

19. Lazennec JY. Lumbar and cervical viscoelastic disc replacement: Concepts and current experience. *World J Orthop*. Aug 18 2020;11(8):345-356. doi:10.5312/wjo.v11.i8.345

20. Chin KR, Lubinski JR, Zimmers KB, Sands BE, Pencle F. Clinical experience and two-year follow-up with a one-piece viscoelastic cervical total disc replacement. *J Spine Surg*. Dec 2017;3(4):630-640. doi:10.21037/jss.2017.12.03

21. Chang HK, Chang CC, Tu TH, et al. Four-Level Cervical Disc Arthroplasty. *Int J Spine Surg*. Nov 8 2024;18(5):514-520. doi:10.14444/8603

22. McAfee PC, Cunningham BW, Devine J, Williams E, Yu-Yahiro J. Classification of heterotopic ossification (HO) in artificial disk replacement. *J Spinal Disord Tech*. Aug 2003;16(4):384-9. doi:10.1097/00024720-200308000-00010

23. Sheng XQ, Wu TK, Liu H, Meng Y. Incidence of Heterotopic Ossification at 10 years After Cervical Disk Replacement: A Systematic Review and Meta-analysis. *Spine*. Jul 1 2023;48(13):E203-E215. doi:10.1097/BRS.0000000000004674

24. Wang H, Wang X, Liu H, Meng Y, Guo Y, Hong Y. Risk Factors for High-Grade Heterotopic Ossification After Total Disc Replacement: A Single-Center Experience of 394 Cases. *Neurosurgery*. Oct 13 2021;89(5):852-861. doi:10.1093/neuros/nyab298

25. Shen YW, Yang Y, Liu H, et al. Effects of endplate coverage and intervertebral height change on heterotopic ossification following cervical disc replacement. *J Orthop Surg Res*. Nov 25 2021;16(1):693. doi:10.1186/s13018-021-02840-5

26. Xu S, Ou Y, Du X, He B, Li Y, Yu H. Heterotopic Ossification After Prestige-LP Cervical Disc Arthroplasty Is Related to Insufficient Sagittal Coverage of the Endplate By the Prosthesis. *Med Sci Monit*. Mar 22 2021;27:e929890. doi:10.12659/MSM.929890

27. Zeng J, Liu H, Chen H, et al. Effect of Prosthesis Width and Depth on Heterotopic Ossification After Cervical Disc Arthroplasty. *Spine*. May 1 2019;44(9):624-628. doi:10.1097/BRS.0000000000002915

28. Wang X, Liu H, Meng Y, et al. Effect of Disc Height and Degree of Distraction on Heterotopic Ossification After Cervical Disc Replacement. *World Neurosurg*. Jan 2021;145:e100-e107. doi:10.1016/j.wneu.2020.09.134

29. Hu L, Zhang J, Liu H, et al. Heterotopic ossification is related to change in disc space angle after Prestige-LP cervical disc arthroplasty. *Eur Spine J*. Oct 2019;28(10):2359-2370. doi:10.1007/s00586-019-06053-7

30. Cheng CC, Ordway NR, Zhang X, Lu YM, Fang H, Fayyazi AH. Loss of cervical endplate integrity following minimal surface preparation. *Spine*. Aug 1 2007;32(17):1852-5. doi:10.1097/BRS.0b013e31811ece5a

31. Lin M, Paul R, Shapiro SZ, et al. Biomechanical Study of Cervical Endplate Removal on Subsidence and Migration in Multilevel Anterior Cervical Discectomy and Fusion. *Asian Spine J*. Oct 2022;16(5):615-624. doi:10.31616/asj.2021.0424

32. Chin KR, Pencle FJR, Mustafa LS, Mustafa MS, Quijada KA, Seale JA. Incidence of Fusion Across Total Disc Replacement With Heterotopic Ossification: Are Ball and Socket Disk Replacements Fusing With and Without Radiographic Evidence. *Clinical spine surgery*. Dec 2019;32(10):E469-E473. doi:10.1097/BSD.0000000000000866

33. Chin KR, Pencle FJR, Benny A, Seale JA. Placing ball and socket cervical total disc replacement using instant center of rotation. *Journal of orthopaedics*. Sep-Oct 2019;16(5):390-392. doi:10.1016/j.jor.2019.04.005

34. Carrera DA, Ricks CB. Catastrophic delayed cervical arthroplasty failure: illustrative case. *J Neurosurg Case Lessons*. Mar 14 2022;3(11)doi:10.3171/CASE21731

35. Gowd AK, Agarwalla A, Beck EC, et al. Prediction of Admission Costs Following Anterior Cervical Discectomy and Fusion Utilizing Machine Learning. *Spine*. Nov 15 2022;47(22):1549-1557. doi:10.1097/BRS.0000000000004436

Figure Legend

Figure 1: Single-level C5-6 case: (A) Intraoperative photo of the implanted AxioMed® disc, (B) Lateral fluoroscopic image, (C) Postoperative lateral radiograph.

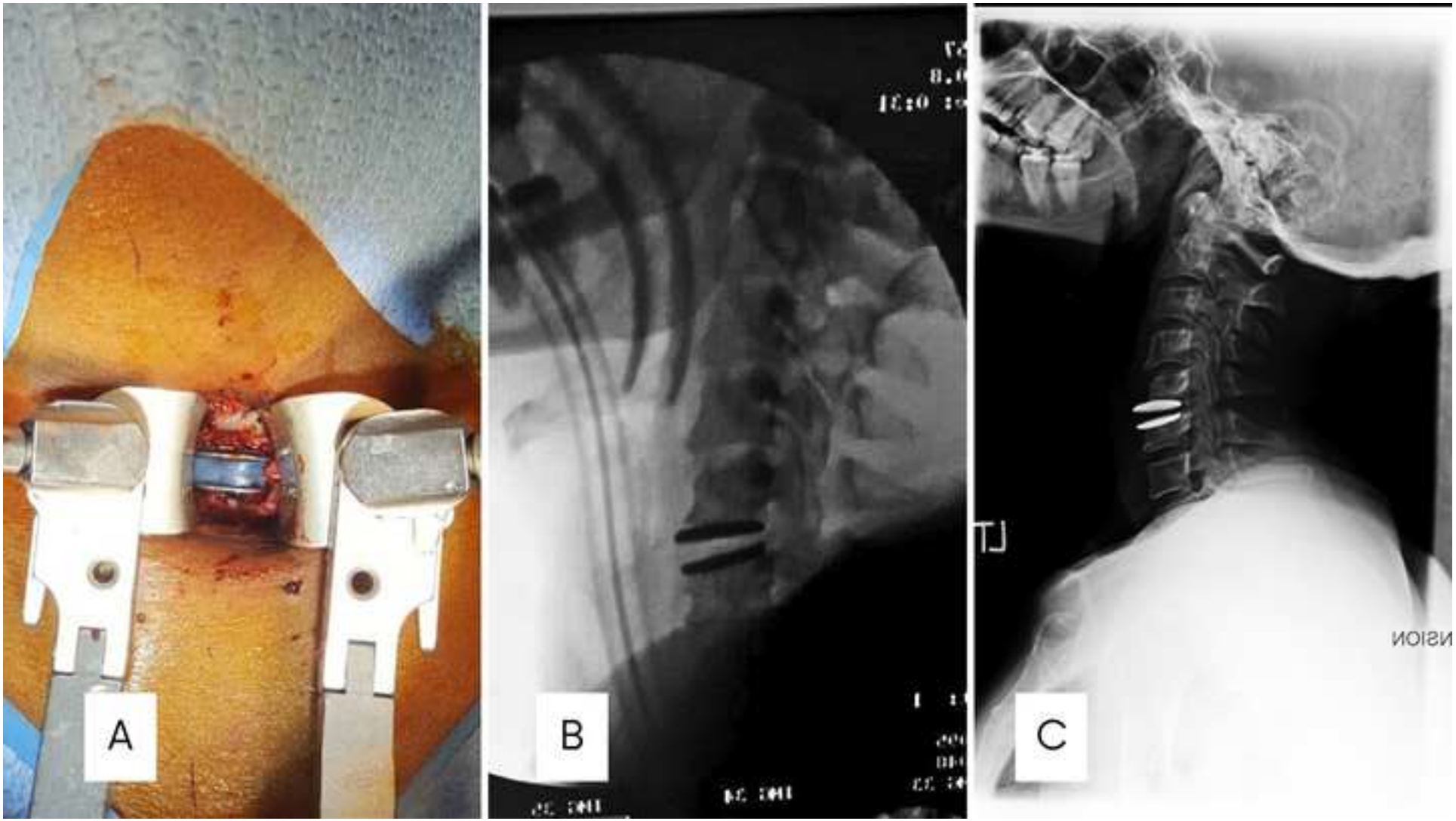
Figure 2: Two-level C4-6 case: (A) Preoperative magnetic resonance imaging (MRI), (B) Intraoperative photo, (C) Postoperative lateral radiograph.

Figure 3: Three-level C4-7 case: (A) Preoperative magnetic resonance imaging (MRI), (B) Intraoperative photo showing 2 of the 3 AxioMed® discs, (C) Postoperative lateral radiograph.

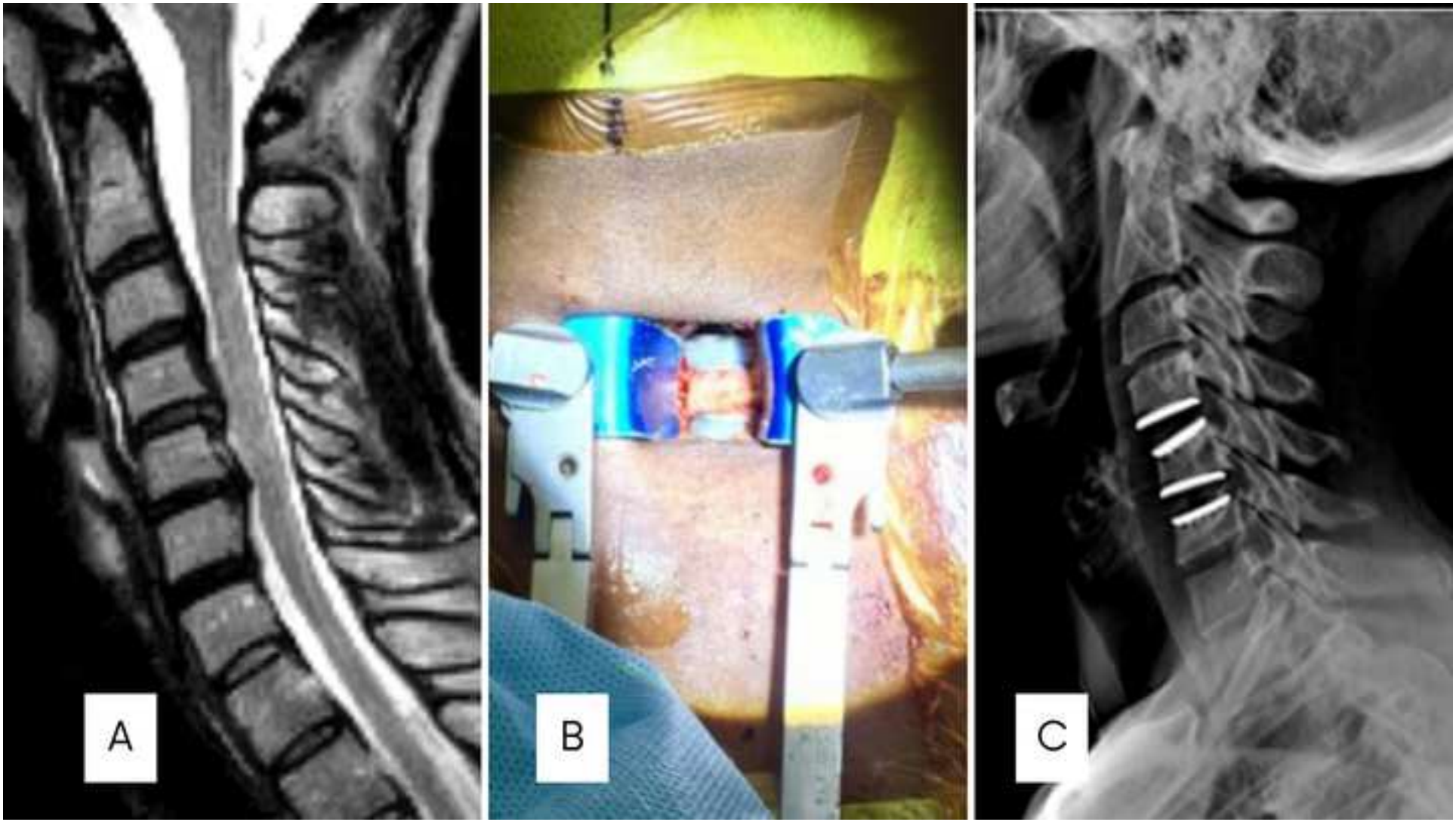
Figure 4: Four-level C3-7 case with ossification of the posterior longitudinal ligament: (A) Preoperative magnetic resonance imaging (MRI), (B) Postoperative lateral radiograph and (C) Postoperative sagittal computed topography (CT) showing stable AxioMed® implants.

Table 1: Patient demographics, levels treated, and complication overview

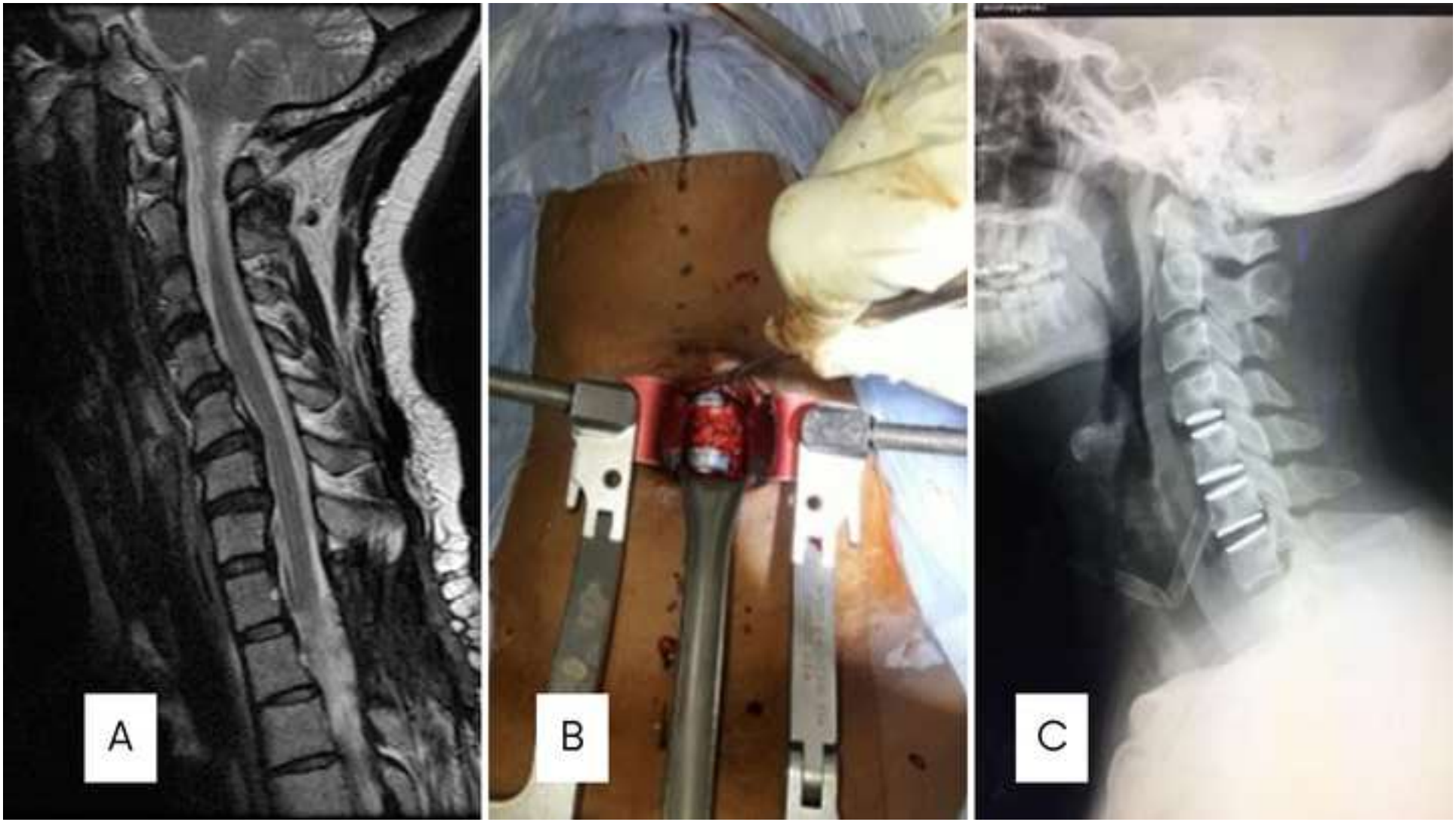
Age	Sex	Number of Level(s)	Level	Complications
54	F	Single	C5-6	None
31	M	Single	C5-6	None
39	F	Two	C4-5, C5-6	None
60	F	Three	C4-5, C5-6, C6-7	None
70	F	Three	C3-4, C4-5, C5-6	None
54	F	Four	C3-4, C4-5, C5-6, C6-7	None


A
B
C

Figures 2



Figures 3



Figures 4