Annual Report 2025

Australian Spine Registry

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Message from the SSA president

Preface to the Australian Spine Registry 2025 Annual Report

As President of the Spine Society of Australia (SSA), and on behalf of the Board of Directors, I am pleased to introduce the 2025 Australian Spine Registry (ASR) Annual Report. This year has been characterised by a dual focus: strengthening our internal operational excellence while expanding our influence within the broader healthcare ecosystem.

Strategic Funding and Governance

The ASR's financial and regulatory foundation remains robust. Our Commonwealth grant position is secure, supported by diligent annual reporting and progress tracking. Beyond primary funding, our Medical Research Future Fund (MRFF) initiatives, conducted in partnership with the University of Melbourne, has been progressing steadily, which includes active consumer engagement through Musculoskeletal (MSK) Australia. This ensures that our research and software interface improvements are grounded in the needs of the patients we serve.

Our engagement with the Clinical Quality Registry (CQR) team and various government-appointed consulting groups remains a priority, ensuring the ASR is aligned with national health data strategies.

Operational Maturity and Team Development

A registry is only as strong as the team and systems behind it. This year, we dedicated significant resources to internal growth, including:

- **Team Education:** Enhancing clinical literacy through theatre visits and specialised workshops.
- **Quality Control:** Hosting software improvement workshops and an operational planning day to refine our workflows.
- **Visibility:** Modernising our public-facing website and implementing citation monitoring to track the ASR's growing impact on scientific literature.
- **Data Insight:** Utilising operational trending to ensure the registry scales efficiently as surgeon recruitment increases.

International Leadership

The ASR continues to benchmark itself against the world's best. In addition to our ongoing work with the International Spine Registry Group, we have conducted meetings with numerous international spine registries to identify and adopt global best practices. These collaborations ensure that Australian spine surgery remains at the forefront of international standards.

Expanding Clinical Frontiers

We continue to broaden our reach into specialised areas of spine care. The Paediatric Australian Spine Registry (pASR) is successfully moving from its pilot phase into a national rollout. Furthermore, our collaboration with the Pain Faculty to develop a pilot neuromodulation registry demonstrates our commitment to capturing the full spectrum of spinal interventions.

I would like to thank our Registry Clinical Director, Dr Michael Johnson; Registry Manager, Dr Esther Apos; and our expanded team, including our new recruitment and compliance managers. Their dedication ensures that the ASR remains an indispensable resource for driving evidence-based practice and improving patient outcomes across Australia.

Sincerely,

Associate Professor John Costi
President, Spine Society of Australia

Message from the ASR Clinical Lead

It is with pleasure that I present the Australian Spine Registry 2025 Annual Report. The past year has been one of considerable progress as we advance into an exciting phase of growth and expansion.

Firstly, I must mention our success in being involved in obtaining a substantial MRFF grant dedicated to exploring ways of enhancing spinal device surveillance. This achievement, secured through a strong partnership with the University of Melbourne, Flinders University, SAHMRI, and Musculoskeletal Health Australia, represents a major milestone for the registry. The grant application was expertly led by Professor Peter Choong AO, the Sir Hugh Devine Professor of Surgery and Head of the Department of Surgery at the Melbourne Medical School, University of Melbourne. We extend our deepest gratitude to Professor Choong and all chief and associate investigators for their commitment and effort in securing this pivotal funding.

Under Professor Choong's leadership, a team of internationally recognised experts has been assembled to support the implementation of key objectives. These include the redevelopment of our data collection platform, exploration of data linkage opportunities, expansion of recruitment, and strengthening of engagement with all stakeholders, particularly patient communities.

In parallel, we are delighted to report significant momentum in our paediatric initiatives. Building on the successful groundwork at Queensland Children's Hospital, which demonstrated the feasibility of collecting a robust and clinically relevant paediatric spine dataset, we are now preparing a multi-site paediatric ethics application to enable participation from additional paediatric spine surgery centres across Australia.

Our collaborations have continued to expand as well. The Faculty of Pain Medicine of the Australian and New Zealand College of Anaesthetists has approached the registry for guidance in establishing a neuromodulator registry. Planning sessions have been highly productive, and a feasibility trial is soon to commence.

This year has also seen excellent results from our recruitment team, whose commitment has driven a marked increase in both participating surgeons and hospitals. As a result, annual patient recruitment has grown significantly, reflecting the growing trust in, and value of, the registry's work.

Our international collaborations likewise continue to flourish. Regular engagements with other national spine registries and the International Spine Registry Group have provided invaluable opportunities for shared learning, shaping our current processes and future directions, particularly as we progress with the MRFF project.

None of these achievements would have been possible without the enduring support of our partners and stakeholders:

The Commonwealth Government, through the Clinical Quality Registry Program, whose guidance and financial backing have been instrumental.

The Australian Orthopaedic Association and the Neurosurgical Society of Australia, whose expertise and counsel remain invaluable.

Monash University, whose statistical expertise underpins our analytic capability.

Our dedicated IT partners — SMAIO, PolarSeven and eNerds — who continue to be essential to our operational success.

Above all, we extend our heartfelt thanks to the many patients who participate in the registry. Their willingness to contribute makes our mission possible, and we remain committed to repaying that trust through improvements in spine care across Australia.

Finally, I wish to acknowledge and thank all our participating surgeons, our Registry Manager Dr Apos, and the amazing team that drives this initiative forward. Their professionalism, skill, and enthusiasm make it a privilege to lead such an accomplished and passionate group.

Dr Michael Johnson MBBS,
FRACS (Orth), GAICD
Chairman, Australian Spine Registry
Steering Committee
Clinical Lead, Australian Spine Registry

Acknowledgements

The ASR can continue to grow only through the efforts of many people.

It is essential that we thank:

- The patients, whose willingness to be involved and to complete the registry specific questionnaires both pre-operatively and post operatively.
- All participating surgeons and their practice and hospital support staff who enter the data into the registry database and keep it up to date.
- The ASR governance committees who are also pivotal for the ongoing success of the registry.
- The ASR and pASR team.
- Guillaume Floret, Jerome Derail, Thibaut Bastien and Philippe Roussouly from SMAIO for the support and continuous improvement of the registry web-based interface.
- The SSA Board for their continuing support.
- The members of the ASR Steering Committee for their time and commitment.
- Terrie O'Brien and Antony Kerslake – Clinical Quality Registry Section, Health Modelling, Partnerships and Evaluation Branch, Australian Government Department of Health and Aged Care, for their advice, direction and financial support.
- Professor Peter Choong, the ASPIRE advisory board, all MRFF chief investigators and the University of Melbourne staff for their time and commitment in 2025 to launch the ASPIRE project.

Data Period

The data contained in this document was extracted from the Australian Spine Registry database and represents data collected between 15 January 2018 and 31 December 2025. As the registry does not capture data in real time, there may be a lag period between the treatment date and the capture of data in the registry database, KEOPs.

Common Terms, Definitions and Abbreviations

ACDF	Anterior Cervical Discectomy and Fusion, or Anterior Cervical Decompression and Fusion
ACSQHC	Australian Commission on Safety and Quality in Health Care
AIS	Adolescent idiopathic scoliosis
AOA	Australian Orthopaedic Association
ALIF	Anterior Lumbar Interbody Fusion
ASA	American Society of Anaesthesiologists physical status classification system
ASD	Adult spinal deformity
ASR	Australian Spine Registry
ASPIRE	MRFF Project - Australian Spine Registry Project
BMPs	Bone Morphogenetic Proteins
Bone Graft	A bone graft is real bone or bone-like tissue that in spine surgery is used to aid bony healing between vertebrae and fill bony defects.
BPD	Back Pain Dominant
Cauda equina syndrome	A condition that occurs when the bundle of nerves below the end of the spinal cord known as the cauda equina is damaged. It is characterized by signs and symptoms that numbness around the anus, and the diminution or loss of bowel bladder control or sexual function
Cervical	Between the occiput and T1
Claudication	Impairment in walking, or pain, discomfort, numbness, or tiredness in the legs that occurs during walking or standing and is relieved by rest
Complex Surgery	Surgery in patients of 60 years or more where ≥7 contiguous vertebrae have been fused in one procedure
CSD	Complex Surgery Deformity
CORRP	Clinical Outcomes data Reporting and Research Program
Deformity	A loss of the normal curvature of the spine
DCM	Degenerative Cervical Myelopathy
Degenerative Cervical Myelopathy	A condition characterised by spinal cord dysfunction due to compression in the neck, often resulting from age-related degenerative changes in the cervical spine.
DBMs	Demineralized Bone Matrices
Discectomy	A type of surgery to decompress nerve compression secondary to disc herniation
DS	Degenerative Spondylolisthesis

EQ-5D-3L	EQ-5D 3-Level
EQ-VAS	EQ Visual Analogue Score
EuroQoL™ EQ-5D-3L	EQ-5D is a standardised measure of health status developed by the EuroQol Group in order to provide a simple, generic measure of health for clinical and economic appraisal[1]. 5D represents five dimensions; 3L represents three levels.
Fusion	Surgery to permanently join two or more vertebrae in the spine eliminating motion between them.
Glassman Classification	A diagnostic classification of symptoms, pathology and site of neural compression for lumbar spine registry usage
HRQOL	Health-Related Quality of Life
IONM	Intraoperative neurophysiological monitoring
ISRG	International Spine Registry Group
IS	Isthmic Spondylolisthesis
LBP	Lower back pain
MCID	Minimum Clinical Important Difference
MDC	Minimum Detectable Change
Mths	Months
Motion Segment	Motion segment is defined as including all anatomical structures (including traversing and exiting nerve roots) between and including the top of the pedicle above to the bottom of the pedicle below.[a]
MSK Australia	Musculoskeletal Health Australia
Navigation	Spinal navigation refers to the use of technologies, such as computer-assisted navigation systems, to guide surgeons during spinal surgery.
Neuromonitoring	A technique used during spinal surgery to monitor the function of the nerves and spinal cord.
NDI	Neck Disability Index
ODI	Oswestry Disability Index
Opt-out	Patients who have been provided a registry information brochure and who have elected not to have their data included in the registry
pASR	Paediatric Australian Spine Registry
Postop	6, 12 and 24-months follow-up after surgical treatment
Preop	Up to 3 months prior to surgery
PROMs	Patient Reported Outcome Measures
QCH	Queensland Children's Hospital
QoL	Quality of Life
SMS	Short Message Service
Spondylolisthesis	A condition in which one vertebra slips forward over the one below it.
SRC(s)	Surgeon Reported Comorbidity (ies)
SRS-22	Scoliosis Research Society Patient Based Outcome Questionnaire
SSA	Spine Society of Australia
Staged Procedure	A surgical procedure that is performed in multiple planned stages
TL	Thoracolumbar
Thoracolumbar	Between T1 and the pelvis

Executive Summary

The Spine Society of Australia (SSA) and the Australian Spine Registry (ASR) is proud to present the 2025 Annual Report.

The data presented in this report was collected for all patients recruited between 15 January 2018 and 31 December 2025 and an analysis was made of both the entire patient group and specific patient cohorts. This year we have added a new cohort, degenerative cervical myelopathy, a subset analysis of the deformity group within complex surgery cohort and a more in-depth analysis of patients who reported back pain as their primary complaint.

We are also reporting on the progress of the paediatric Australian Spine Registry (pASR), a collaborative project with the Queensland Children's Hospital which commenced in 2023. The pASR has now recruited over 60 patients and will be expanding to a national registry in 2026.

One of the ASR's strengths during 2025 has been the robust hospital and surgeon recruitment in addition to the data acquisition and compliance. The addition of dedicated recruitment managers has enabled the registry to double the number of surgeons. ASR has also consistently maintained patient data completion and surgeon data entry at approximately 79%.

A quick glance at time of data cut off:

- The registry had a total of 52 active participating surgeons with at least another 33 surgeons pending approval.
- The registry had a total of 11 public hospitals and 25 private hospitals approved with another 10 pending approvals.
- The registry had a total of 6,679 participants who had surgery. This comprised of 3530 (53%) males and 3145 (47%) females, and 4 (0.1%) gender not defined. Median age at the time of surgery was 62 years for males and 65 years for females.
- The largest decile having spine surgery was 70-79 years, followed by 60-69 years.
- There is a discrepancy of the data between surgeon reported comorbidities (SRCs) and American Society of Anaesthesiologists classification (ASA) in all cohorts. For example, for the entire ASR cohort, SRC show that 62.6% of patients had no comorbidities compared to ASA where 21.0% of patients were scored ASA 1. This is likely due to under-reporting of comorbidities by surgeons.
- In 2025, 6.6% of ASR procedures reported the use of neuromonitoring, which was a slight decrease from 2024.
- In 2025, of the procedures recorded, 26.8% used some type of navigation, which was a decrease from 32.1% in 2024.
- In the total number of fusion procedures recorded, 73.7% used autologous bone graft, 27.4% used an allograft and 17.2% used one or more non-autograph/allograft bone graft substitute.
- Discectomy, ACDF and Isthmic spondylolisthesis patients were generally younger (median age of 48, 56 and 49 years respectively) and had fewer comorbidities when compared to the total patient cohort.
- Patients who presented with L4-L5 degenerative spondylolisthesis had a median age of 71 years.
- Patients who underwent a 1-2 level ALIF had a median age of 49 years. 63.8% of this cohort were males.
- Of patients 60 years old and over who underwent complex surgery, 69.1% were females. The median age of this cohort was 69 years. 53.0% of patients had previous spine surgery.
- Patient reported outcome measure (PROMs) analysis showed:
  - For thoracolumbar and spinal deformity patients, the median ODI pre-op score was 44 compared to median follow up scores of 18 (6 months) and 16 (12 and 24 months). This did not change from 2024.
  - For cervical patients, the median NDI pre-op score was 42 compared to post-op follow up scores of 16 at all time points (6, 12 and 24 months). There was a small increase in the NDI from 2024 (14) to 2025 (16) only at 24 months.
  - For ACDF patients, the median NDI pre-op score was 42 compared to median follow up scores of 18 (6 months), 16 (12 and 24 months).
  - For DCM patients, the median NDI pre-op score was 42 compared to median follow up scores of 18 (6 months), 20 at 12 months and 18 at 24 months.

- EQ-5D-3L scores improved at the 6, 12 and 24-month time points for the entire cohort, with improvements across all domains.
- ACDF patients whose scores indicated severe disability or worse (NDI score > 25) reduced from 33.4% preoperatively to 8.5% at 6 months, 8.4% at 12 months, and 10.3% at 24 months.
- DCM patients whose scores indicated severe disability or worse (NDI score > 25) reduced from 40.0% preoperatively to 6.5% at 6 months, 11.6% at 12 months, and 4.6% at 24 months.
- Discectomy patients whose scores indicated severe disability or worse (ODI score > 40) reduced from 63.1% preoperatively to 6.2% at 6 months, 7.8% at 12 months, and 6.7% at 24 months.
- L4-L5 Degenerative spondylolisthesis patients whose scores indicated severe disability or worse (ODI score > 40) reduced from 48.5% preoperatively to 13.6% at 6 months, 12.0% at 12 months, and 9.0% at 24 months.
- L5-S1 Isthmic spondylolisthesis patients whose scores indicated severe disability or worse (ODI score > 40) reduced from 59.7% preoperatively to 16.0% at 6 months, 13.6% at 12 months, and 10.5% at 24 months.
- EQ-5D-3L scores for complex surgery patients indicated a more gradual improvement than other cohorts with scores continuing to improve at 24 months.
- There is 28.7% of the complex surgery cohort that remain with ODI scores greater than 40 at 24 months post- surgery.
- Patients in the complex surgery cohort whose scores indicated severe disability or worse (ODI score > 40) reduced from 69.3% preoperatively to 29.1% at 6 months, 29.6% at 12 months, and 28.7% at 24 months.
- Patients in the Complex Surgery Deformity cohort whose scores indicated severe disability or worse (ODI score > 40) reduced from 66.3% preoperatively to 25.5% at 6 months, 32.0% at 12 months, and 29.2% at 24 months.
- BPD patients whose scores indicated severe disability or worse (ODI score > 40) reduced from 57.9% preoperatively to 17.6% at 6 months, 14.6% at 12 months, and 15.4% at 24 months.

A data supplement has also been developed for various cohorts, which can be accessed on the ASR website.

Sustainable funding has always been a key goal of the ASR. We completed year 2 of the 4 years of funding from the Commonwealth Government ($1.8m). The ASR is pleased to report that the funding milestones were approved by the Commonwealth Government and is well on track for 2026.

In addition, the ASR was awarded a Medical Research Futures Fund (MRFF) grant in February 2025 which was directed to “Enhancing Medical Device Surveillance Through Registries”. The ASR worked with Professor Peter Choong (Department of Surgery, University of Melbourne) and Professor Michelle Dowsley and recruited a national and international team with extensive experience in data linkage (Registry of Senior Australians, Adelaide), software engineering (School of Computing and Information Systems and Centre for Digital Transformation of Health, University of Melbourne) and international registry expertise from the Canadian Spine Registry CSORN. The ASR team sincerely thanks the entire team for their input into the grant.

Additional funding support for the registry was also gratefully received in 2025 from the Spine Society of Australia (SSA).

The Australian Spine Registry's Vision

Our Vision

The Australian Spine registry aims to be a world class, state of the art clinical quality registry.

Our Mission

The ASR aims to assist spine care professionals to improve patient care through providing improved access to outcome data and facilitating research.

Our Committment

Data today.
Better care tomorrow.

Snapshot of The Australian Spine Registry

1385

Increase in the number of patients in the past 12 months from 15 January 2025 to 31 December 2025.

7142

Total number of procedures captured.

148 (2.2%)
opted-out

39 (0.6%)
deceased†

Male	Female	Not defined
53%	47%	0.1%
3530	3145	4

PROMs completion	Pre-Op	6 Mth	12 Mth	24 Mth
Patients eligible (n)	6679	5663	5228	4433
Complete data (n)	5175	4258	3906	3057
Complete data (%)	77.5	75.2	74.7	69.0

(Patients recruited up to 31 December 2025)

** Total number of patients entered into the database with or without entered questionnaire or surgeon reported data*

† Data collected directly from families or practices

‡ 4 surgeons retired or inactive

Patients
6679*

Surgeons
56‡

Sites
36

Prologue

Global Burden of Back Pain

The World Health Organisation estimated in 2020 that there were over 500 million cases of low back pain worldwide, and this represented the greatest contribution to the world's disability burden[2]. This figure is predicted to rise 36% by 2050 due to population growth and an ageing population[2].

In Australia in 2022, the National Health Survey estimated back problems were the third leading disease burden, affecting 4 million Australians[3]. Musculoskeletal disorders as a whole, accounted for the highest health spending of all disease groups, at $14.7 billion (9.8%) while spinal surgery was responsible for approximately $5 billion[4].

The annual number of spine operations is increasing in almost all developed nations, but with considerable variation in the rates and types of surgery performed for particular conditions, both within and between countries.

Within Australia, spinal surgery has increased both in number of procedures and complexity. This has been associated with an increase in the implantation of spinal devices, rising from 150,000 in 2012 to 220,000 in 2023[5].

The rates of Australian spinal surgery exhibit significant variation both geographically and between the public and private sectors. This variation for spinal fusion can be up to 12-fold between regions[6].

These changes and variations have many possible causes including infrastructure availability, insurance type and surgical culture.

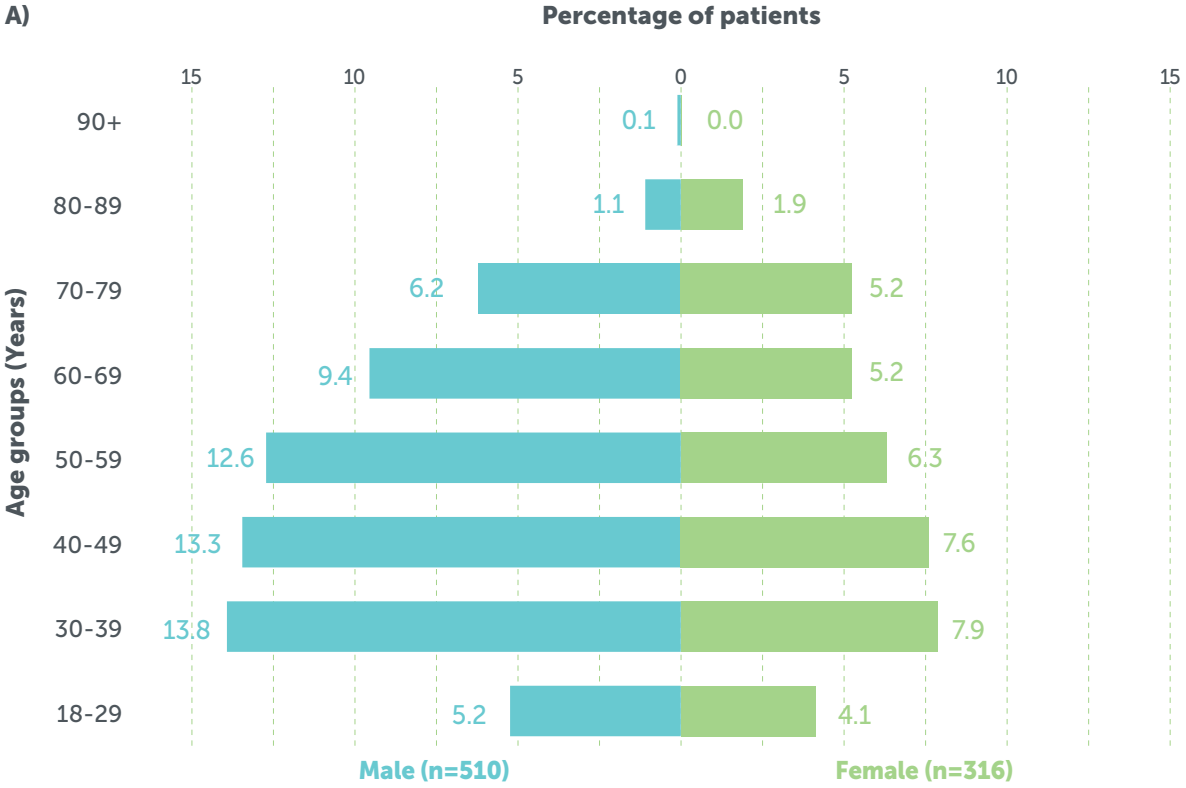
The recent expansion of national spine registries will be one avenue to explore these differences.

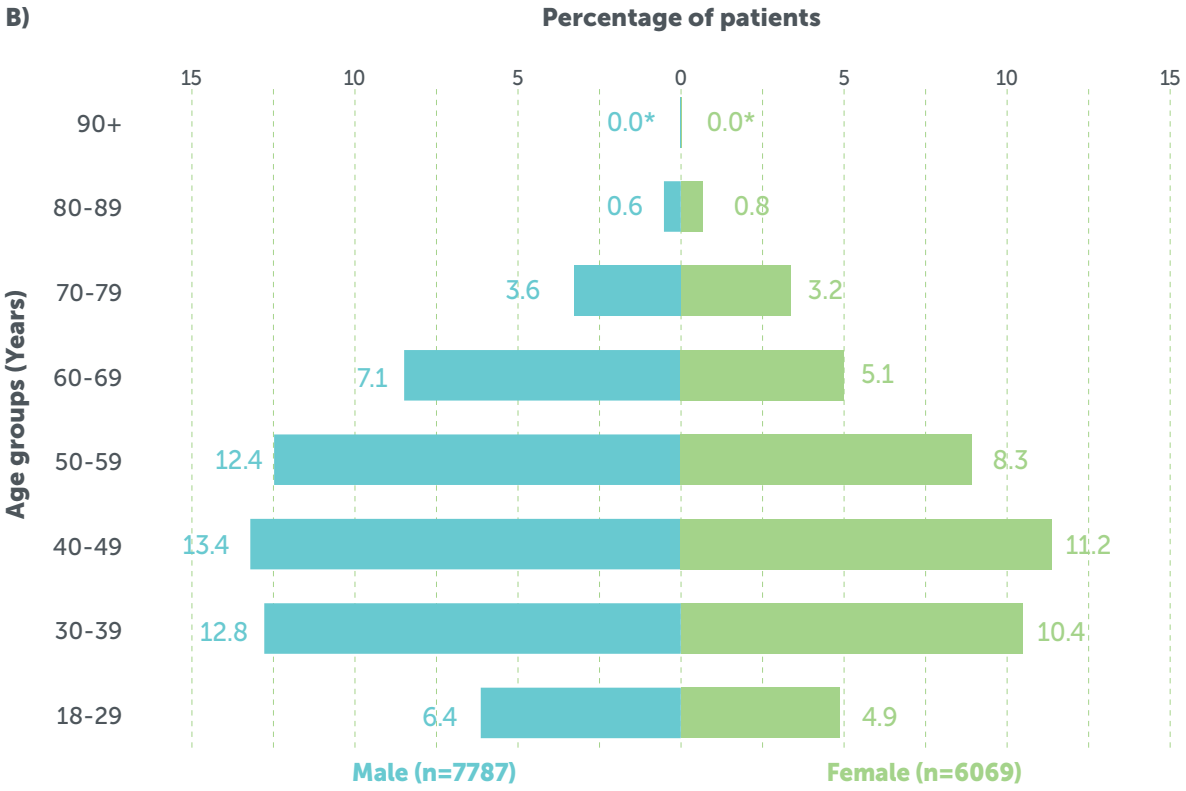
It is well acknowledged that registries can provide rich information on the number and types of surgical interventions and patient outcomes, quality of life and cost effectiveness and could enable comparisons between countries, populations, pathologies and surgery types. In 2022, an international spine registry group (ISRG) was initiated to enable communication and collaboration across multiple jurisdictions.

The Australian Spine Registry is actively participating in this group and has established strong communication and research collaborations with the various members. An initial initiative of the ASR with the Norwegian Registry is the comparison of patients that have had single level discectomies. Figures 1 and 2 show the comparisons between the Norwegian and Australian patients. Comparisons of the demographics and the Oswestry Disability Index scores indicate that the populations are similar and outcomes are comparable. This suggests that although there may be differences in methodology between the two registries, the results obtained are comparable, opening the potential to explore differences in other surgical cohorts.

The ability to harness international aggregate data from other registries is extremely valuable. As the ASR dataset increases and matures, this ability to collaborate and compare the ASR data with international datasets is vital so that the Australian experience can be compared internationally. We hope you enjoy the 2025 annual report.

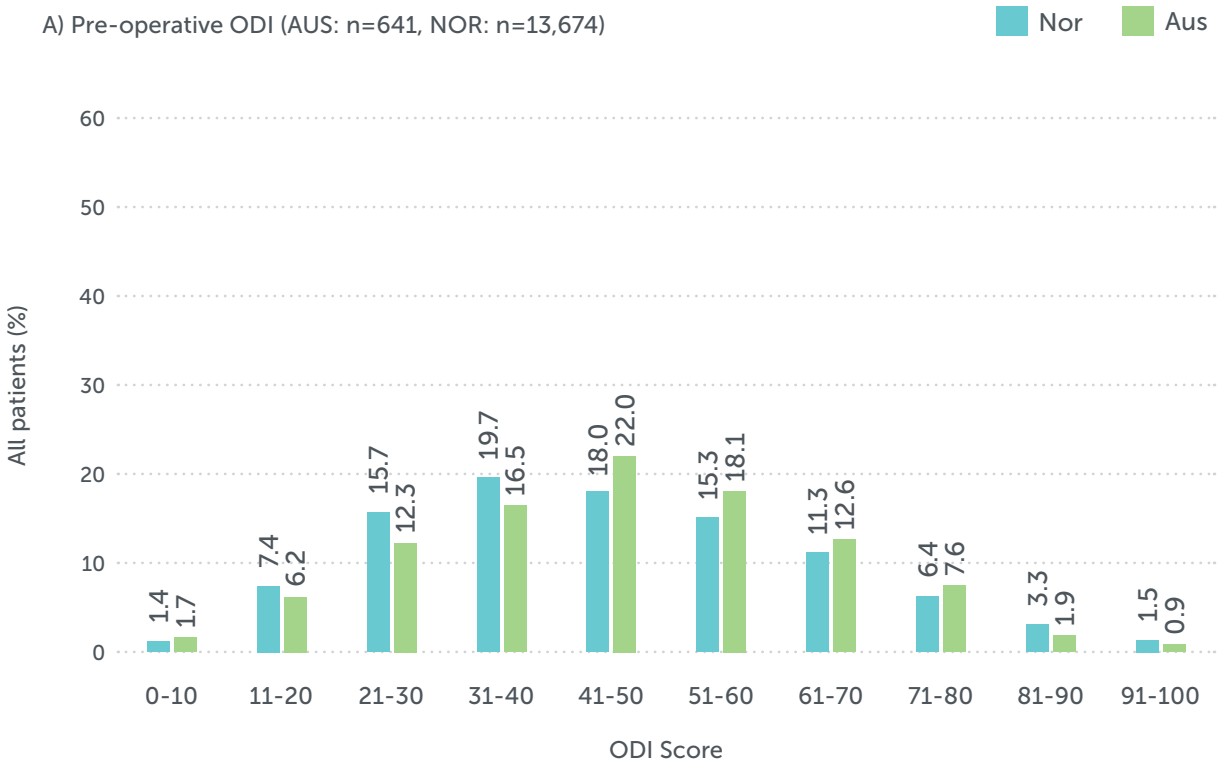
Figure 1: *Distribution of discectomy procedures by patient age and sex across (A) Australia and (B) Norway, 2018–2025.*

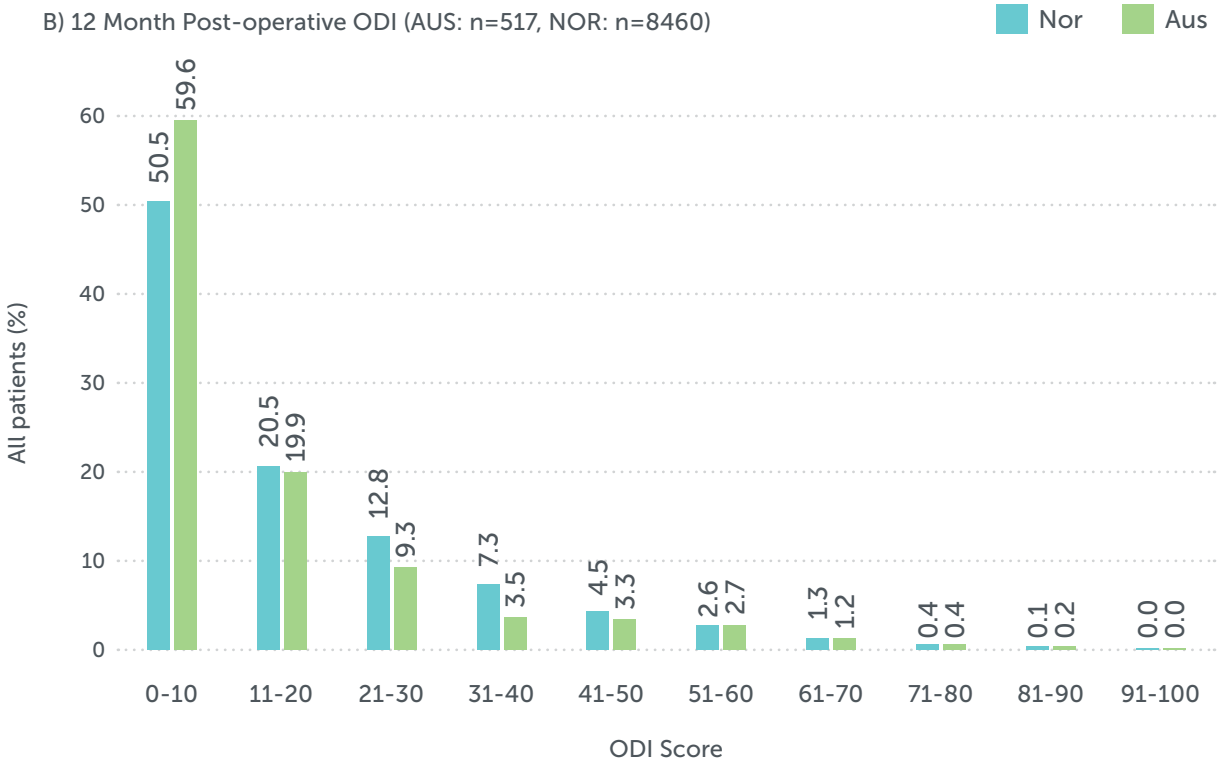




** Note: Percentages 0.0 = 0.01%*

Figure 2: *Comparison of ODI score distributions for discectomy patients who completed any ODI across Australia and Norway at (A) pre-operative and (B) 12-months post-operative*



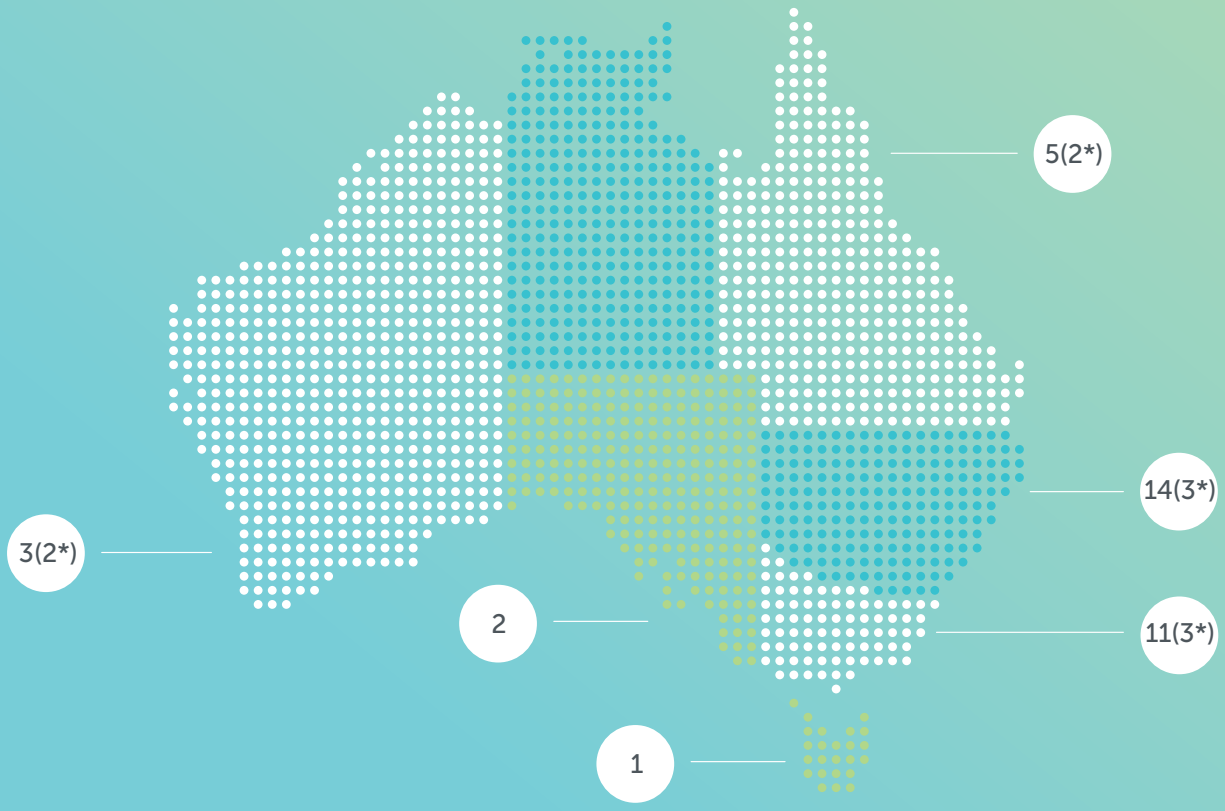


Summary of the Registry

Surgeon and Hospital Engagement

Spine surgery is performed by both orthopaedic surgeons and neurosurgeons. To date, the ASR has recruited 56 surgeons (41 orthopaedic spine surgeons and 15 neurosurgeons), with 51 surgeons actively entering data. Additional staff were recruited to support engagement and recruitment activities, resulting in an increase of 31 participating surgeons compared with 2024.

Figure 3: *Total number of public, private and pending hospitals in the registry across Australia*



11
Public sites approved

25
Private sites approved

10*
Sites Pending

Patient Uptake

Patient recruitment into the ASR increased by 75% in 2025, compared to 2024 (Figure 4 and Figure 5). Variation between jurisdictions and individual hospitals continues to be very resource intensive. In 2025 the registry accelerated its surgeon and hospital participation through more targeted recruitment approach and attendance at other national meetings, such as the 2025 Neurosurgical Society ASM.

Figure 4: *Accumulation rate of patients from registry launch on 15 January 2018 to 31 December 2025*

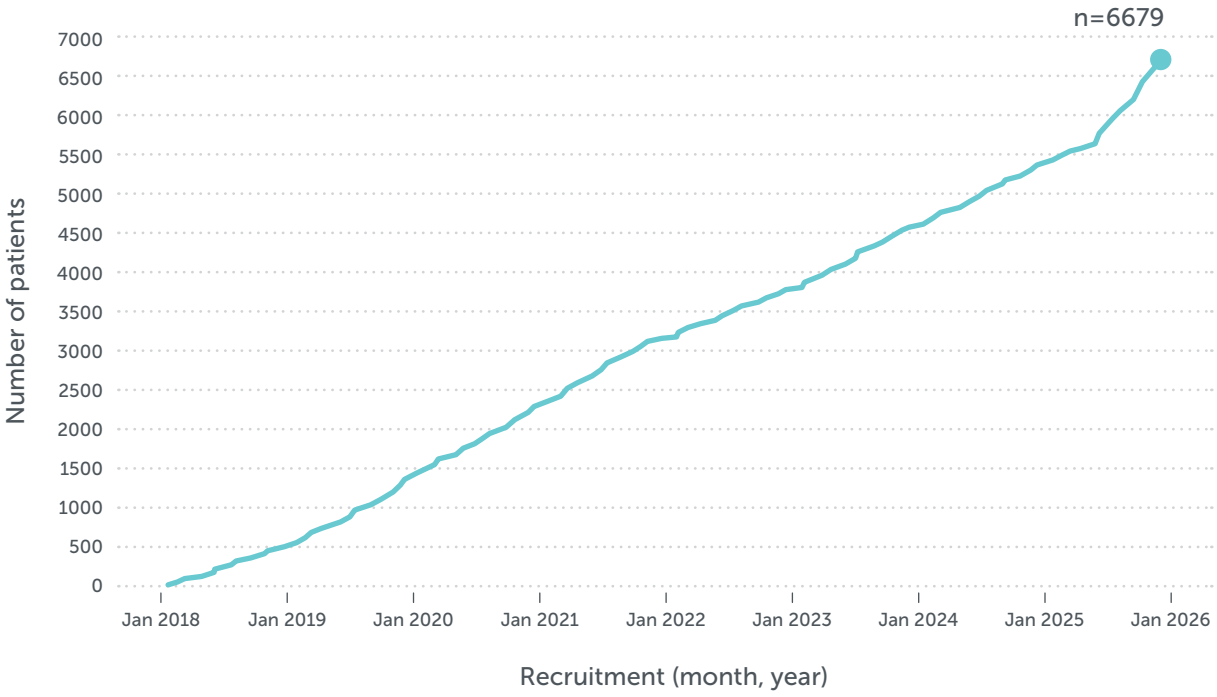
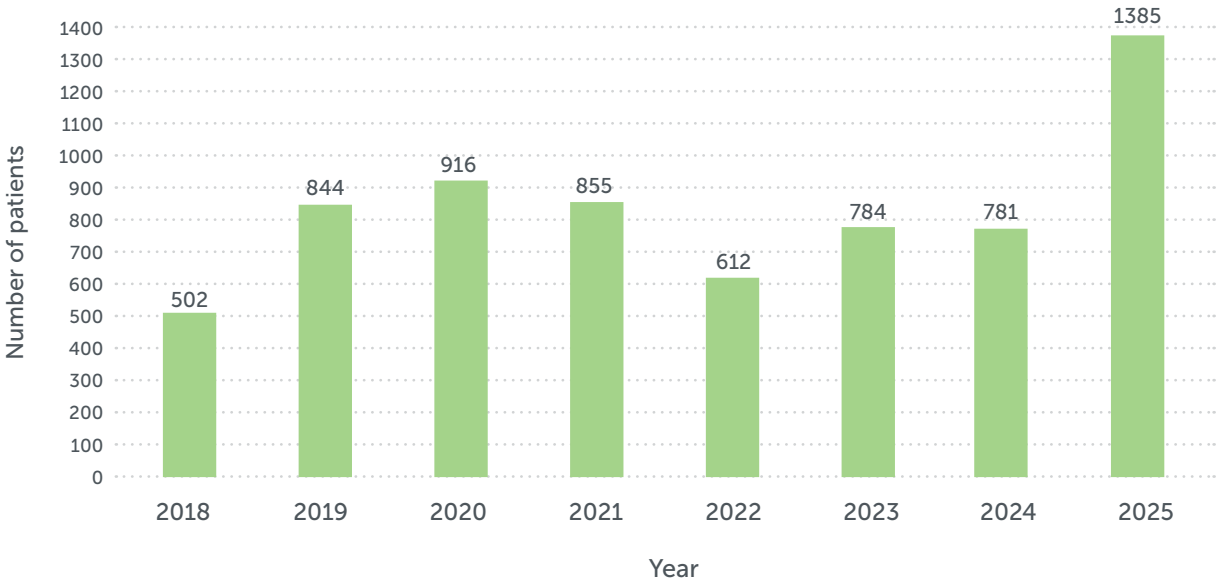


Figure 5: *Patient recruitment by year*

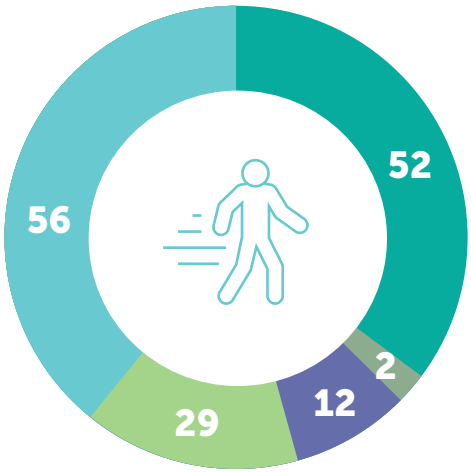


The opt-out rate for the registry is 2.2% in 2025. Main reasons for opt-out has been identified as "not interested" or "other" (Figure 6). The percentage of patients that have been reported to the registry as deceased is 0.6%. The registry acknowledges that this figure may be under-represented. The ASR is seeking approval for data linkage to the National Death Index and other linkage databases.

Figure 6: *Reasons for patient opt-out (n*)*

- Not Interested (34.2%)
- Privacy Concerns (2.0%)
- Patient Unwell (7.9%)
- No Reason Provided (19.1%)
- Other (36.8%)

** Note: Patients could select multiple reasons for opting out.*



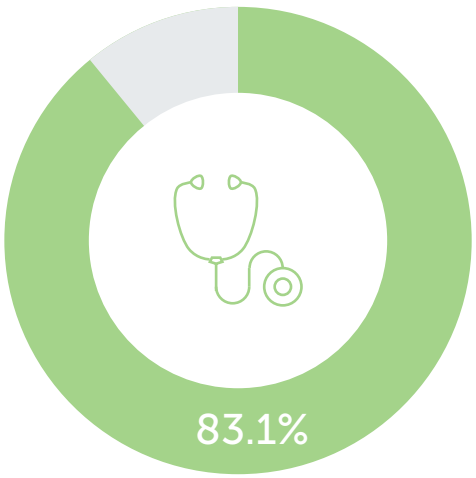
Registry Communications and Responses

The registry actively communicates with patients to ensure that their contact details remain up to date. The ASR includes a patient detail verification form with every postoperative questionnaire letter. The registry has also employed staff solely responsible for following up patients to assist with questionnaire compliance. These additional resources have been able to identify email transcription errors and has increased patient compliance. As a result, 93% of patients in the ASR have provided an email address (up from 91% in 2024).

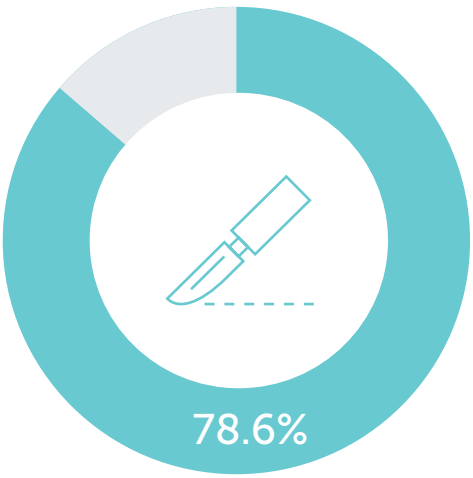
Surgeon Reported Data

The registry management consistently provides feedback and support to surgeons and their practice staff regarding patient recruitment and data completeness. The data entry completion rate by surgeons for the 2025 is shown in Figure 7. The ASR is working hard to increase this to >80% through greater engagement with surgeons, their practice staff and hospitals. The diagnosis form completion rate increased to 83.1% up from 76.2% in 2024. The surgical treatment form increased slightly to 78.6% up from 76.1% in 2024. This increase has been facilitated by additional data entry support.

Figure 7: *Surgeon data entry completion rate*



Diagnosis Form



Surgical Treatment Form

Section 1

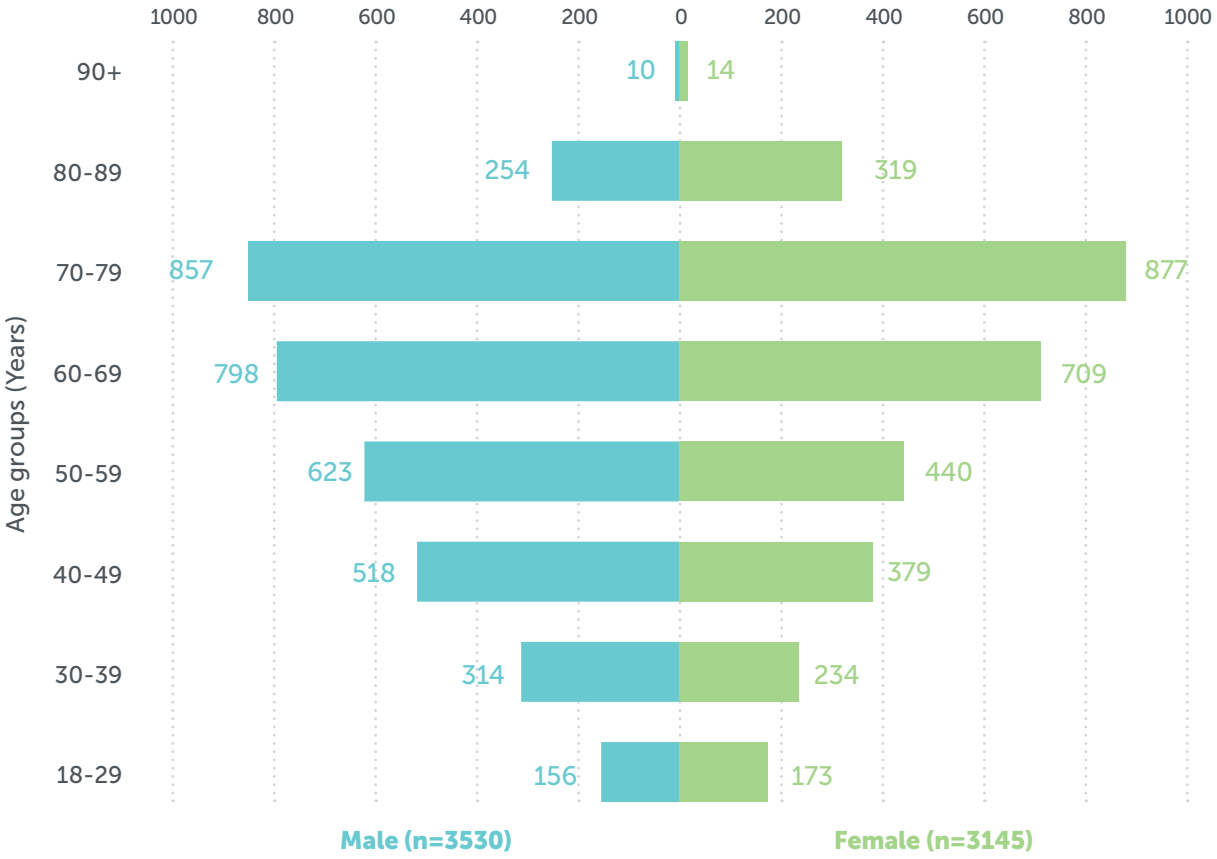
Overview of Patients

Overview of ASR Patients

Patient Demographics

6679 patients were eligible for analysis. There were 3530 (53%) males and 3145 (47%) females with 4 patients not identifying as male or female. 72% of male and 75% of female patients were over the age of 50 (Figure 8). The most common decile having spine surgery is between 70-79 years of age, representing 26% of the patients undergoing spine surgery.

Figure 8: *Patient age distribution at the time of surgery*



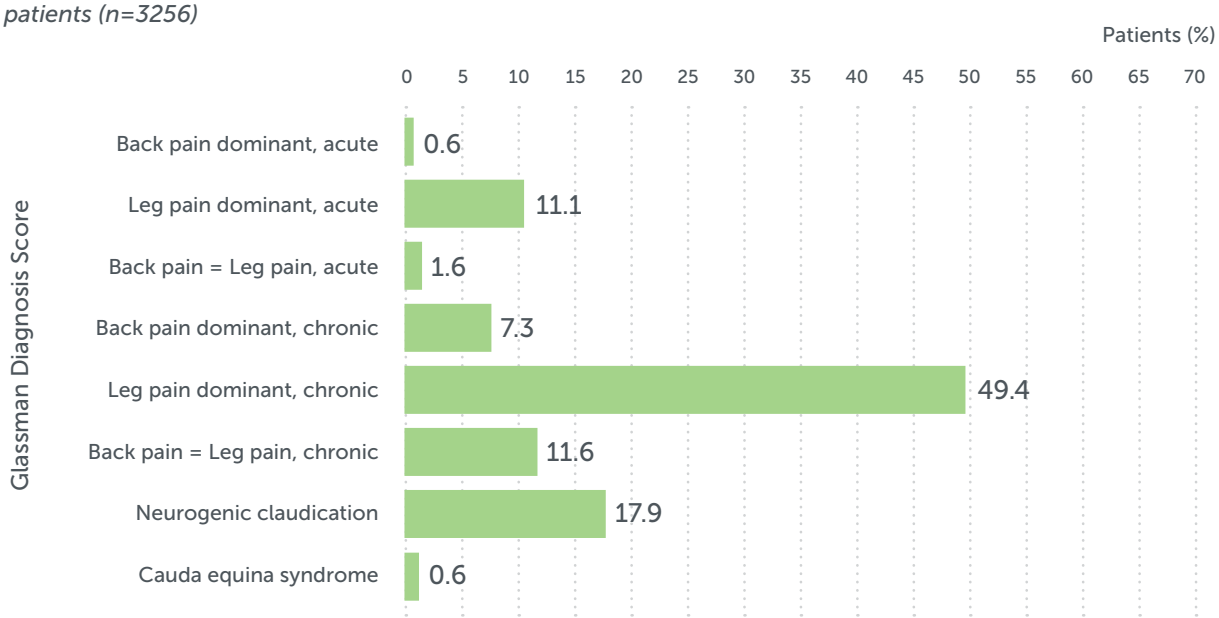
Glassman Classification in the ASR total cohort

The ASR uses the Glassman classification score which is a simple diagnostic classification scheme designed to categorise the primary characteristics of a given patient such that the impact of treatment can be correlated with the identified pathology (Table 1)[7]. Our Glassman analysis of the total ASR cohort has identified that the vast majority of patients have surgery for clinical problems associated with significant leg pain or neurological deficit. A minority (7.9%) had surgery performed for the dominant complaint of back pain (Figure 9).

Table 1: *Glassman Index table for Clinical symptoms*

Digit 1	Symptoms	Description
1	**Back Pain Dominant • Acute**	Primary complaint is Low Back Pain. Symptoms: 3 months duration.
2	**Leg Pain Dominant • Acute**	Primary complaint is Leg Pain. Symptoms: 3 months duration.
3	**Back Pain = Leg Pain - Acute**	Patient reports 50% ± 10% Low Back Pain and 50% ± 10% Leg Pain. Symptoms: 3 months duration.
4	**Back Pain Dominant• Chronic**	Primary complaint is Low Back Pain. Symptoms> 3 months duration. May include multiple recurrent episodes of back pain (acute on chronic).
5	**Leg Pain Dominant • Chronic**	Primary complaint is Leg Pain. Symptoms> 3 months duration. May include multiple recurrent episodes of leg pain (acute on chronic).
6	**Back Pain = Leg Pain - Chronic**	Patient reports 50% ± 10% Low Back Pain and 50% ± 10% Leg Pain. Symptoms > 3 months duration. May include multiple recurrent episodes of back and leg pain (acute on chronic).
7	**Neurogenic Claudication**	Numbness, weakness or pain to the buttocks or legs, exacerbated by walking or standing, relieved by sitting.
8	**Cauda Equina Syndrome**	Dominant complaint is motor weakness, incontinence or Cauda Equina Syndrome, with or without associated complaints of pain.

Figure 9: *Glassman clinical symptoms classification for the cumulative thoracolumbar and deformity patients (n=3256)*



Patient Sub-groups

The data collection software categorises patients into 3 basic groups:

- Cervical
- Deformity
- Thoracolumbar

The breakdown of patients in each group is shown below (Table 2). The majority of patients in the registry undergo thoracolumbar procedures which has been an ongoing trend within the registry. It must be noted that given that the ASR only has 15 neurosurgeons, the proportion of cervical cases may be under represented.

Table 2: *Percentage of patients by treatment types (n=6,679)*

Treatment Type	N (%)
Total	6,679
Cervical	1,009 (15.1%)
Deformity	240 (3.6%)
Thoraco-lumbar	5,430 (81.3%)

Given the small number of sites and surgeons currently participating in the registry, these figures are not necessarily indicative of the percentage breakdown of procedures that typically occur within Australia.

Surgery

The ASR analyses data on the total surgical cohort as well as specific cohorts. Specific topics of analysis for the total cohort include:

- The use of neuromonitoring in spine surgery
- The use of navigation
- Surgical approaches used in spine surgery

Neuromonitoring

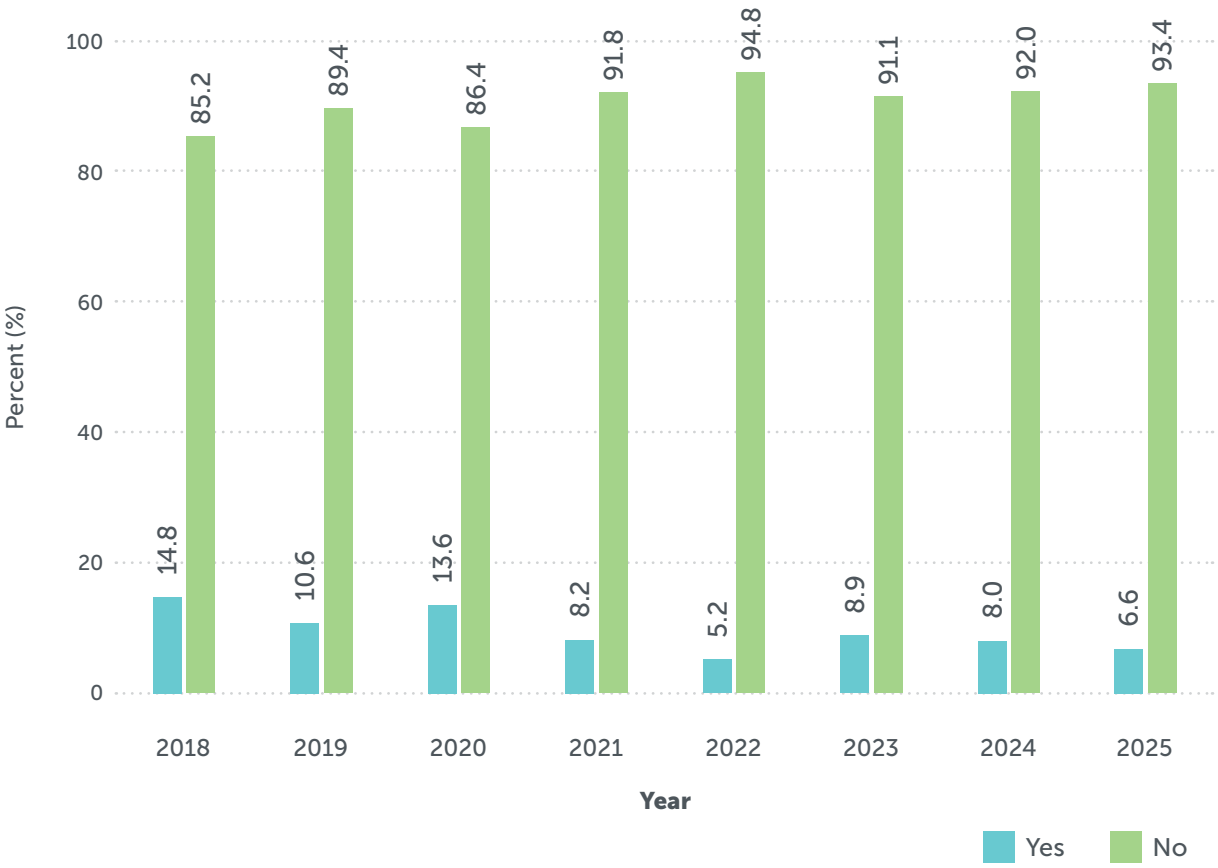
Neuromonitoring in spine surgery is a technology that allows surgeons to assess spinal cord and nerve function during the procedure through real-time feedback from individual nerve roots, motor tracts, and sensory tracts[8]. It involves various electrophysiological modalities to monitor different aspects of the central and peripheral nervous system[9].

The primary goal of intraoperative neurophysiological monitoring (IONM) is to assist with preservation of nerve function during surgery. Specifically, it aims to:

1. Identify damage or functional neurological disturbances as early as possible.
2. Ensure spinal cord functionality and avoid neurological complications.
3. Reduce the incidence of postoperative neurological complications, including issues at the level of the spinal cord, cauda equina, and nerve roots[10].

As shown in Figure 10, the use of neuromonitoring reduced in 2025. Note that 21% of the procedures entered did not have a record of neuromonitoring usage.

Figure 10: *Percentage of neuromonitoring use between 2018 – 2025 for ALL reported spine procedures*



Navigation

Navigation in spine surgery is an advanced technology that provides real-time imaging and tracking systems to assist surgeons in performing spine procedures with enhanced precision and accuracy[11]. It combines image acquisition and processing with intraoperative navigation, allowing surgeons to visualize the operative field and see the exact position of handheld instruments in relation to the patient's bony anatomy.

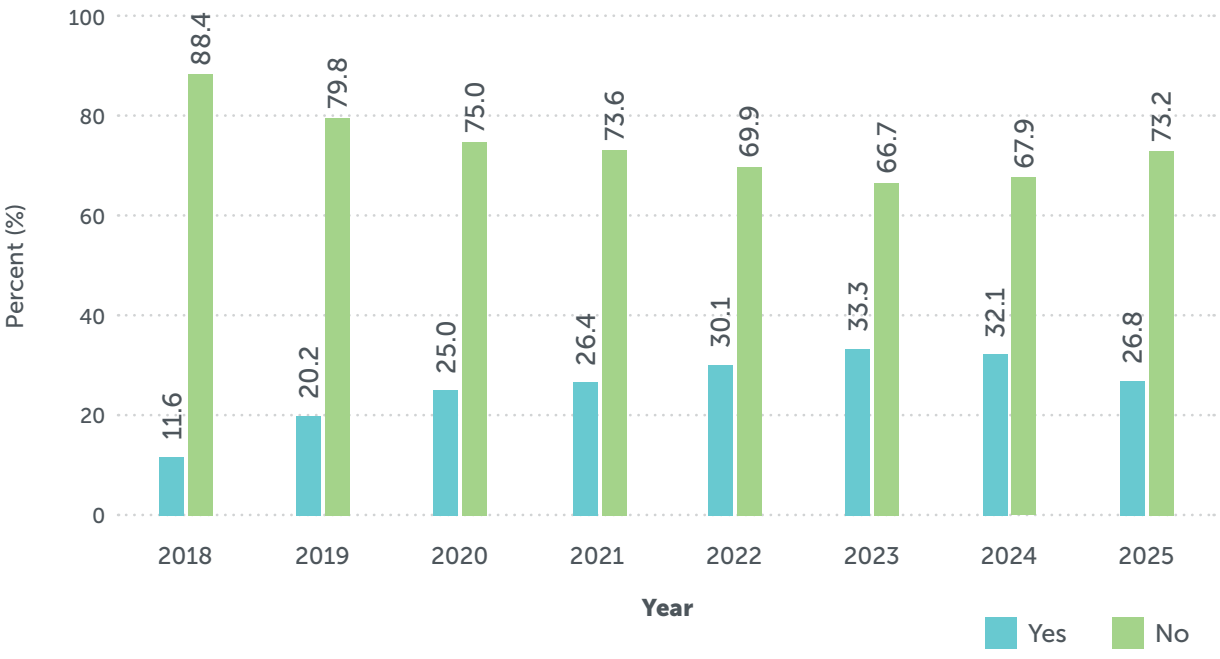
The benefits of navigation in spine surgery include:

1. Improved accuracy: For many surgeons, navigation delivers more accurate pedicle screw and interbody placement compared to conventional surgical techniques[12].
2. Reduced radiation exposure: It significantly decreases X-ray exposure for both patients and surgical staff[11,12].
3. Enhanced visualization: Surgeons can better visualize complex spinal anatomy, especially in minimally invasive procedures where traditional anatomic landmarks may not be visible[11,13].
4. Increased safety: The improved accuracy may assist to lower the risk of complications and reduced the need for revision surgeries[11,13].
5. Surgical planning: It enables more accurate planning of incisions and trajectories with any instrument[12].
6. Versatility: Navigation is useful in various spine procedures, including minimally invasive surgeries, cervical spine surgery, revision surgery, and spine tumour resection however it can be surgeon dependent[13].
7. Shorter operative times: Studies have shown that navigation in many instances can lead to reduced surgical duration[13,14].

As shown in Figure 11, the frequency of navigation use in surgery is tending to increase over time.

The recent minor reduction in frequency may not be due to a real reduction, but due to other factors such as a change in the case mix of our enlarged surgeon cohort.

Figure 11: *Percentage of navigation use between 2018-2025 for ALL reported spine procedures*



Surgical Approach

Surgical approach refers to the specific technique or pathway used by the surgeon to access the area of the spine requiring treatment. The choice of surgical approach depends on various factors, including the location and nature of the spinal pathology, the patient's anatomy, the surgeon's preference and expertise, and the desired surgical outcome. Different surgical approaches offer distinct advantages and are selected based on the individual patient's needs.

Anterior Approach: In an anterior approach, the surgeon accesses the spine from the front of the body, typically through an incision made in the abdomen or neck. This approach allows direct access to the vertebral bodies, intervertebral discs, and potentially the spinal cord or nerve roots from the front. Anterior approaches are commonly used for procedures such as spinal fusion, disc replacement, corpectomy and some types of scoliosis correction.

Posterior Approach: A posterior approach involves accessing the spine from the back of the body, usually through an incision made along the midline of the back. This approach provides access to the spinal canal, lamina, facet joints, and nerve roots. Posterior approaches are often used for procedures such as laminectomy, laminotomy, decompression, spinal fusion, and instrumentation.

Lateral Approach: In a lateral approach, the surgeon accesses the spine from the side of the body, typically through a small incision made in the flank or abdomen. This approach allows access to the disc space and vertebral bodies from the side, without disrupting the spinal muscles and structures in the back. Lateral approaches are commonly used for procedures such as lateral lumbar interbody fusion (LLIF) and lateral access surgery for spinal deformities.

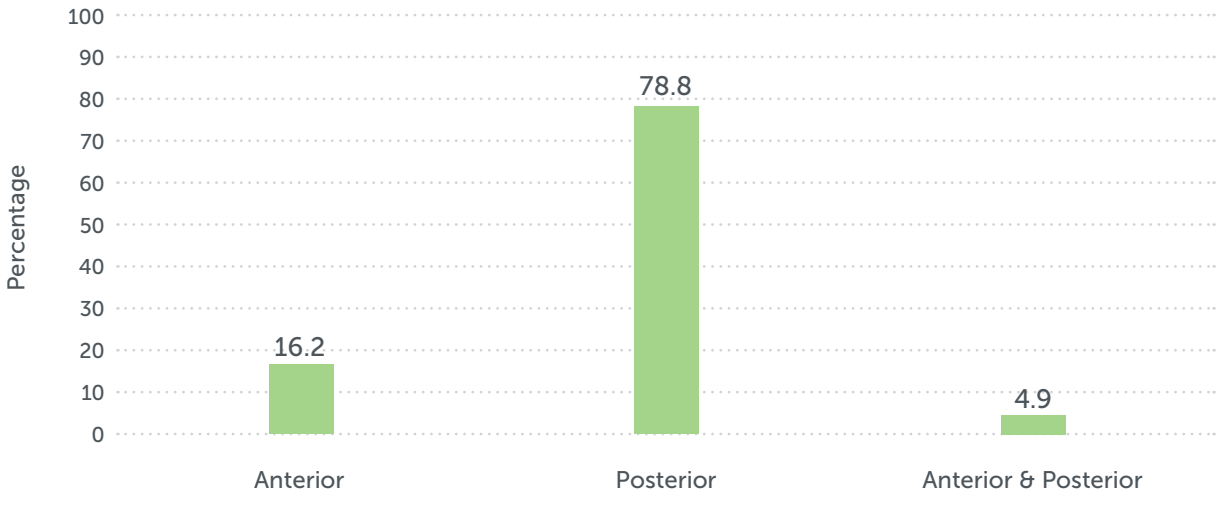
Minimally Invasive Approach: Minimally invasive surgical approaches involve smaller incisions with potentially less disruption of surrounding tissues compared to traditional open approaches. These approaches may utilise specialised surgical and optical instruments, endoscopic techniques, or navigation systems to access the spine with minimal trauma. Minimally invasive approaches can be applied to various surgical procedures, including discectomy, decompression, fusion, and instrumentation.

Combined Approaches: In some cases, surgeons may employ a combination of anterior, posterior, lateral, or minimally invasive approaches to address complex spinal conditions or achieve specific surgical goals. Combined approaches may be necessary to adequately decompress the spinal cord and nerve roots, restore spinal alignment, and achieve spinal stability.

The selection of the most appropriate surgical approach in spine surgery requires careful consideration of the patient's clinical condition, imaging findings, surgical goals, and potential risks and benefits. Surgeons often tailor the approach to each patient's specific needs to optimize outcomes and minimise complications.

The ASR has collected data on the frequency of surgical approach. Of all the procedures captured by the registry where the approach was recorded, 78% have been carried out using a posterior approach. Only 5% of procedures have been carried out using both anterior and posterior approaches. These procedures typically represent more complex surgery and may include staged procedures (Figure 12).

Figure 12: *Percentage of surgical approaches in ALL captured procedures (n=5537)*



Bone graft use

Bone grafts are used in spine surgery to promote bone growth and fusion between vertebrae. It involves placing additional bone or bone-like material between the vertebrae to create a solid bone bridge, enhancing stability and potentially reducing pain. Several types of bone grafts are commonly used in spine surgery:

A. **Autografts.** Autografts, considered the gold standard for bone grafting, involve using bone from the patient's own body[15].

B. **Allografts.** Allografts use bone tissue obtained from cadaveric donors or living donors. These grafts eliminate the need for an additional surgical site on the patient. Allografts undergo various forms of processing to ensure sterility and are available in various forms.

C. **Demineralized Bone Matrices (DBMs).** DBMs are acid-extracted organic allografts with osteoinductive properties[15]. They retain the collagen and growth factors of the original bone tissue while removing the mineral component.

D. **Synthetic Bone Grafts.** Synthetic grafts attempt to mimic the properties of natural bone and provide a framework for new bone growth.

E. **Bone Morphogenetic Proteins (BMPs).** BMPs are naturally occurring proteins that play a critical role in bone formation and healing. They can be used alone or in combination with other graft types to enhance fusion rates.

The ASR has grouped the bone graft types into 3 general categories:

- Autograft
- Allograft
- Other – Non autograph or allograft proprietary products (these include the DBMs, BMPs and any other type of proprietary bone grafts).

The registry has carried out an initial analysis on the types of bone grafting materials used in fusion procedures (Table 3). Whilst autograft is the most common material used, it is important ongoing data is obtained for future trend analysis.

Table 3: *Total number of procedures that recorded the use of bone graft (n=2798)*

Bone graft type	All grafting procedures* n (%)
Autograft – Procedures using one or more type of autograft	2061 (73.7%)
Allograft – Procedures using one or more type of allograft	768 (27.4%)
Other – Procedures using one or more types of non-auto or allograft	480 (17.2%)

**Multiple options may have been used in one procedure*

Surgeon Reported Comorbidities (SRCs) and ASA

According to the Australian National Health Survey[16], in 2022 an estimated 2.9 million people who were living with back problems reported one or more comorbidities. These comorbidities include:

- Osteoporosis
- Mental or behaviour problems
- Heart, stroke or vascular disease
- Chronic Obstructive pulmonary disease (COPD)
- Cancer
- Asthma
- Arthritis

The AIHW reported that an estimated 72% of Australians living with back problems reported 1 or more chronic conditions/comorbidities[17]. Therefore, many patients undergoing spine surgery have one or more chronic conditions/comorbidities especially as the most common age group for surgical interventions is people between 60 and 80 years of age[18]. These chronic conditions/comorbidities may contribute to outcomes following surgery.

The ASR collects both surgeon reported comorbidities (SRC) and ASA. To stratify patient comorbidities, the ASR has analysed both SRCs and ASA scores.

The ASA classification system, developed by the American Society of Anesthesiologists, is a widely used method to assess a patient's overall health status and risk factors prior to surgery[19]. It is primarily used by anaesthetists and surgeons to stratify patients into different risk categories. This can assist with perioperative risk assessment and management[20]. It is a scored system 1-6[20] and classifies the following:

Table 4: *American Society of Anesthesiologists (ASA) Physical Status Classification (Scores 1–6)*

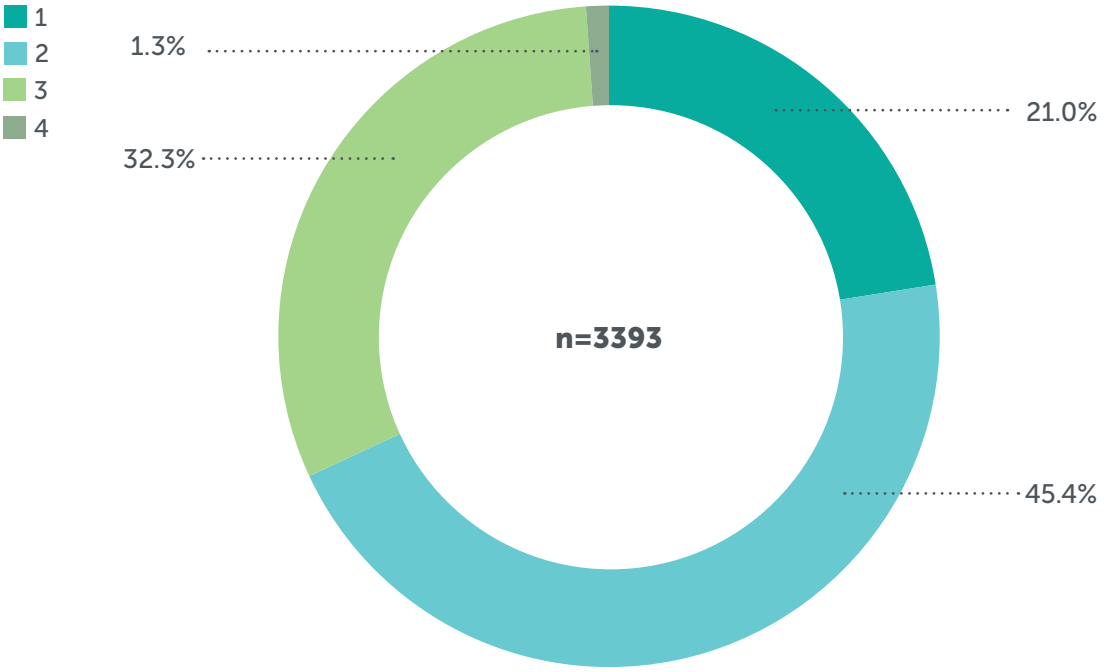
ASA I	A 'normal', healthy patient without acute or chronic disease, overweight or obesity
ASA II	A patient with 'mild' disease without significant limitation – includes smoker, pregnancy, overweight or obesity, diabetes, high blood pressure and lung disease
ASA III	A patient with 'severe' disease and substantial limitation – as above plus end stage kidney disease, stroke, and treated cardiovascular disease
ASA IV	A patient with 'severe' disease that is a constant threat to life – includes recent heart attack, stroke, dialysis, heart failure
ASA V	A patient declining in health not expected to survive without operation
ASA VI	A patient declared brain dead whose organs are being harvested for transplant

ASA scores were recorded for 3393 (51%) of patients in the registry.

When comparing the ASA scores with the SRCs, variability was noted. For example, 21.0% of patients were given an ASA score of 1 indicating that these patients were healthy at the time of their surgery (Figure 13).

In comparison, SRCs indicated that 62.6% of patients are recorded as having no comorbidities (Figure 14).

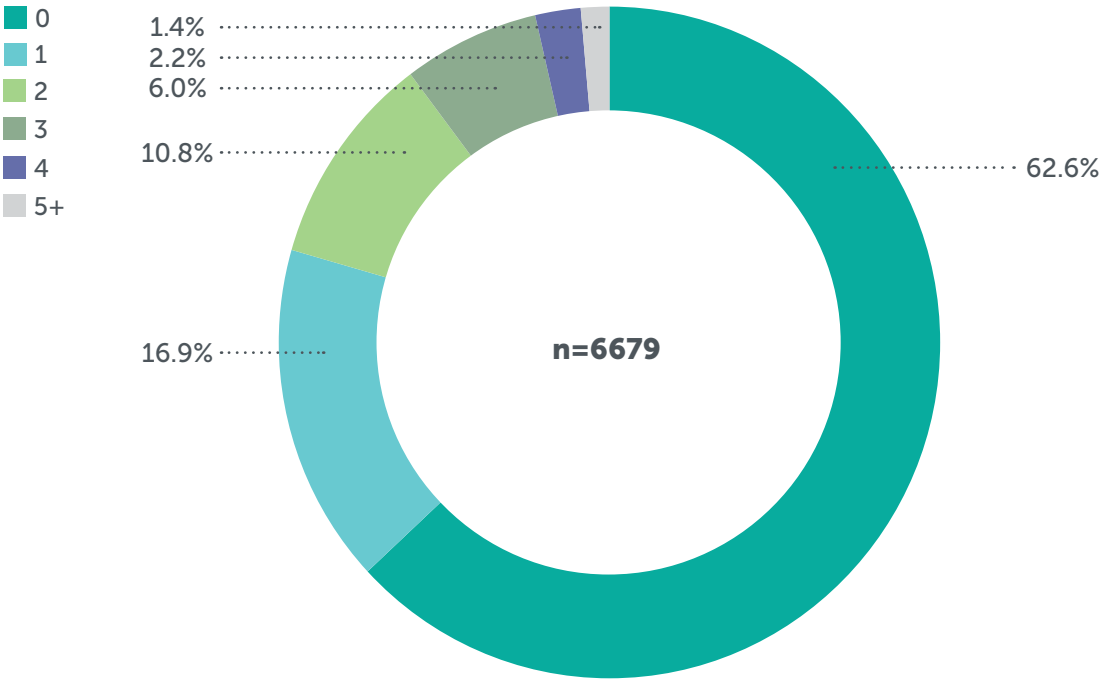
Figure 13: *ASA score reported in ALL patients where ASA scores were recorded (n=3393)*



When SRCs were broken down by surgeon, the rate of reporting varied, suggesting that there may be an under reporting of comorbidities by some surgeons (data not shown).

The registry is currently exploring other methods of comorbidity reporting such as patient reported comorbidities and data linkage with the Pharmaceutical Benefits Scheme (PBS) and other national datasets to improve the accuracy of the ASR comorbidity data.

Figure 14: *Number of surgeon reported comorbidities (SRCs) in all patients*



Patient Reported Outcome Measures - Total Cohort

Patient-reported outcome measures (PROMs) in spine surgery are validated tools used to assess patients' perceptions of their health status, functional abilities, and quality of life before and after undergoing spinal procedures. These measures capture subjective information directly from patients, including pain levels, functional abilities, and quality of life, providing valuable insights into the effectiveness of treatment from the patient's perspective. PROMs are essential for evaluating treatment outcomes in a standardised way, guiding clinical decision-making, engaging patients in their own medical care, and improving patient-centred care in spine surgery.

PROMs may focus on the patient's overall health (e.g. EQ-5D) or be more specifically tailored for individual health problems (e.g. ODI for thoracolumbar problems, NDI for cervical problems).

The ASR surveys patients before surgery and at 6, 12 and 24-months post-surgery to assess functional and quality of life improvement.

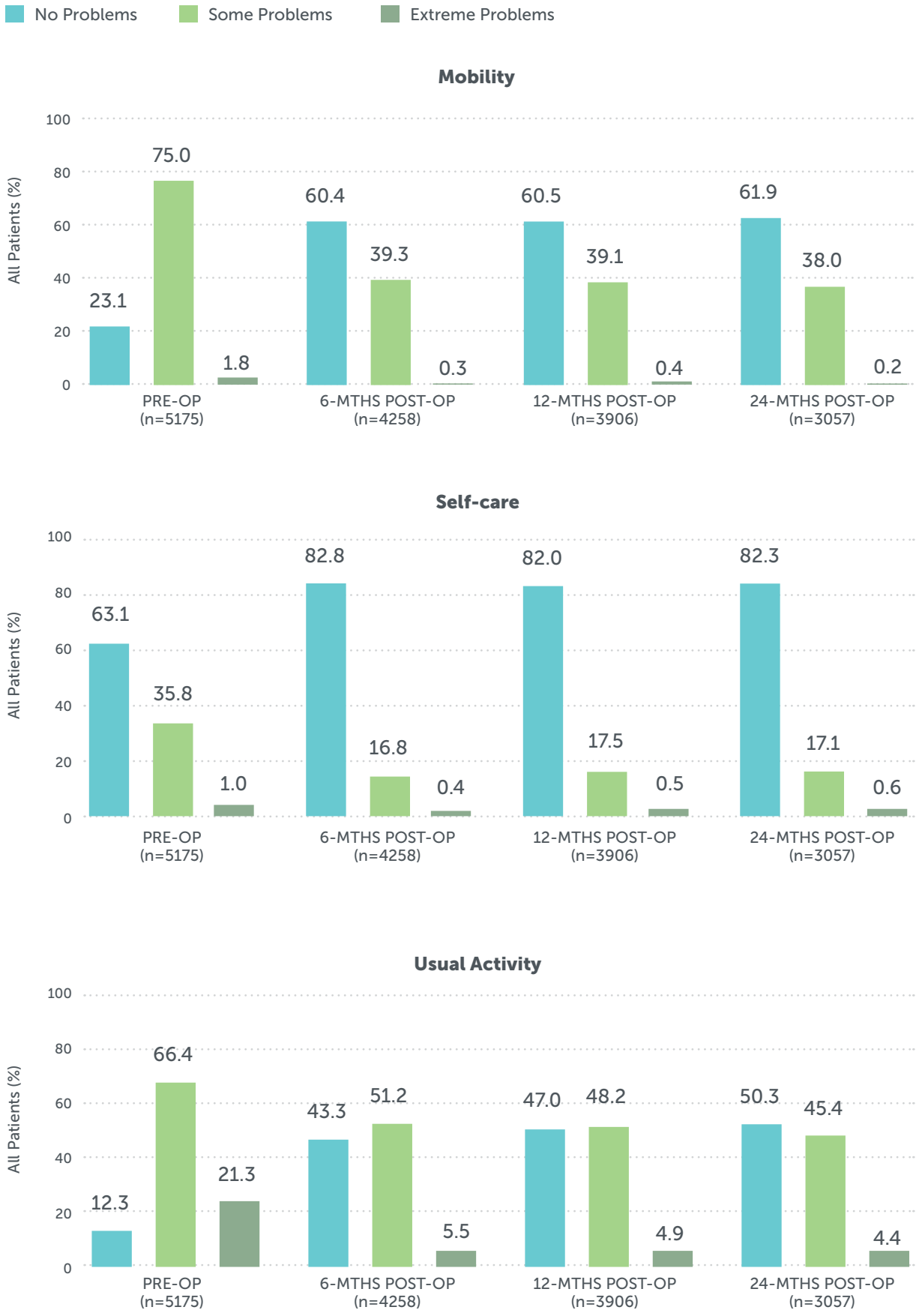
EQ-5D-3L Quality of Life

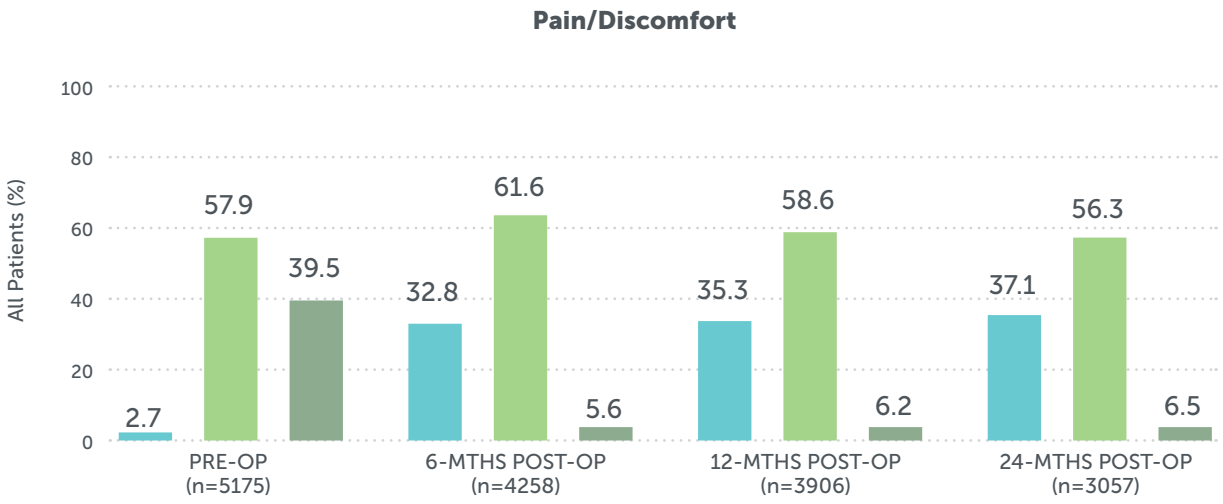
Figure 15 shows the EQ-5D-3L scores for any patient that has completed the EQ-5D-3L for each of the 5 domains (mobility, pain/discomfort, usual activity, self-care, and depression/anxiety) up to 24 months.

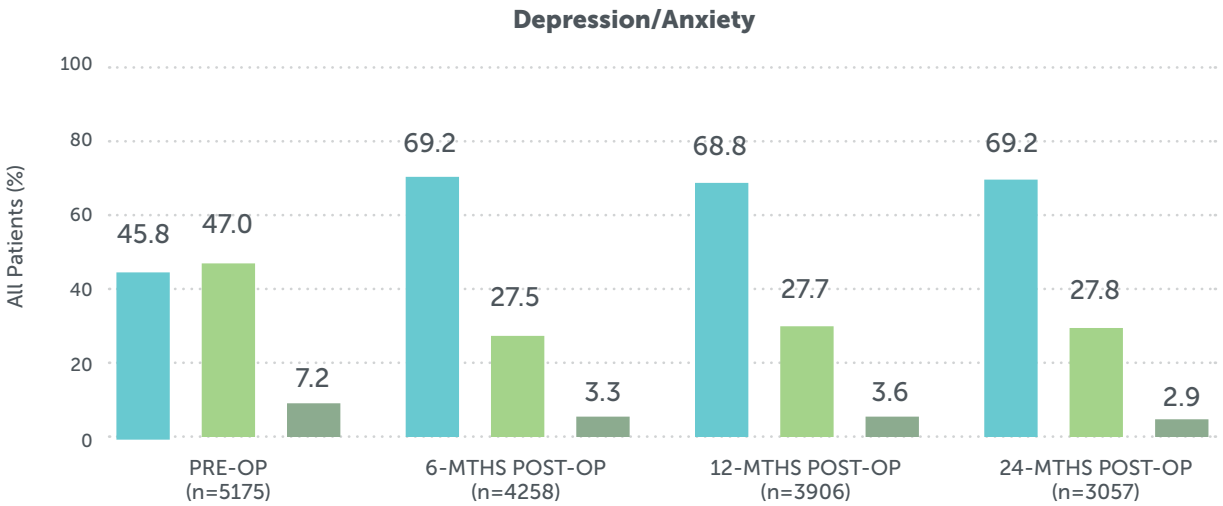
For each domain, an improvement was observed. The data indicates that these improvements are sustained after 12 months.

- **Mobility:** 77% of patients experienced some/extreme mobility problems preoperatively and this reduced to 40% at 6 months and remained stable. Given the age demographic distribution some of the persisting mobility problems may be non-spinal in origin.
- **Self-care:** 63% of patients reported no problems with their self-care at preoperative. For the 37% that reported some or extreme problems with self-care preoperatively, there was a reduction to 18%.
- **Usual activity:** 88% of patients reported some/extreme problems preoperatively compared to 50% postoperatively at 24 months post-surgery.
- **Pain/discomfort:** 97% of patients reported some or extreme problems preoperatively as compared to 67% at 6 months, 65% at 12 months and 63% at 24 months postoperative. Furthermore, the number of patients with no problems preoperatively was 3%. This increased to 37% at 24 months.
- **Depression/anxiety:** Patient who experienced some/extreme anxiety/depression preoperatively decreased from 54% to approximately 31% at all postoperative timepoints; a reduction of 23%.

Figure 15: *EQ-5D-3L scores for each domain for all patients who completed any EQ-5D-3L at pre-op, 6, 12 and 24-months post-op*







The EQ-5D includes a visual analogue scale (VAS), often referred to as the EQ-VAS. This is a patient reported measure of overall health on a scale from 0 to 100, with 0 representing the worst imaginable health state and 100 representing the best imaginable health state. The EQ-VAS provides a single index value that can be used to assess overall health status and changes over time.

A higher score with the EQ-VAS indicates improved patient perception of general health. The median EQ-VAS scores improved by almost 20 points from a median score of 60 preoperatively, to a median score of 79 at 6 months and 80 at 12 months postoperatively. This improved score of 80 was maintained at 24 months follow up (Table 5; Figure 16).

Table 5: *EQ-VAS mean and median scores for all patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

EQ-VAS	Pre-operative	6-months	12-months	24-months
n	5175	4258	3906	3057
Mean (SD)	58.1 (20.5)	73.5 (18.1)	74.1 (18.3)	74.1 (18.4)
Median (IQR)	60.0 (41.0, 74.0)	79.0 (65.0, 87.0)	80.0 (65.0, 90.0)	80.0 (65.0, 90.0)

Figure 16: *EQ-VAS distribution for all patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op. Note, the higher the score, the better the perception of overall health.*

Oswestry Disability Index (ODI)

The Oswestry Disability Index (ODI) is a widely used patient-reported outcome measure designed to assess functional disability in individuals with low back pain. It is commonly used in clinical practice and research settings.

The ODI consists of 10 sections covering various aspects of daily life. Each section contains six statements describing different levels of disability, scored from 0 (least disability) to 5 (most severe disability)[21]. The total score is calculated with higher scores indicating greater disability.

Table 6: *ODI Scoring*

ODI Score	Level of Disability
0 - 20	Minimal disability
21 - 40	Moderate disability
41 - 60	Severe disability
61 - 80	Crippled
81 - 100	Bed bound

The ODI is completed by patients who undergo thoracolumbar surgery or who fall into the 'deformity' category of patients who are predominately adult degenerative scoliosis patients. The levels of patient disability based on score is shown in Table 6[21].

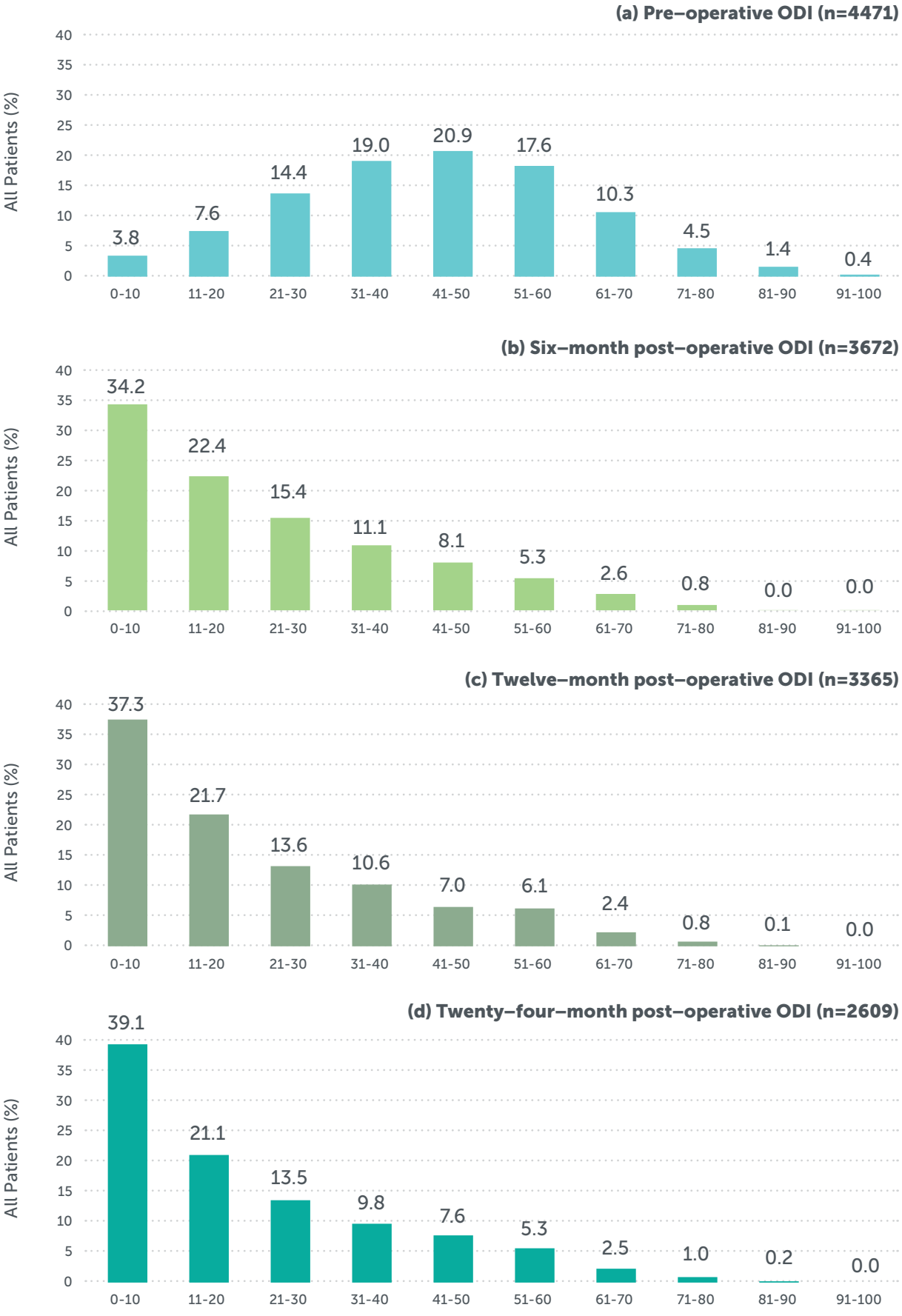
The overall ODI scores were analysed for all patients who completed the ODI questionnaire at any time point. As shown in Table 7, after surgery, median preoperative ODI scores reduced from 44 points (within the severe disability range) to 18 points at 6 months and 16 points at 12 and 24 months (within the minimal disability range).

Table 7: *ODI mean and median scores for all patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	4471	3672	3365	2609
Mean (SD)	43.1 (17.9)	21.8 (18.1)	20.9 (18.5)	20.6 (18.7)
Median (IQR)	44.0 (30.0, 56.0)	18.0 (7.0, 33.0)	16.0 (6.0, 32.0)	16.0 (6.0, 32.0)

Figure 17 illustrates the shift in ODI scores. Patients whose scores indicated severe disability or worse (ODI score > 40) reduced from 55.1% preoperatively to 16.8% at 6 months, 16.4% at 12 months, and 16.6% at 24 months.

Figure 17: *ODI distribution for all patients who completed <u>any</u> ODI at pre-op, 6, 12 and 24-months post-op*



Neck Disability Index (NDI)

The Neck Disability Index (NDI) is a widely used patient-reported outcome measure designed to assess functional disability in individuals with neck pain. It is similar to the Oswestry Disability Index (ODI) but focuses specifically on neck-related disability. The NDI consists of 10 items covering various aspects of daily life affected by neck pain (Table 8)[22]. These questions cover areas such as pain intensity, ability to perform specific activities (e.g. lifting, working, driving), and the impact of pain on personal care and leisure activities. For each question, the respondent selects one of six statements that best describes their current level of disability, with each statement assigned a score ranging from 0 to 5. The scores for all ten questions are then summed into a cumulative score, with higher scores indicating greater disability. The maximum possible score is 50[22], representing total disability, while a score of 0 indicates no disability.

Table 8: *NDI Scoring*

NDI Score	Level of Disability
0 – 4	No disability
5 – 14	Mild disability
15 – 24	Moderate disability
25 – 34	Severe disability
35 or over	Complete disability

The NDI is completed by patients who have undergone surgery in the cervical region of the spine. This cohort represents 15.1% of patients in the ASR. For the NDI, 10 domains are examined which provide individual domain scores and an overall score. A higher score indicates a higher level of disability.

The classification of patient disability based on score is shown in Table 8[22].

As shown in Table 9, median preoperative NDI scores reduced from 42 (complete disability) to 16 (mild disability) at all follow-up timepoints.

Table 9: *NDI mean and median scores for all patients who completed any NDI at pre-op, 6, 12 and 24-months post-op*

NDI	Pre-operative	6-months	12-months	24-months
n	724	603	556	461
Mean (SD)	41.1 (19.5)	20.3 (18.1)	20.8 (19.1)	20.3 (18.5)
Median (IQR)	42.0 (26.0, 54.0)	16.0 (6.0, 30.0)	16.0 (6.0, 30.0)	16.0 (6.0, 30.0)

Preoperatively, 35.1% of patients had an NDI score of 25 or greater indicating a score consistent with severe disability or worse. This reduced to 9.0% of patients at 6 months with improvement remaining stable at 12 and 24 months.

Figure 18: *NDI distribution for all patients who completed <u>any</u> NDI at pre-op, 6, 12 and 24-months post-op*

Section 2

Cervical Cohort Analyses

Anterior Cervical Discectomy and Fusion (ACDF)

ACDF is a surgical procedure performed on the cervical (neck) region of the spine to relieve pressure on the spinal cord or nerve roots caused by herniated discs or bone spurs. ACDF surgery aims to alleviate symptoms such as pain, weakness, numbness, or tingling in the neck, and upper limbs caused by pressure on the spinal cord or nerve roots. Less commonly the major complaint can be of worsening leg function.

The surgery is performed via an anterior approach through the front of the neck. This method allows direct access to the cervical spine while preserving surrounding muscles and tissues, reducing postoperative discomfort. Surgeons remove the damaged or herniated disc(s) and bone spurs compressing the spinal cord or nerve roots, to relieve pressure on affected nerves. After disc removal, the intervertebral space is typically filled with a bone graft, which promotes fusion between the vertebrae over time, forming a stable bone bridge. In some cases, surgeons reinforce the area with metal plates, screws, or interbody cages to enhance stability during the fusion process.

For analysis, the ACDF cohort was selected using the following criteria:

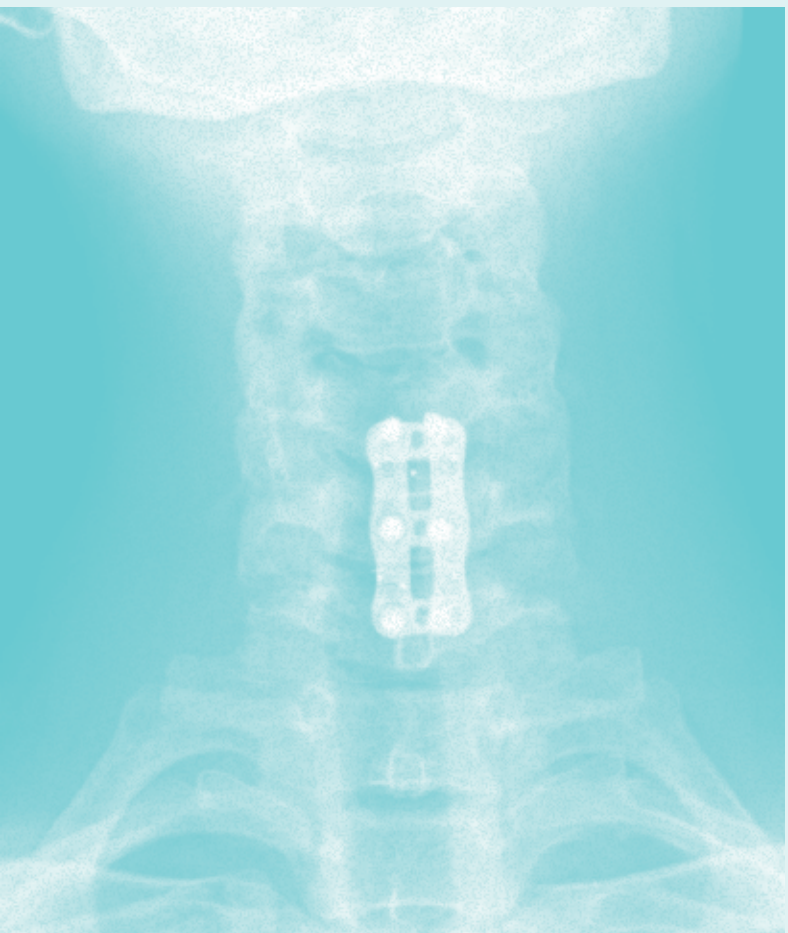
Inclusions:

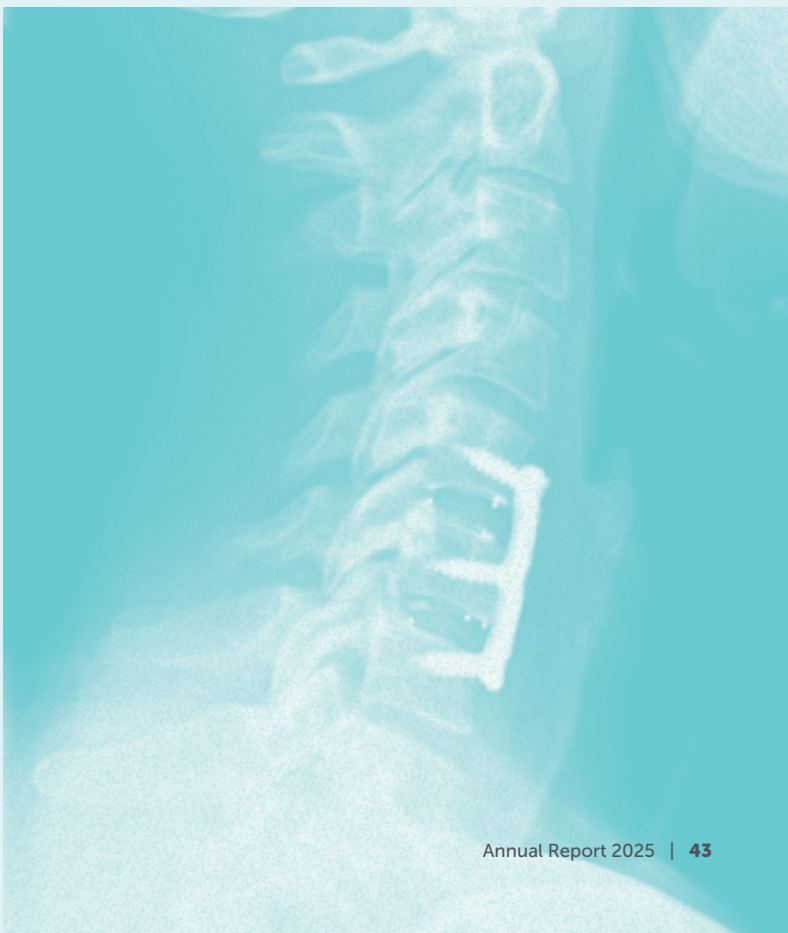
- Surgery Type –
  - Cervical Discectomy AND
  - Anterior approach AND
  - Fusion
- Number of levels ≤2
- Number of stages =1

Exclusions:

- ACDF surgery was revision surgery
- Scoliosis

Images courtesy of Dr Rob Kuru

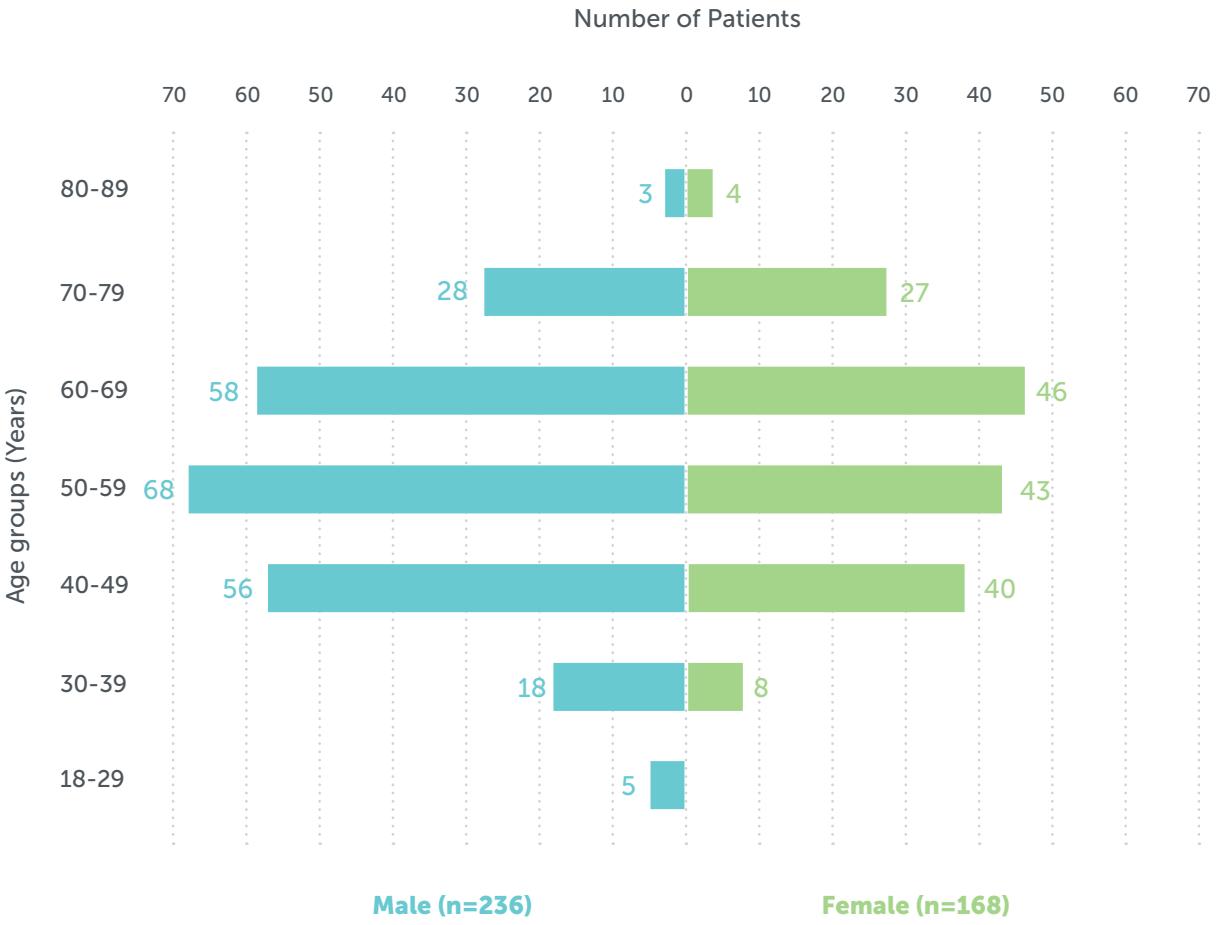




Demographics

404 ACDF procedures that met the eligibility criteria were analysed. ACDFs were more commonly performed in male patients especially between 50-69 years of age. There were 236 males (58%) and 168 females (42%) in this cohort as shown in Figure 19. The median age for males was 54 years, with a median of 57 years for females, which is slightly younger than the median patient age from the total ASR patient cohort (62 years for males and 65 years for females).

Figure 19: *ACDF procedures by patient age and gender*



Surgeon Reported Comorbidities and ASA

Examination of the SRCs in this group identified that ACDF patients were not significantly different when compared to all patients in the registry (Table 10 and Table 11).

Table 10: *Number of ACDF patients diagnosed with any comorbidity prior to surgery compared to all patients*

Any reported comorbidity	All patients (n=6,679) n (%)	ACDF patients (n=404) n (%)
Yes	2,497 (37.4%)	169 (41.8%)
No	4,182 (62.6%)	235 (58.2%)

Table 11: *Number of SRCs reported in ACDF patients compared to all patients*

Number of reported comorbidities	All patients (n=6,679) n (%)	ACDF patients (n=404) n (%)
None	4,182 (62.6%)	235 (58.2%)
1	1,131 (16.9%)	88 (21.8%)
2	724 (10.8%)	41 (10.1%)
3	402 (6.0%)	24 (5.9%)
4	145 (2.2%)	11 (2.7%)
5+	95 (1.4%)	5 (1.2%)

Examination of the ASA scores for this cohort revealed that 55.4% of the ACDF procedures had listed an ASA score. Of the data collected, 23.8% of the patients were considered "normal" healthy patients with 49.6% with mild disease and 25.8% with severe disease which closely resembles the ASA score percentages for the total ASR patient cohort (Table 12).

Table 12: *ASA scores for ACDF patients compared to all patients*

ASA Classification	All patients (n=3,393) n (%)	ACDF patients (n=244) n (%)
1	712 (21.0%)	58 (23.8%)
2	1,537 (45.4%)	121 (49.6%)
3	1,092 (32.3%)	63 (25.8%)
4	42 (1.2%)	2 (0.8%)

PROMs Analysis

The Neck Disability Index (NDI) and the EQ-5D- 3L scores were analysed for the ACDF cohort preoperatively and at 6, 12 and 24-months postoperatively. A lower NDI score indicates an improvement in relief from pain and disability (Table 8)[22].

Neck Disability Index (NDI)

Median NDI scores (Table 13) reduced from 42 preoperatively, to 18 at 6 months postoperatively. These results are further detailed in Figure 20.

Table 13: *NDI mean and median scores for ACDF patients who completed any NDI at pre-op, 6, 12 and 24-months post-op*

NDI	Pre-operative	6-months	12-months	24-months
n	299	246	227	184
Mean (SD)	41.7 (19.1)	21.0 (17.8)	20.6 (18.0)	20.7 (18.5)
Median (IQR)	42.0 (26.0, 55.6)	18.0 (6.0, 32.0)	16.0 (6.0, 30.0)	16.0 (6.0, 30.0)

Patients whose scores indicated severe disability or worse (NDI score > 25) reduced from 33.4% preoperatively to 8.5% at 6 months, 8.4% at 12 months, and 10.3% at 24 months (Figure 20).

Figure 20: *NDI distribution for ACDF patients who completed <u>any</u> NDI questionnaires at pre-op, 6, 12 and 24-months post-op*

Analysis of each of the ten NDI domains for the ACDF cohort is shown in Table 14. This table presents the mean number of NDI domain points preoperatively and at 6, 12 and 24-months postoperatively. Average scores across all domains were lower at all postoperative time points which indicate that all NDI domains improved.

Table 14: *NDI mean scores for each domain for ACDF patients who completed any NDI at pre-op, 6, 12 and 24-months post-op*

NDI	Pre-operative	6-months	12-months	24-months
n	299	246	227	184
Pain, mean (SD)	2.26 (1.18)	1.04 (0.94)	0.96 (0.92)	0.95 (1.01)
Personal Care, mean (SD)	1.00 (1.07)	0.38 (0.78)	0.39 (0.80)	0.42 (0.80)
Lifting, mean (SD)	2.57 (1.44)	1.60 (1.52)	1.53 (1.55)	1.41 (1.48)
Reading, mean (SD)	1.89 (1.26)	0.97 (1.06)	1.05 (1.13)	1.09 (1.13)
Headaches, mean (SD)	1.71 (1.54)	0.94 (1.17)	0.91 (1.13)	1.05 (1.21)
Concentration, mean (SD)	1.22 (1.11)	0.61 (0.92)	0.56 (0.86)	0.55 (0.83)
Work, mean (SD)	2.42 (1.47)	1.29 (1.33)	1.24 (1.32)	1.24 (1.31)
Driving*, mean (SD)	2.17 (1.49)	0.93 (1.25)	0.98 (1.22)	0.91 (1.15)
Sleeping, mean (SD)	2.70 (1.38)	1.37 (1.25)	1.33 (1.26)	1.37 (1.34)
Recreation, mean (SD)	2.89 (1.43)	1.34 (1.34)	1.30 (1.36)	1.36 (1.46)

** Note: Driving question is optional; lower numbers of 294, 241, 221 and 182 (for each time-point, respectively).*

ACDF specific MCID is highly variable depending on the calculation techniques used. The ASR has used the MCID percentage threshold of 17.3 for the NDI, as specified by Parker et al (2013)[23]. We note that there is considerable variation in the MCID percentage thresholds reported in the literature for cervical surgery.

Tables 15 - 17 show patient data for all patients and ACDF patients who completed the NDI.

All patients were within or exceeded this MCID for NDI from pre-op to 6-months. At 24-months postoperatively there were 3.4% of patients whose NDI worsened, however the number of patients is very small in this group.

Table 15: *MCID for NDI from pre-op to 6-months post-op for ACDF patients compared to all cervical patients*

NDI*	All cervical patients (n=458) n (%)	ACDF patients (n=199) n (%)
Exceeding the MCID (Improved)	241 (52.6%)	108 (54.3%)
Within the MCID (Unchanged)	213 (46.5%)	91 (45.7%)
Exceeding the MCID (Worsened)	4 (0.9%)	0 (0.0%)

Table 16: *MCID for NDI from pre-op to 12-months post-op for ACDF patients compared to all cervical patients*

NDI*	All cervical patients (n=458) n (%)	ACDF patients (n=181) n (%)
Exceeding the MCID (Improved)	225 (53.6%)	101 (55.8%)
Within the MCID (Unchanged)	188 (44.8%)	78 (43.1%)
Exceeding the MCID (Worsened)	7 (1.7%)	2 (1.1%)

Table 17: *MCID for NDI from pre-op to 24-months post-op for ACDF patients compared to all cervical patients*

NDI*	All cervical patients (n=338) n (%)	ACDF patients (n=145) n (%)
Exceeding the MCID (Improved)	184 (54.4%)	86 (59.3%)
Within the MCID (Unchanged)	146 (43.2%)	54 (37.2%)
Exceeding the MCID (Worsened)	8 (2.4%)	5 (3.4%)

**Only patients that have completed both timepoint questionnaires are included.*

EQ-5D-3L Quality of Life

The ACDF cohort EQ-5D-3L dimension scores and the EQ-VAS were examined. Review of the domain scores at each time point showed improvement for all domains (Table 18).

For example, examination of the pain/discomfort domain, 95.9% of patients reporting some or extreme pain/discomfort preoperatively which reduced to 65.2% at 6-months post-surgery and to 60.6% at 24-months post-surgery.

Table 18: *EQ-5D-3L scores for each domain for ACDF patients at pre-op, 6 and 12 and 24-months post-op*

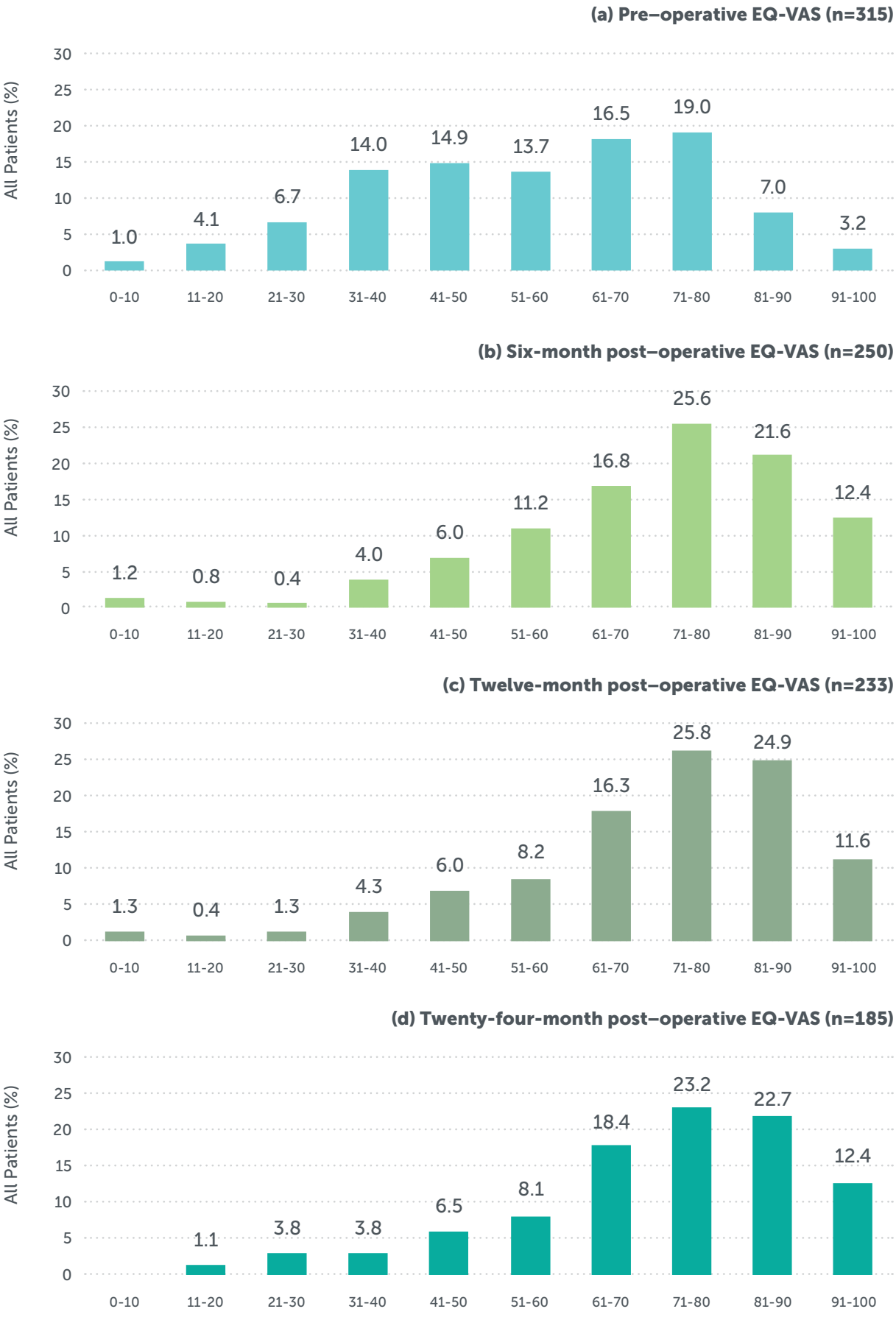
ACDF Patients EQ-5D-3L					
Domain	**Level of problem**	**Pre-op (%) n=315**	**6-months (%) n=250**	**12-months (%) n=233**	**24-months (%) n=185**
Mobility	1 – no problems	60.6	78.4	78.5	76.2
	2 – some problems	38.7	21.6	21.5	23.8
	3 – extreme problems	0.6	0.0	0.0	0.0
Self-Care	1 – no problems	69.2	85.6	82.4	81.6
	2 – some problems	29.8	14.4	17.6	18.4
	3 – extreme problems	1.0	0.0	0.0	0.0
Usual Activity	1 – no problems	20.3	50.8	51.1	54.6
	2 – some problems	61.9	44.0	43.3	41.6
	3 – extreme problems	17.8	5.2	5.6	3.8
Pain/ Discomfort	1 – no problems	4.1	34.8	34.8	39.5
	2 – some problems	68.3	61.6	60.5	56.8
	3 – extreme problems	27.6	3.6	4.7	3.8
Anxiety/ Depression	1 – no problems	46.7	65.6	66.1	62.7
	2 – some problems	44.4	30.8	30.0	34.1
	3 – extreme problems	8.9	3.6	3.9	3.2

The EQ-VAS median scores improved from 60 preoperatively to 75 at 6 months and improved slightly at 12 and 24 months (Table 19). These are further detailed in Figure 21.

Table 19: *EQ-VAS mean and median scores for ACDF patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

EQ-VAS	Pre-operative	6-months	12-months	24-months
n	315	250	233	185
Mean (SD)	58.7 (20.2)	73.0 (17.9)	73.1 (18.0)	72.6 (18.8)
Median (IQR)	60.0 (40.0, 75.0)	75.0 (62.0, 85.0)	76.0 (65.0, 87.0)	78.0 (64.0, 87.0)

Figure 21: *EQ-VAS distribution for ACDF patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*



Degenerative Cervical Myelopathy (DCM)

Degenerative Cervical Myelopathy (DCM) is a progressive neurological condition caused by age-related degenerative changes in the cervical spine—such as disc degeneration, osteophyte formation, ligament thickening, and facet joint hypertrophy—that result in compression of the spinal cord. DCM can lead to symptoms including gait disturbance, hand dysfunction, limb weakness, sensory changes, and impaired balance or coordination. It is the most common cause of non-traumatic spinal cord dysfunction in adults and often requires surgical decompression to prevent further neurological decline.

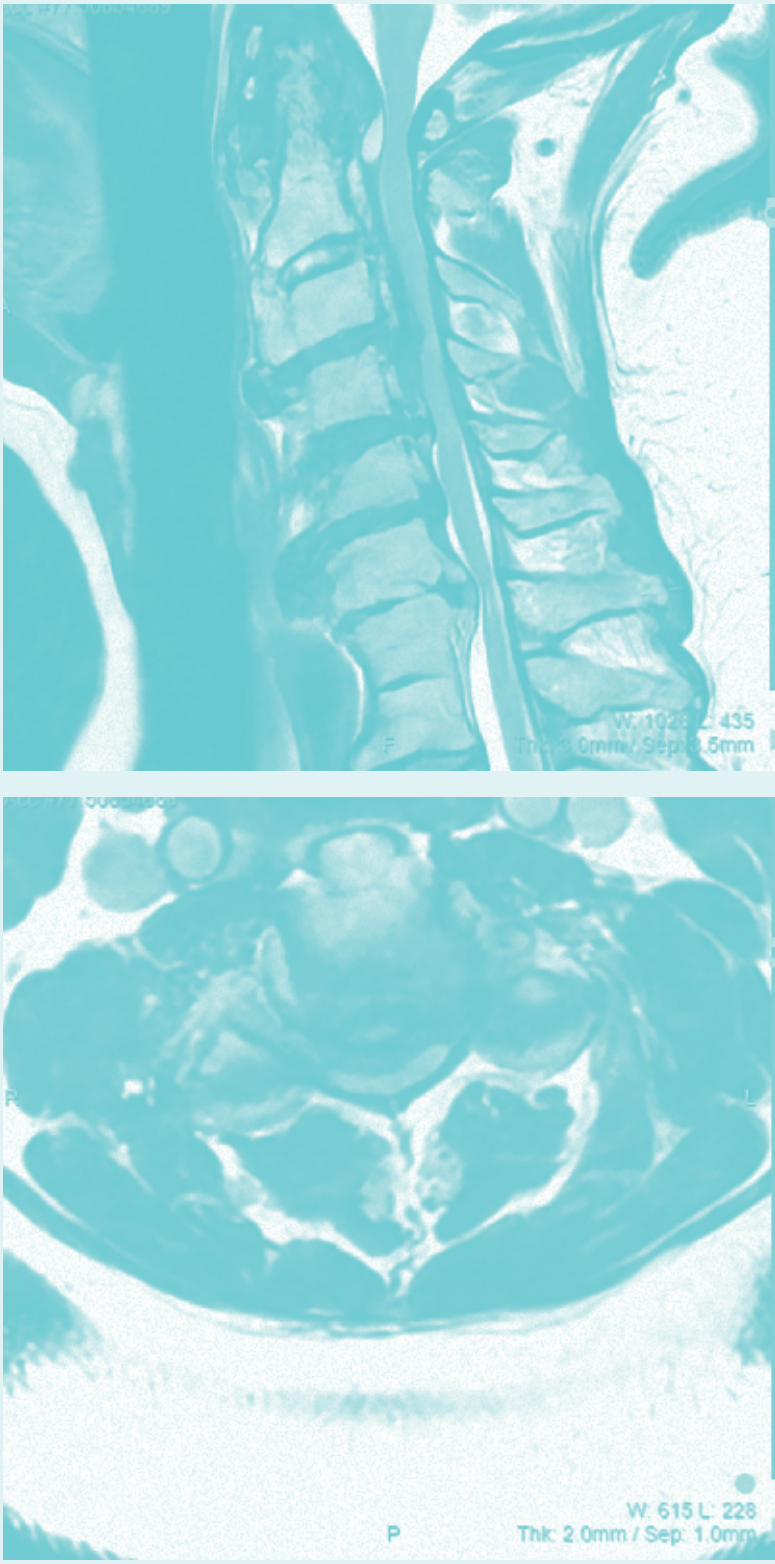
For analysis, the DCM cohort was selected using the following criteria:

Inclusions:

- Cervical myelopathy diagnosis
- Levels C1 – T1

Exclusions:

- Infection
- Tumour



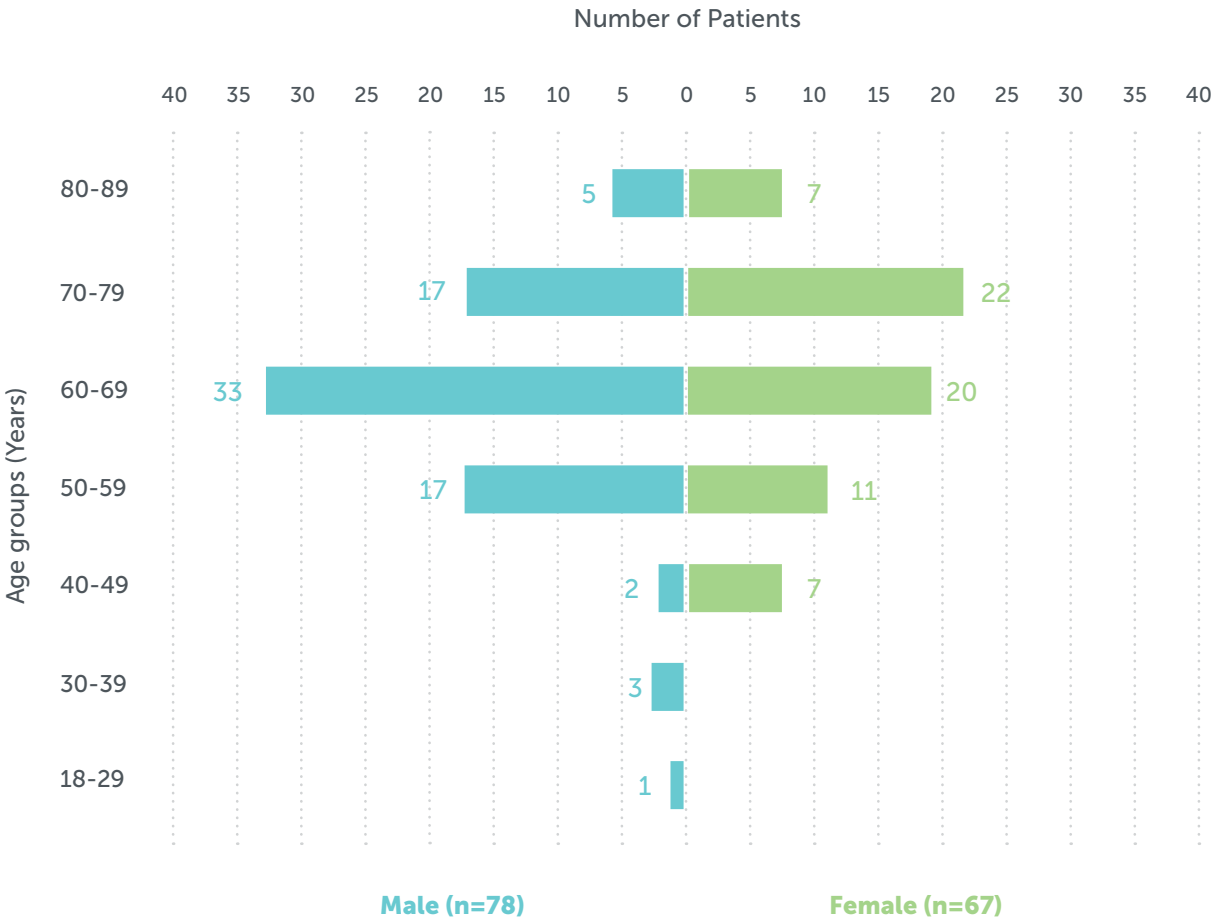
Images courtesy of Dr Radek Kindl

Demographics

145 patients met the eligibility criteria were analysed. There were 78 males (54%) and 67 females (46%) who were included in the DCM cohort are shown in Figure 22.

The median age for males was 65 years and 68 years for females, which is older than the median patient age from the total ASR patient cohort (62 years for males and 65 years for females).

Figure 22: *DCM cohort by patient age and gender*



Surgeon Reported Comorbidities and ASA

The number of patients who were reported to have a comorbidity is shown in Table 20; 57.2% of DCM patients were reported to have at least one comorbidity compared to 29.0% of all cervical patients. Patients were then categorised into groups by the number of SRCs reported (Table 21).

Table 20: *Number of DCM patients with any comorbidity prior to surgery compared to all patients and cervical patients*

Any reported comorbidity	All patients (n=6,679) n (%)	All cervical patients (n=1,009) n (%)	DCM patients (n=145) n (%)
Yes	2,497 (37.4%)	293 (29.0%)	83 (57.2%)
No	4,182 (62.6%)	716 (71.0%)	62 (42.8%)

Table 21: *Number of SRCs reported in DCM patients compared to all patients and cervical patients*

Number of reported comorbidities	All patients (n=6,679) n (%)	All cervical patients (n=1,009) n (%)	DCM patients (n=145) n (%)
None	4,182 (62.6%)	716 (71.0%)	62 (42.8%)
1	1,131 (16.9%)	137 (13.6%)	26 (17.9%)
2	724 (10.8%)	86 (8.5%)	34 (23.4%)
3	402 (6.0%)	41 (4.1%)	12 (8.3%)
4	145 (2.2%)	19 (1.9%)	7 (4.8%)
5+	95 (1.4%)	10 (1.0%)	4 (2.8%)

Patients were also categorised by their ASA score. For the 66.2% of the patients who had an ASA score recorded, 43.7% had an ASA score of greater than or equal to 3 (Table 22).

Table 22: *ASA score reported for DCM patients compared to all patients and cervical patients*

ASA Classification	All patients (n=3,393) n (%)	All cervical patients (n=1,009) n (%)	DCM patients (n=96) n (%)
1	712 (21.0%)	120 (28.3)	18 (18.8%)
2	1537 (45.4%)	200 (47.2)	36 (37.5%)
3	1092 (32.3%)	99 (23.3)	41 (42.7%)
4	42 (1.2%)	5 (1.2)	1 (1.0%)

PROMs Analysis

The Neck Disability Index (NDI) and the EQ-5D- 3L scores were analysed for the DCM cohort preoperatively and at 6, 12 and 24-months postoperatively. A lower NDI score indicates an improvement in relief from pain and disability (Table 8)[22]. As shown in Figure 23, a higher proportion of patients (40%) in this cohort reported a severe or complete disability preoperatively. This reduced to 4.5% by 2 years. It is important to note that 67.1% remain with a mild to moderate disability.

Neck Disability Index (NDI)

Median NDI scores (Table 23) reduced from 42 preoperatively, to 18 at 6 months. These results are further detailed in Figure 23.

Table 23: *NDI mean and median scores for DCM patients who completed any NDI at pre-op, 6, 12 and 24-months post-op*

NDI	Pre-operative	6-months	12-months	24-months
n	115	93	95	64
Mean (SD)	39.2 (22.1)	20.7 (15.3)	22.5 (18.1)	21.7 (16.3)
Median (IQR)	40.0 (18.0, 56.0)	18.0 (8.0, 28.0)	20.0 (8.0, 34.0)	18.0 (8.0, 30.0)

Figure 23: *NDI distribution for DCM patients who completed any NDI questionnaires at pre-op, 6, 12 and 24-months post-op*

Analysis of each of the ten NDI domains for the DCM cohort is shown in Table 24. This table presents the mean number of NDI domain points preoperatively and at 6, 12 and 24-months postoperatively. Average scores across all domains were lower at all postoperative time points which indicate that all NDI domains improved.

Table 24: *NDI mean scores for each domain for DCM patients who completed any NDI at pre-op, 6, 12 and 24-months post-op*

NDI	Pre-operative	6-months	12-months	24-months
n	115	93	95	64
Pain, mean (SD)	1.93 (1.31)	0.90 (0.99)	1.00 (0.98)	1.11 (0.98)
Personal Care, mean (SD)	1.19 (1.33)	0.37 (0.88)	0.54 (1.03)	0.36 (0.78)
Lifting, mean (SD)	2.70 (1.69)	1.80 (1.61)	1.89 (1.70)	1.59 (1.56)
Reading, mean (SD)	1.69 (1.31)	0.97 (1.04)	1.15 (1.14)	1.12 (1.09)
Headaches, mean (SD)	1.48 (1.56)	0.68 (0.93)	0.85 (1.13)	0.91 (1.16)
Concentration, mean (SD)	1.03 (1.16)	0.44 (0.68)	0.52 (0.86)	0.56 (0.71)
Work, mean (SD)	2.44 (1.67)	1.53 (1.45)	1.59 (1.54)	1.41 (1.19)
Driving*, mean (SD)	1.97 (1.77)	1.01 (1.56)	1.17 (1.59)	1.06 (1.33)
Sleeping, mean (SD)	2.41 (1.41)	1.33 (1.19)	1.24 (1.23)	1.31 (1.32)
Recreation, mean (SD)	2.69 (1.75)	1.25 (1.36)	1.51 (1.59)	1.42 (1.39)

** Note: Driving question is optional; lower numbers of 109, 88, 90 and 62 (for each time-point, respectively).*

Low, medium and high preoperative NDI analysis

We further examined the DCM cohort specifically looking at patients who preoperatively reported low (0 to 14), medium (15 to 24) and high (>25) NDI scores. The postoperative change in NDI scores amongst these patient subsets was then analysed. Patients were selected based on NDI questionnaires being completed at both pre-operative and 12-month postoperative time points. Box plots were used to analyse the data.

The three patient populations characteristics are shown in Table 25.

In the low NDI group, there were more men than women with degenerative cervical myelopathy compared to the medium and high NDI groups where it was almost even. The median age was very similar across all groups. When looking at the change in the NDI, each group improved however the high NDI group showed the greatest change (Figure 24 and Figure 25).

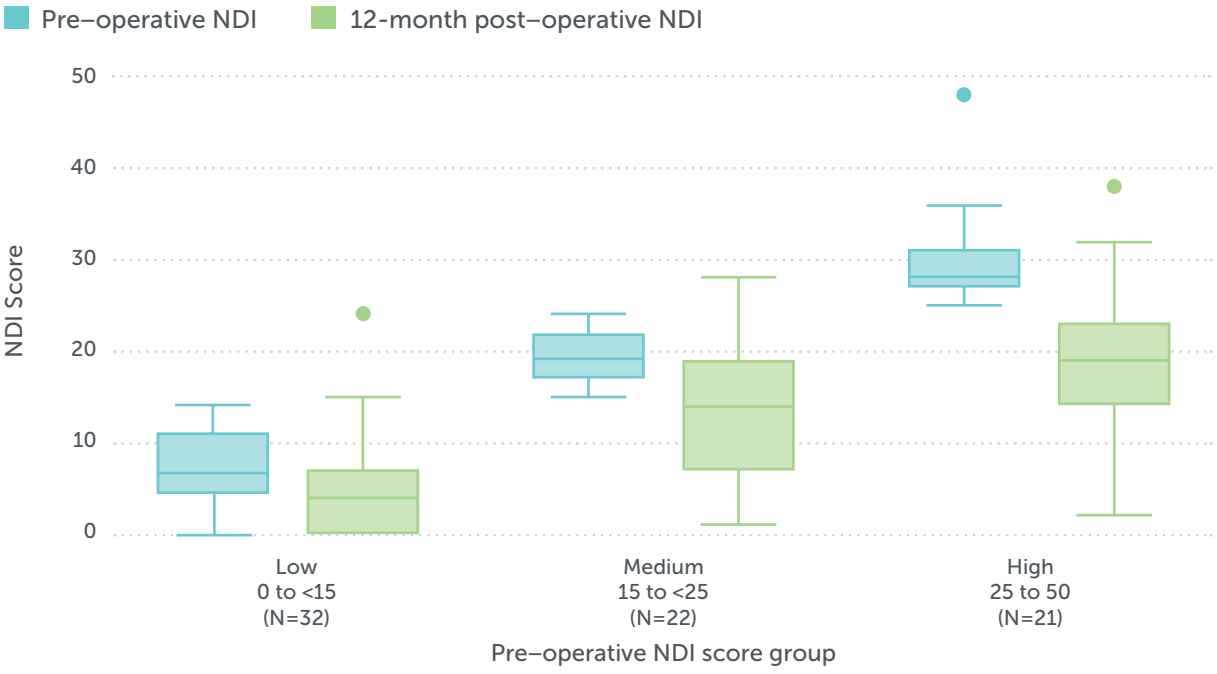
There were statistically significant differences in the 12-month NDI scores between the three different pre-operative NDI groups ($p<0.001$). This was also the case for the absolute NDI score change between the different groups ($p=0.002$). Age, sex, comorbidities, number of comorbidities and ASA classification did not differ significantly between groups (Appendix 4).

Table 25: *Characteristics of the low medium and high NDI DCM cohort*

	Low	Medium	High
n	32	22	21
Sex: Male	22 (68.8%)	10 (45.5%)	10 (47.6%)
Sex: Female	10 (31.2%)	12 (54.5%)	11 (52.4%)
Age, mean (SD)	62.9 (12.3)	64.2 (12.4)	63.0 (13.9)
Age, median (IQR)	64.0 (56.0-71.0)	66.5 (60.0-69.0)	65.0 (50.0-74.0)
Exceeding the MCID (Improved)	6 (18.8%)	8 (36.4%)	14 (66.7%)
Within the MCID (Unchanged)	24 (75.0%)	13 (59.1%)	7 (33.3%)
Exceeding the MCID (Worsened)	2 (6.2%)	1 (4.5%)	0 (0.0%)

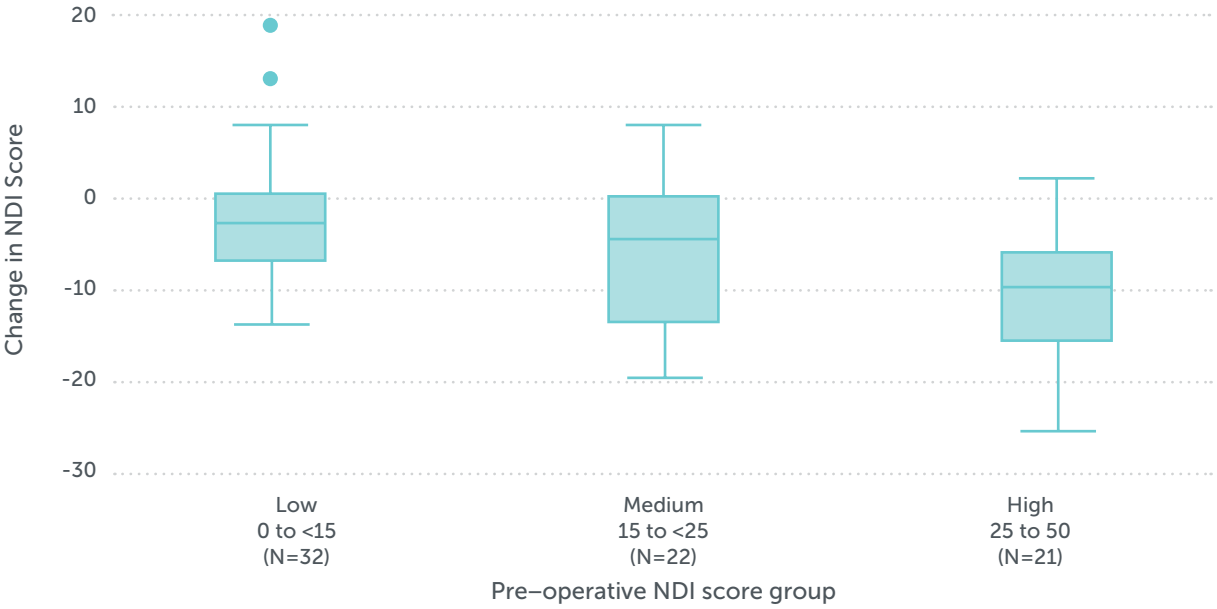
Out of the 145 DCM patients, only 75 patients had scores at both timepoints and are included in the analysis (Figure 24 and Figure 25)

Figure 24: *Box plots showing the differences in low, medium and high NDI scores in DCM patients at pre-op and 12 months post-op**



** The boxes mark the first quartile (Q1), median and third quartile (Q3) of ODI score. Tukey values have been used for the whiskers. The lower whisker value is the smallest value that is greater or equal to Q1 - 1.5*IQR. The upper whisker value is the largest value that is less than or equal to Q3 + 1.5*IQR.*

Figure 25: *Box plots showing the change in low, medium and high NDI scores in DCM patients over 12 months**



** The boxes mark the first quartile (Q1), median and third quartile (Q3) of change in NDI score. Tukey values have been used for the whiskers. The lower whisker value is the smallest value that is still greater or equal to Q1 - 1.5*IQR. The upper whisker value is the largest value that is still less than or equal to Q3 + 1.5*IQR.*

DCM specific MCID is highly variable depending on the calculation techniques used. As indicated previously, The ASR has used the MCID percentage threshold of 17.3 for the NDI[23].

Tables 26 - 28 show patient data for all patients and DCM patients who completed the NDI.

All patients were within or exceeded this MCID for NDI from pre-op to 6-months. At 24-months postoperatively there were 3.4% of patients whose NDI worsened, however the number of patients is very small in this group.

Table 26: *MCID for NDI from pre-op to 6-months post-op for DCM patients compared to all cervical patients*

NDI*	All cervical patients (n=458) n (%)	DCM patients (n=77) n (%)
Exceeding the MCID (Improved)	241 (52.6%)	32 (41.6%)
Within the MCID (Unchanged)	213 (46.5%)	45 (58.4%)
Exceeding the MCID (Worsened)	4 (0.9%)	0 (0.0%)

Table 27: *MCID for NDI from pre-op to 12-months post-op for DCM patients compared to all cervical patients*

NDI*	All cervical patients (n=458) n (%)	DCM patients (n=76) n (%)
Exceeding the MCID (Improved)	225 (53.6%)	28 (36.8%)
Within the MCID (Unchanged)	188 (44.8%)	45 (59.2%)
Exceeding the MCID (Worsened)	7 (1.7%)	3 (3.9%)

Table 28: *MCID for NDI from pre-op to 24-months post-op for DCM patients compared to all cervical patients*

NDI*	All cervical patients (n=338) n (%)	DCM patients (n=52) n (%)
Exceeding the MCID (Improved)	184 (54.4%)	15 (28.8%)
Within the MCID (Unchanged)	146 (43.2%)	36 (69.2%)
Exceeding the MCID (Worsened)	8 (2.4%)	1 (1.9%)

**Only patients that have completed both timepoint questionnaires are included.*

EQ-5D-3L Quality of Life Analysis

The DCM cohort EQ-5D-3L dimension scores and the EQ-VAS were examined. Review of the domain scores at each time point showed improvement for all domains (Table 29).

For example, examination of the pain/discomfort domain, 89.4% of patients reporting some or extreme pain/discomfort preoperatively which reduced to 63.4% at 6-months post-surgery and to 66.1% at 24-months post-surgery.

Table 29: *EQ-5D-3L scores for each domain for DCM patients at pre-op, 6 and 12 and 24-months post-op*

		DCM Patients EQ-5D-3L			
Domain	**Level of problem**	**Pre-op (%) n=114**	**6-months (%) n=93**	**12-months (%) n=95**	**24-months (%) n=65**
Mobility	1 – no problems	30.7	57.0	61.1	58.5
	2 – some problems	66.7	43.0	37.9	41.5
	3 – extreme problems	2.6	0.0	1.1	0.0
Self-Care	1 – no problems	59.6	88.2	75.8	80.0
	2 – some problems	36.8	11.8	24.2	20.0
	3 – extreme problems	3.5	0.0	0.0	0.0
Usual Activity	1 – no problems	19.3	44.1	45.3	44.6
	2 – some problems	61.4	50.5	46.3	55.4
	3 – extreme problems	19.3	5.4	8.4	0.0
Pain/ Discomfort	1 – no problems	10.5	36.6	31.6	33.8
	2 – some problems	67.5	60.2	62.1	64.6
	3 – extreme problems	21.9	3.2	6.3	1.5
Anxiety/ Depression	1 – no problems	48.2	74.2	70.5	67.7
	2 – some problems	41.2	24.7	27.4	29.2
	3 – extreme problems	10.5	1.1	2.1	3.1

The EQ-VAS median scores improved from 70 preoperatively to 77 at 6 months and was further maintained at 12 and 24 months postoperatively (Table 30). These are further detailed in Figure 26.

Table 30: *EQ-VAS mean and median scores for DCM patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

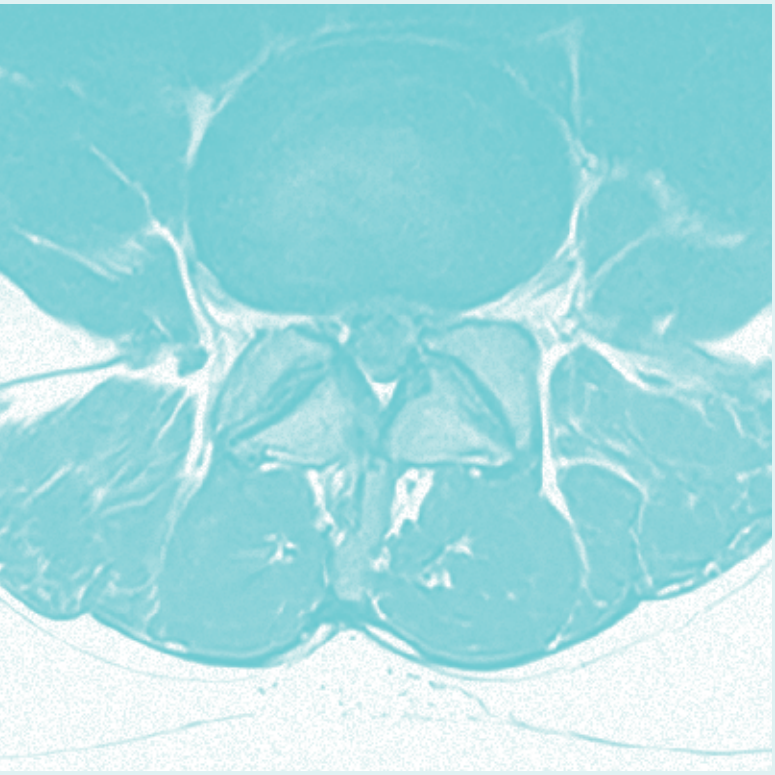
EQ-VAS	**Pre-operative**	**6-months**	**12-months**	**24-months**
n	114	93	95	65
Mean (SD)	60.5 (20.0)	72.1 (18.1)	69.4 (19.8)	70.8 (17.3)
Median (IQR)	69.5 (50.0, 76.0)	77.0 (60.0, 85.0)	72.0 (60.0, 85.0)	72.0 (64.0, 85.0)

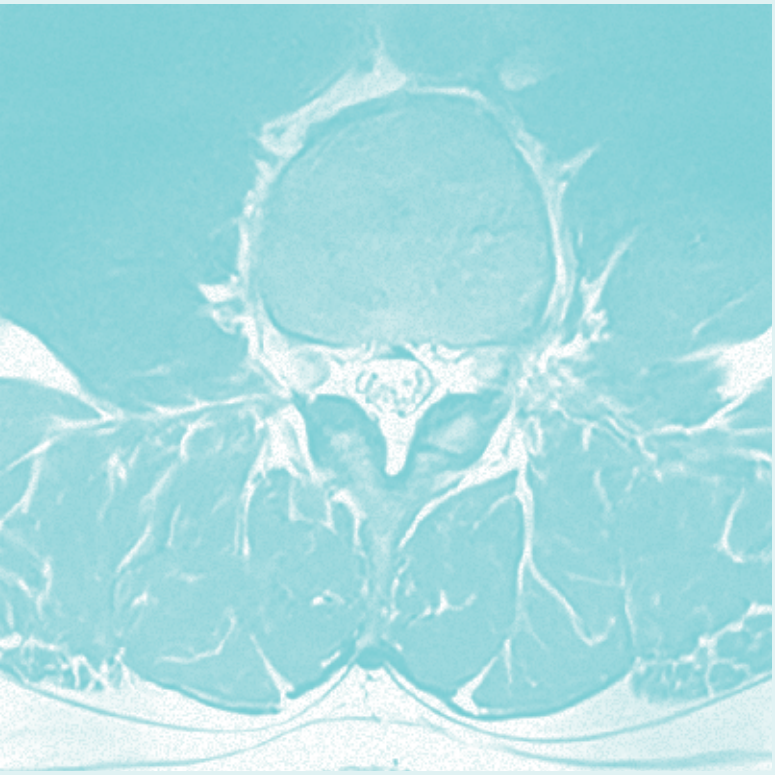
Figure 26: *EQ-VAS distribution for DCM patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

Section 3

Thoracolumbar Cohort Analyses

Single Level Lumbar Discectomy





Images courtesy of Dr Radek Kindl

Lumbar discectomy is one of the most common spinal procedures[24]. It is most frequently performed to relieve symptoms of leg pain called "sciatica", possibly with neurological deficits caused by spinal nerve compression due to herniated or bulging discs in the lumbar spine. Herniation is usually treated conservatively but discectomy may be performed for persistent or severe pain, significant weakness or bladder and bowel incontinence and sexual dysfunction. It involves removing the damaged portion of an intervertebral disc and often some overlying bone, via a posterior approach, to relieve the compression of the affected nerve.

For analysis, discectomy cohort patients were selected based on the following inclusion criteria:

Inclusions:

- Surgery Type – Lumbar Discectomy only
- Number of levels = 1
- Number of stages = 1

Exclusions:

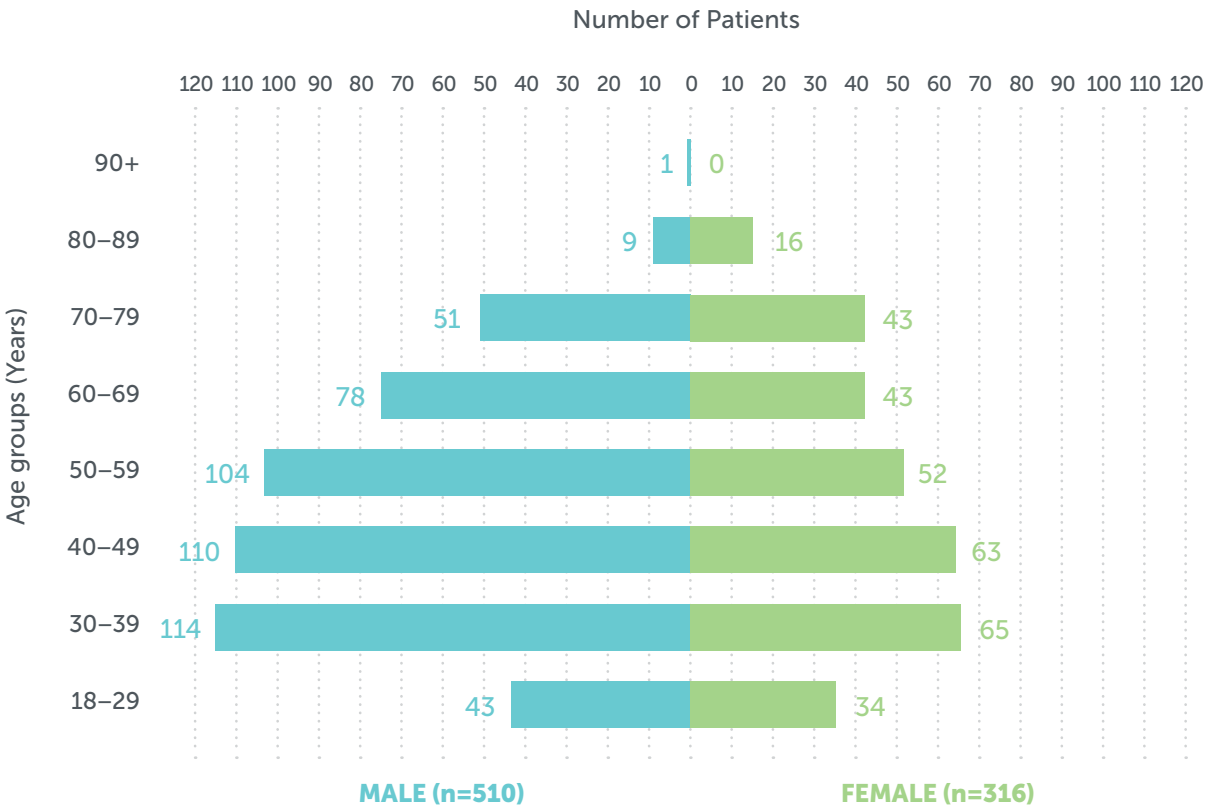
- Revision surgery
- Scoliosis
- Fusion

Demographics

826 patients met the discectomy cohort inclusion criteria which represents 15% of patients undergoing thoracolumbar procedures.

The single level lumbar discectomy procedures were performed more commonly on male patients. There were 510 males (62%) and 316 females (38%) in this group as shown in Figure 27. The median age of both males and females was 48 years, which is younger than the median patient age from the total ASR patient cohort (62 years for males and 65 years for females). This has not changed from previous annual reports.

Figure 27: *Discectomy procedures by patient age and gender*



Surgeon Reported Comorbidities and ASA

The number of patients that were reported with a comorbidity is shown in Table 31 below.

Examination of SRCs in this group identified that discectomy patients had fewer comorbidities when compared to all patients in the registry. 22% of discectomy patients were reported to have at least one comorbidity whereas 37% of the entire registry patient population were reported to have at least one comorbidity. Patients were further categorised into groups by the number of SRCs reported (Table 32).

Table 31: *Number of Discectomy patients diagnosed with any comorbidity prior to surgery*

Any reported comorbidity	All patients (n=6,679) n (%)	Discectomy patients (n=826) n (%)
Yes	2,497 (37.4%)	182 (22.0%)
No	4,182 (62.6%)	644 (78.0%)

Table 32: *Number of comorbidities reported in Discectomy patients compared to all patients*

Number of reported comorbidities	All patients (n=6,679) n (%)	Discectomy patients (n=826) n (%)
None	4,182 (62.6%)	644 (78.0%)
1	1,131 (16.9%)	103 (12.5%)
2	724 (10.8%)	47 (5.7%)
3	402 (6.0%)	24 (2.9%)
4	145 (2.2%)	4 (0.5%)
5+	95 (1.4%)	4 (0.5%)

62% of discectomy patients had ASA data reported in the registry.

When ASA scores were examined for discectomy patients, 41% of the patients were scored with an ASA of 1 indicating that these patients were 'normal', healthy patients without acute or chronic disease, overweight or obesity. An additional, 45% of patients had mild disease without significant limitations. Only 14% of patients had severe disease (Table 33). This showed similar patterns between SRCs and ASA data, as seen in the total cohort.

Table 33: *ASA scores for Discectomy patients compared to all patients*

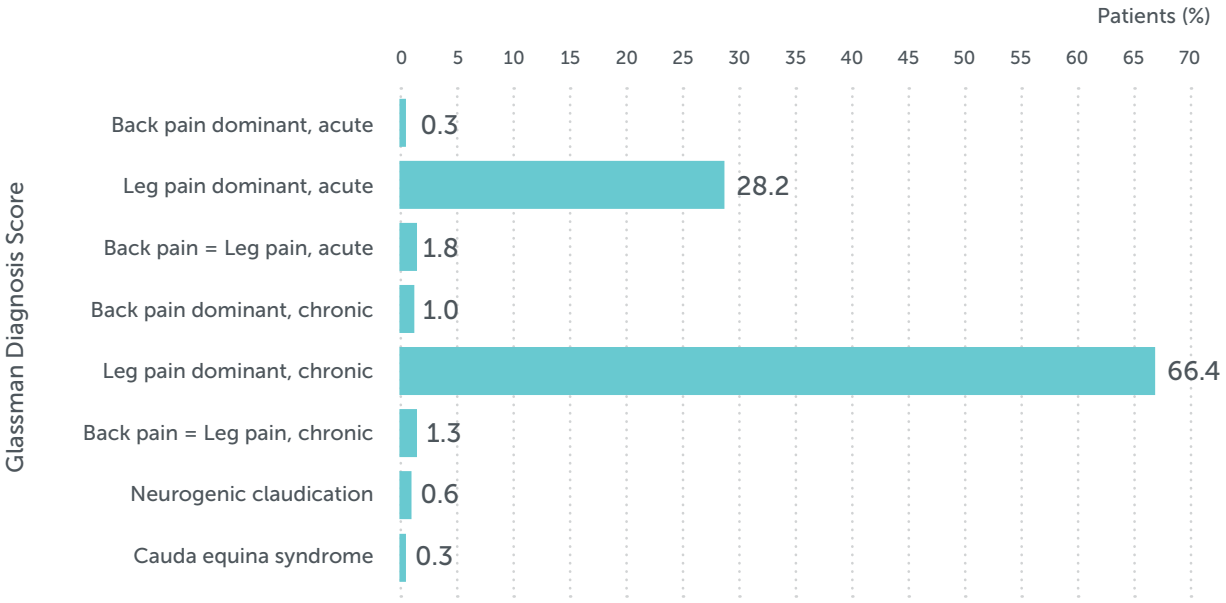
ASA Classification	All patients (n=3,393) n (%)	Discectomy patients (n=512) n (%)
1	712 (21.0%)	211 (41.2%)
2	1,542 (45.4%)	231 (45.1%)
3	1,096 (32.3%)	69 (13.5%)
4	43 (1.3%)	1 (0.2%)

Glassman Classification Scores

The Glassman Classification Scores are a simple diagnostic classification scheme which categorises the patient's primary characteristics so that the treatment's impact can be linked to the recognised pathology[7]. Glassman scores are only reported for patients who have had thoracolumbar or deformity procedures. Glassman scores were reported in 74.6% of the discectomy cohort.

Acute and chronic leg pain were the most commonly reported symptoms by these patients. Dominant back pain and neurogenic claudication was infrequently reported. This is consistent with the commonly seen clinical presentation of disc herniations (Figure 28).

Figure 28: *Glassman Score for 'Symptoms' among Discectomy patients (n=616)*



PROMs Analysis

The Oswestry Disability Index (ODI) and the EQ-5D-3L scores were evaluated for the discectomy cohort preoperatively and at 6-months, 12-months and 24-months postoperatively.

It must be noted that these results show unadjusted outcomes and must be interpreted with caution.

Adjustments for known predictors of outcomes after spine surgery such as age, sex and severity of a patient's condition at baseline have not been performed at the time of this publication and may account for some of the differences seen in the figures presented below.

Oswestry Disability Index (ODI)

A lower ODI score indicates improved relief in pain and disability (Table 6)[21]. ODI mean, median and overall scores for any questionnaires completed at each time point are shown in Table 34 and Figure 29 respectively. As shown in Table 34, median ODI scores improved from 46 preoperatively to 10 at 6-months postoperatively, which was sustained at 12 and 24 months.

Table 34: *ODI mean and median scores for Discectomy patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	641	557	517	404
Mean (SD)	47.2 (18.0)	14.6 (15.2)	13.0 (15.2)	12.6 (14.7)
Median (IQR)	46.0 (34.0, 60.0)	10.0 (4.0, 20.0)	8.0 (2.0, 18.0)	8.0 (0.0, 18.0)

Figure 29 shows that there is a shift to the left (lower scores) in the overall ODI for the discectomy cohort at the 6-month follow up time point indicating improvement over the 6-month period. This was maintained at both 12 and 24 months.

Patients whose scores indicated severe disability or worse (ODI score > 40) reduced from 63.1% preoperatively to 6.2% at 6 months, 7.8% at 12 months, and 6.7% at 24 months.

Figure 29: *ODI distribution for Discectomy patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

Analysis of the ten ODI domains for the discectomy cohort is shown in Table 35.

Mean scores across all domains were lower at 6, 12 and 24-months postoperatively compared to preoperatively. A lower ODI score indicates an improvement for that domain. The domains of the ODI indicated that the pain caused by disc prolapse affects all aspects of life and all aspects are improved by the surgery.

Table 35: *ODI mean scores for each domain for Discectomy patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	641	557	517	404
Pain, mean (SD)	2.68 (1.02)	0.88 (0.89)	0.79 (0.91)	0.76 (0.90)
Personal Care, mean (SD)	1.45 (1.16)	0.25 (0.72)	0.23 (0.66)	0.20 (0.61)
Lifting, mean (SD)	2.88 (1.26)	1.26 (1.40)	1.12 (1.31)	1.14 (1.35)
Reading, mean (SD)	1.87 (1.29)	0.39 (0.84)	0.36 (0.82)	0.28 (0.69)
Headaches, mean (SD)	2.46 (1.25)	1.03 (1.04)	0.90 (0.98)	0.86 (0.97)
Concentration, mean (SD)	2.54 (1.40)	0.85 (1.09)	0.77 (1.05)	0.75 (1.11)
Work, mean (SD)	1.91 (1.07)	0.62 (0.78)	0.61 (0.81)	0.62 (0.75)
Driving*, mean (SD)	2.61 (1.71)	0.53 (1.02)	0.49 (1.02)	0.48 (1.03)
Sleeping, mean (SD)	2.77 (1.20)	0.76 (1.11)	0.58 (1.03)	0.56 (0.98)
Recreation, mean (SD)	2.49 (1.38)	0.66 (0.95)	0.62 (0.93)	0.60 (0.91)

** Note: Sex life question is optional; lower numbers of 550, 498, 456 and 372 (for each time-point, respectively).*

The Minimum Clinically Important Difference (MCID) is the minimum change in PROMs score associated with a significant difference to the patient. It is based on Minimum Detectable Change (MDC) which is generally considered in the literature to be a MCID of 12.8 for the ODI[25]. This figure has been used to define MCID for this patient cohort.

Greater than 84% of discectomy patients exceeded this MCID (improved), as shown by ODI scores, 6-months postoperatively (Tables 36 – 38).

Table 36: *MCID for ODI from pre-op to 6-months post-op for Discectomy patients compared to all TL patients*

ODI*	All TL patients (n=3,074) n (%)	Discectomy patients (n=459) n (%)
Exceeding the MCID (Improved)	1,959 (63.7%)	386 (84.1%)
Within the MCID (Unchanged)	1,021 (33.2%)	63 (13.7%)
Exceeding the MCID (Worsened)	94 (3.1%)	10 (2.2%)

Table 37: *MCID for ODI from pre-op to 12-months post-op for Discectomy patients compared to all TL patients*

ODI*	All TL patients (n=2,829) n (%)	Discectomy patients (n=422) n (%)
Exceeding the MCID (Improved)	1,832 (64.8%)	356 (84.4%)
Within the MCID (Unchanged)	910 (32.2%)	63 (14.9%)
Exceeding the MCID (Worsened)	87 (3.1%)	3 (0.7%)

Table 38: *MCID for ODI from pre-op to 24-months post-op for Discectomy patients compared to all TL patients*

ODI*	All TL patients (n=2,187) n (%)	Discectomy patients (n=329) n (%)
Exceeding the MCID (Improved)	1,417 (64.8%)	267 (81.2%)
Within the MCID (Unchanged)	697 (31.9%)	58 (17.6%)
Exceeding the MCID (Worsened)	73 (3.3%)	4 (1.2%)

**Only patients that have completed both timepoint questionnaires are included.*

Low, medium and high preoperative ODI analysis

We further examined the discectomy cohort specifically looking at patients who preoperatively reported low (0 to 30), medium (30 to <61) and high (61 to 100) ODI scores. The postoperative change in ODI scores amongst these patient subsets was then analysed. Patients were selected based on ODI questionnaires being completed at both pre-operative and 12-month postoperative time points. Box plots were used to analyse the data.

The three patient populations characteristics are shown in Table 39.

In the low ODI group, there were more men than women having discectomies compared to the medium and high ODI groups where it was almost even. The median age was very similar across all groups. When looking at the change in the ODI, each group improved however the high ODI group showed the greatest change (Figure 30 and Figure 31).

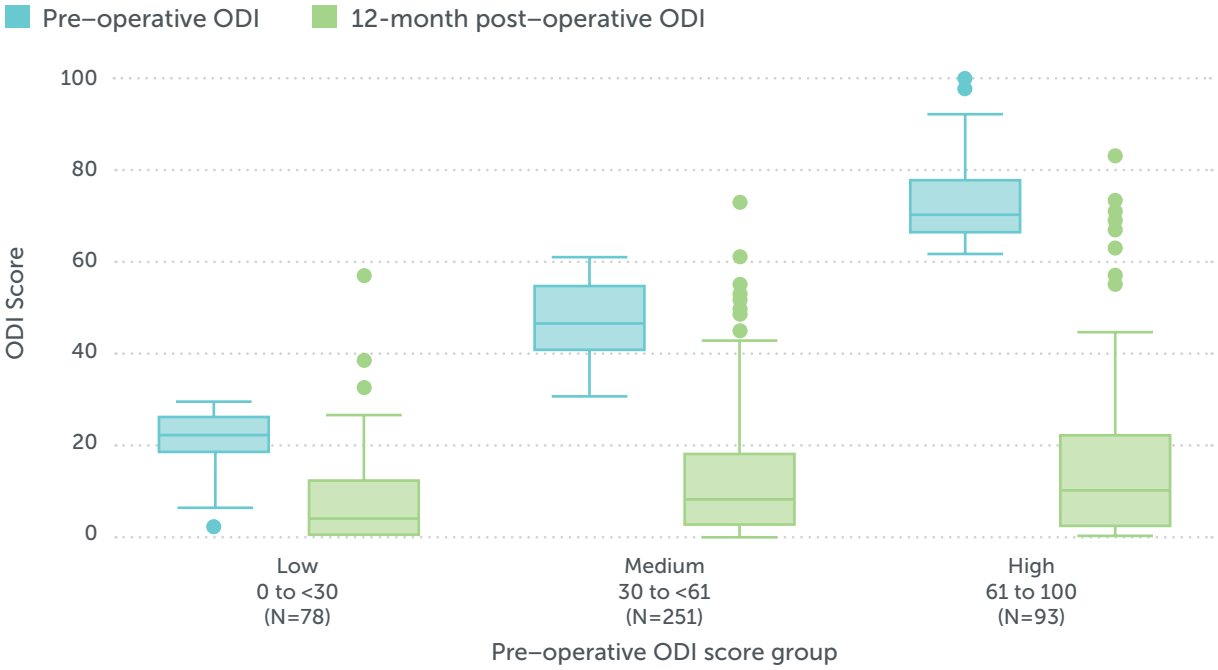
There were statistically significant differences in the 12-month ODI scores between the three different pre-operative ODI groups (p=0.005). This was also the case for the absolute ODI score change between the different groups (p<0.001). Age, sex, comorbidities, number of comorbidities and ASA classification did not differ significantly between groups (Data not shown).

Table 39: *Characteristics of the low medium and high ODI Discectomy cohort*

	Low	Medium	High
n	78	251	93
Sex: Male	59 (75.6%)	150 (59.8%)	50 (53.8%)
Sex: Female	19 (24.4%)	101 (40.2%)	43 (46.2%)
Age, mean (SD)	48.8 (15.8)	51.6 (16.2)	49.1 (15.3)
Age, median (IQR)	46.0 (36.0-62.0)	51.0 (39.0-66.0)	46.0 (36.0-61.0)
Exceeding the MCID (Improved)	45 (57.7%)	224 (89.2%)	87 (93.5%)
Within the MCID (Unchanged)	31 (39.7%)	26 (10.4%)	6 (6.5%)
Exceeding the MCID (Worsened)	2 (2.6%)	1 (0.4%)	0 (0.0%)

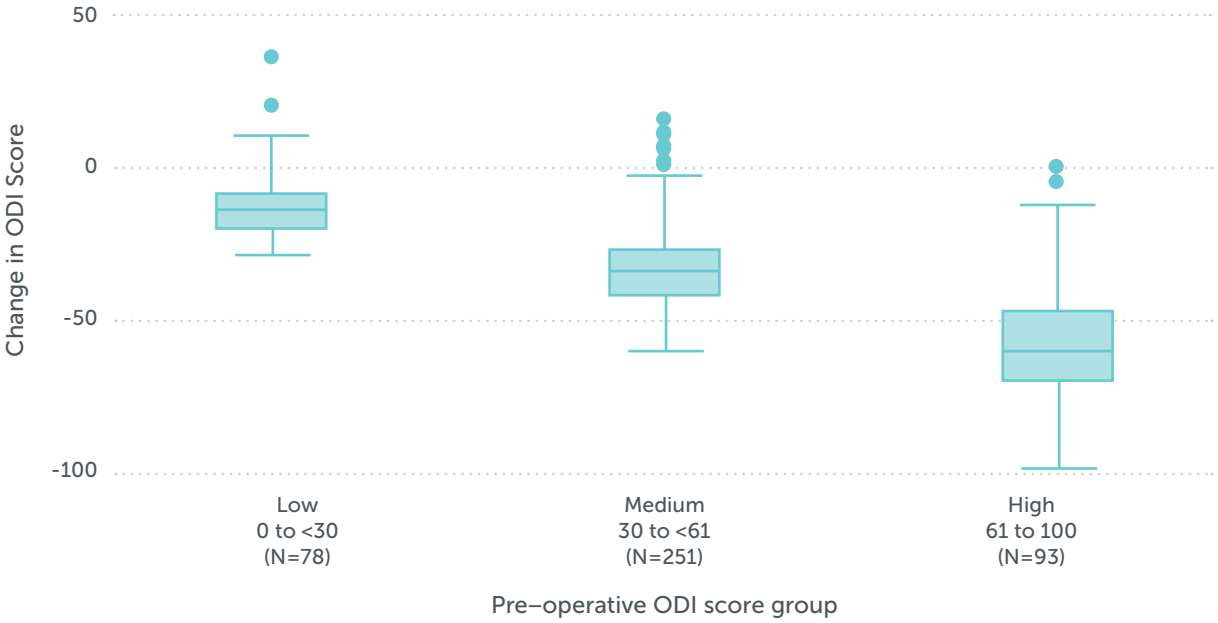
Out of the 826 discectomy patients, only 422 patients have scores at both timepoints and are included in the analysis (Figure 30 and Figure 31).

Figure 30: *Box plots showing the differences in low, medium and high ODI scores in Discectomy patients at pre-op and 12 months post-op**



** The boxes mark the first quartile (Q1), median and third quartile (Q3) of ODI score. Tukey values have been used for the whiskers. The lower whisker value is the smallest value that is greater or equal to Q1 - 1.5*IQR. The upper whisker value is the largest value that is less than or equal to Q3 + 1.5*IQR.*

Figure 31: *Box plots showing the change in low, medium and high ODI scores in Discectomy patients over 12 months**



** The boxes mark the first quartile (Q1), median and third quartile (Q3) of change in ODI score. Tukey values have been used for the whiskers. The lower whisker value is the smallest value that is still greater or equal to Q1 - 1.5*IQR. The upper whisker value is the largest value that is still less than or equal to Q3 + 1.5*IQR.*

The amount that patients improve (based on MCID threshold) appears to be greater as initial severity of symptoms increases. It would appear patients with less severe symptoms would potentially obtain a lower proportional benefit after surgery.

(The ability to investigate the relationship between initial burden of disease and outcomes 12-months post-operation may be limited/ confounded by sample imbalances in sex and Glassman score for symptoms. Therefore, these results should be interpreted with caution).

This analysis identified several findings:

- Analysis of Glassman classification demonstrated that surgery performed in less than 3 months was significantly more common in patients with more severe symptoms (p = 0.024; data not shown).
- Patients with more severe preoperative symptoms obtained more proportional benefit from the surgery.
- Age, gender, or the frequency of comorbidities were not statistically relevant.

EQ-5D-3L Quality of Life

The discectomy cohort EQ-5D-3L domain scores and the EQ-VAS were analysed and indicate improvement across all domains at all time points (Table 40 and Figure 32).

Table 40: *EQ-5D-3L scores for each domain for Discectomy patients at pre-op, 6, 12 and 24-months post-op*

Discectomy Patients EQ-5D-3L					
Domain	**Level of problem**	**Pre-op (%) n=641**	**6-months (%) n=557**	**12-months (%) n=518**	**24-months (%) n=404**
Mobility	1 – no problems	13.9	74.7	74.7	78.7
	2 – some problems	82.5	25.3	25.1	21.3
	3 – extreme problems	3.6	0.0	0.2	0.0
Self-Care	1 – no problems	53.4	90.8	91.1	91.1
	2 – some problems	44.8	9.2	8.7	8.7
	3 – extreme problems	1.9	0.0	0.2	0.2
Usual Activity	1 – no problems	6.2	56.4	64.3	66.3
	2 – some problems	62.2	40.9	32.6	31.9
	3 – extreme problems	31.5	2.7	3.1	1.7
Pain/ Discomfort	1 – no problems	1.9	43.3	49.6	51.5
	2 – some problems	53.8	54.2	46.3	45.5
	3 – extreme problems	44.3	2.5	4.1	3.0
Anxiety/ Depression	1 – no problems	43.8	75.0	78.4	78.0
	2 – some problems	49.0	23.2	18.9	19.6
	3 – extreme problems	7.2	1.8	2.7	2.5

The EQ-VAS identifies the way in which patients perceive their general health at a given time point. A shift to the right in the EQ-VAS indicates an improvement of patient perception of their general health status. As shown in Table 41 median patient scores improved from 56 preoperatively to 81 at 12 months postoperatively and were sustained until 24 months (Figure 32).

Table 41: *EQ-VAS mean and median scores for Discectomy patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

EQ-VAS	**Pre-operative**	**6-months**	**12-months**	**24-months**
n	641	557	518	404
Mean (SD)	54.5 (20.4)	77.6 (15.9)	79.6 (15.0)	79.4 (15.7)
Median (IQR)	55.0 (40.0, 70.0)	80.0 (70.0, 90.0)	81.0 (73.0, 90.0)	81.0 (71.0, 90.0)

Figure 32: *EQ-VAS distribution for Discectomy patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

L4-L5 Degenerative Spondylolisthesis (L4-L5 DS)

Spondylolisthesis is defined as an anterior displacement of a vertebral body in relation to the one below it.

Degenerative L4-L5 spondylolisthesis is a condition where due to degenerative change, one vertebra slips forward over the one beneath it in the lumbar (lower back) region of the spine. This condition typically occurs due to age-related wear and tear on the spinal discs and facet joints, leading to instability and eventual loss of alignment of the vertebrae. As a result of this, the central canal narrows, and the nerves become compressed. Typically, DS occurs at the L4-L5 and less commonly at L3-L4.

It most commonly presents as leg pain restricting walking and standing but other symptoms can include:

- Lower back pain, often worsened by activity and relieved by rest.
- Pain that radiates into the buttocks and thighs.
- Numbness, tingling, or weakness in the legs.
- Difficulty walking or standing for prolonged periods.
- Changes in posture or gait.

It is reported that DS is strongly age and gender specific[26] and is uncommon under the age of 50[27].

For analysis, the L4-L5 DS cohort was selected using the following criteria:

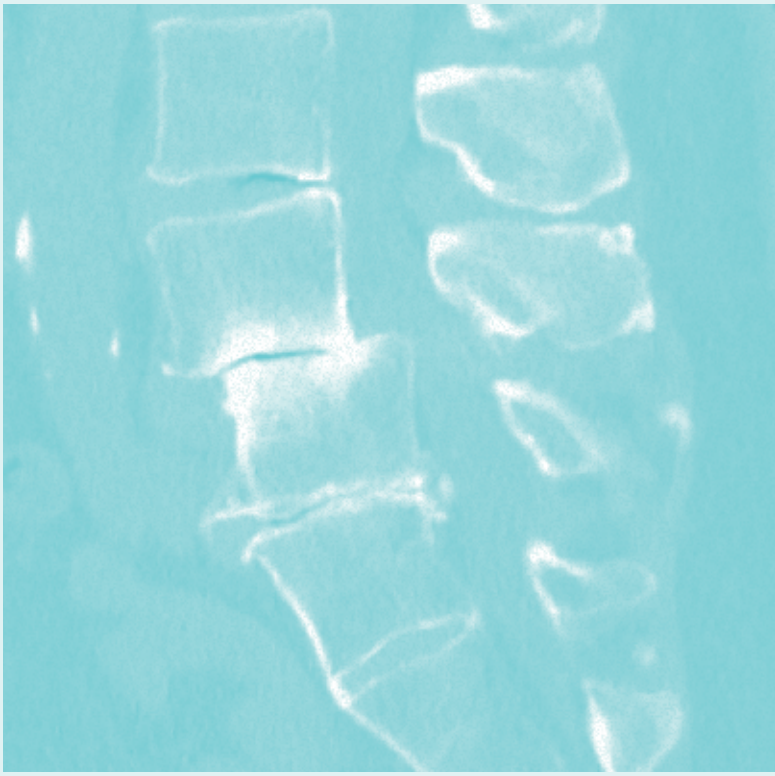
Inclusions:

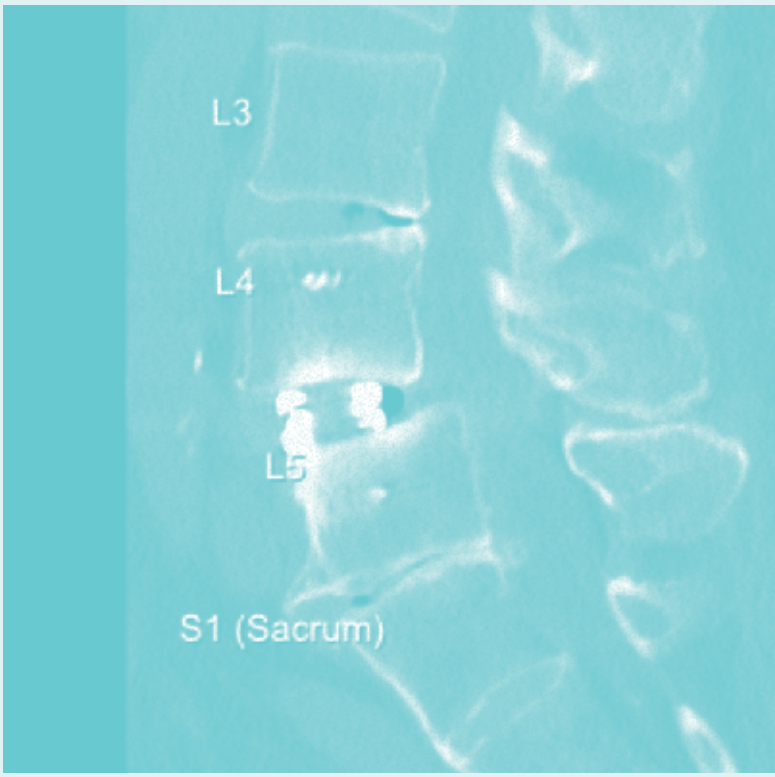
- Type of spondylolisthesis - degenerative
- Only at the L4-L5 level
- All grades (1-4) including spondyloptosis

Exclusions:

- Revision surgery
- Scoliosis
- Inflammation
- Infection
- Tumour

As at 31 December 2025, 397 patients met the L4-L5 DS cohort inclusion criteria.





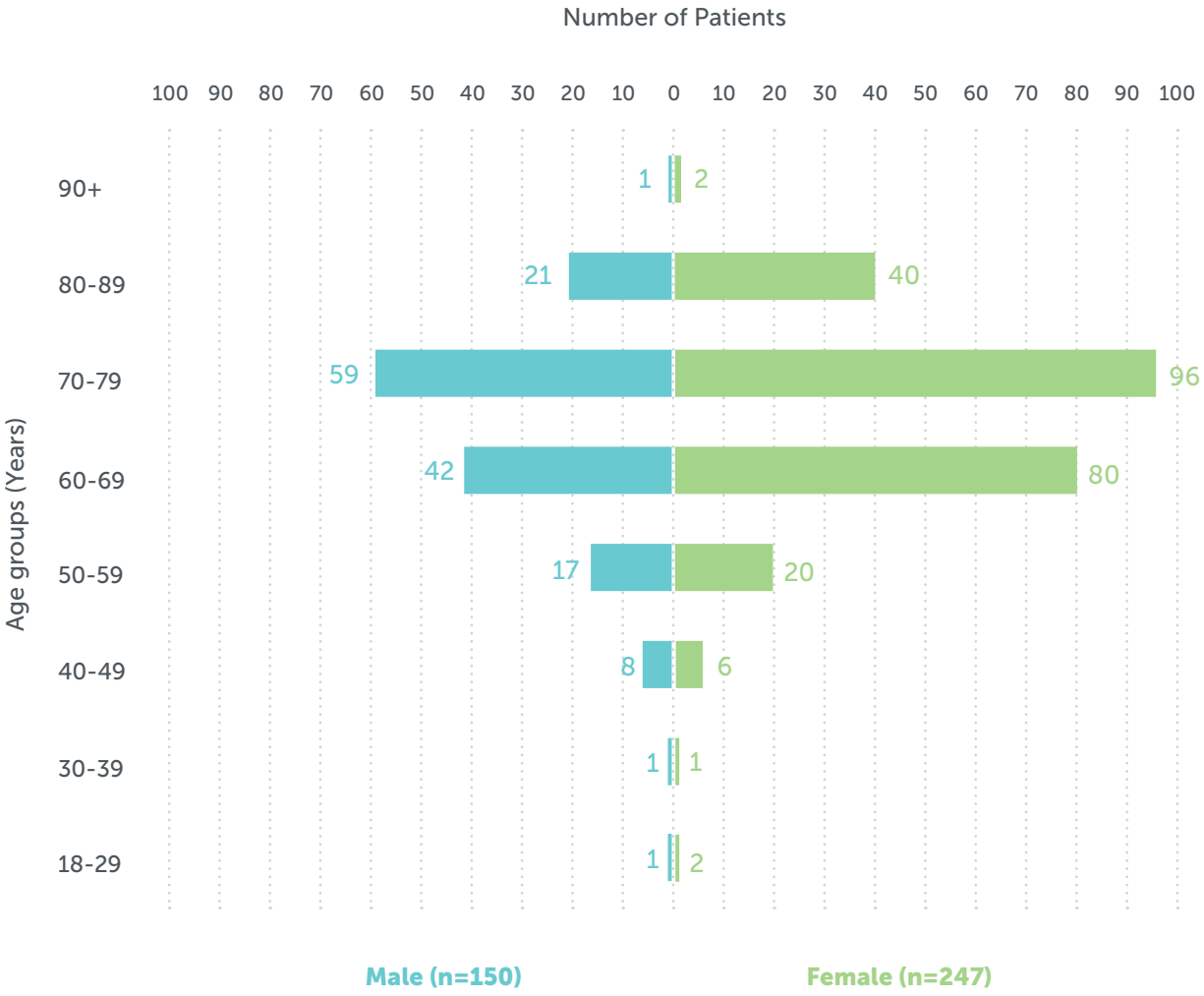
Images courtesy of Dr Brian Owler

Demographics

There were 150 males (38%) and 247 females (62%) who were diagnosed with L4-L5 DS as shown in Figure 33.

The median age for both males and females were 71 years, which is older than the median patient age from the total ASR patient cohort (62 years for males and 65 years for females).

Figure 33: *L4-L5 DS cohort by patient age and gender*



Surgeon Reported Comorbidities and ASA

The number of patients who were reported to have a comorbidity is shown in Table 42; 65.6% of L4-L5 DS patients were reported to have at least one comorbidity compared to 37.4% of the total patients. Patients were then categorised into groups by the number of SRCs reported (Table 43).

Table 42: *Number of L4-L5 DS patients with any comorbidity prior to surgery compared to all patients*

Any comorbidity	All patients (n=6,679) n (%)	L4-L5 DS patients (n=397) n (%)
Yes	2,497 (37.4%)	260 (65.5%)
No	4,182 (62.6%)	137 (34.5%)

Table 43: *Number of SRCs reported in L4-L5 DS patients compared to all patients*

Number of reported comorbidities	All patients (n=6,679) n (%)	L4-L5 DS patients (n=397) n (%)
None	4,182 (62.6%)	137 (34.5%)
1	1,131 (16.9%)	114 (28.7%)
2	724 (10.8%)	79 (19.9%)
3	402 (6.0%)	39 (9.8%)
4	145 (2.2%)	16 (4.0%)
5+	95 (1.4%)	12 (3.0%)

Patients were also categorised by their ASA score (Table 44). For the patients who had an ASA score recorded, 91.1% had a score of greater than 2, which is consistent with this cohort's age profile.

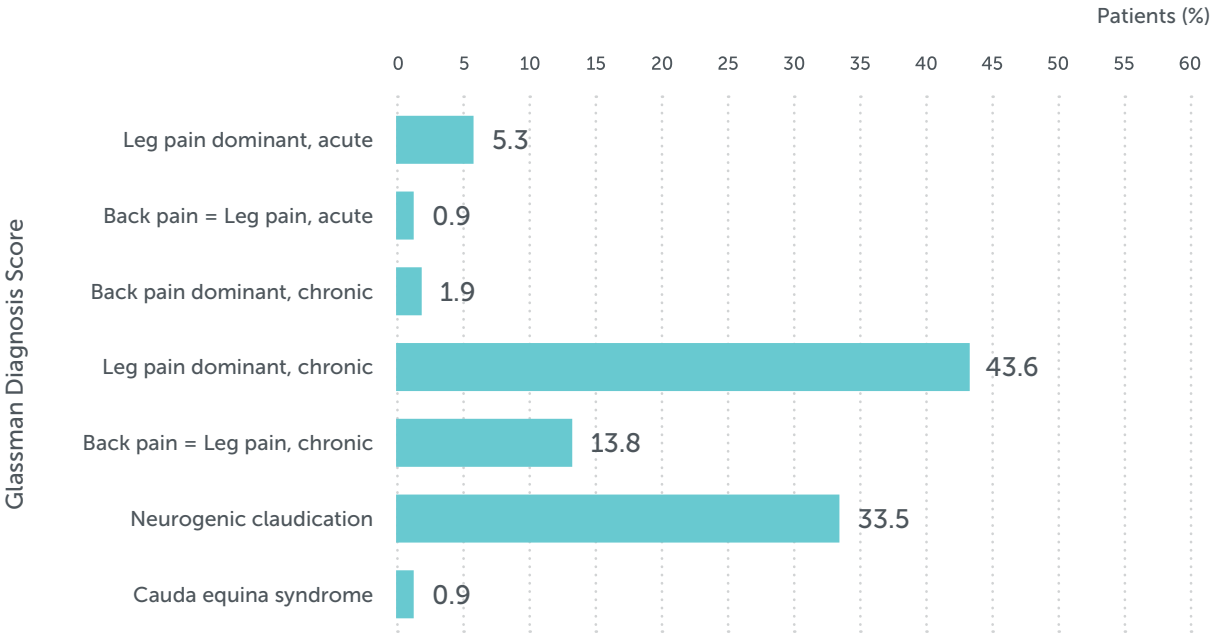
Table 44: *ASA score reported for L4-L5 DS patients compared to all patients*

ASA Classification	All patients (n=3,383) n (%)	L4-L5 DS patients (n=260) n (%)
1	712 (21.0%)	23 (8.8%)
2	1,542 (45.4%)	131 (50.4%)
3	1,096 (32.3%)	101 (38.8%)
4	43 (1.3%)	5 (1.9%)

Glassman Classification Scores

The Glassman classification scores for L4-L5 DS cohort was examined. Analysis of the "Symptoms" category indicate that for most of these patients, surgery was performed for neuro compressive pain (Figure 34).

Figure 34: *Glassman Score for 'Symptoms' among L4-L5 DS patients (n=319)*



PROMs Analysis

The Oswestry Disability Index (ODI) and the EQ-5D-3L scores were analysed for the L4-L5 DS cohort. As indicated previously, these results show unadjusted outcomes and must be interpreted with caution.

Oswestry Disability Index (ODI)

ODI median scores improved from 40 preoperatively to 16 at 6-months postoperatively with further slight improvement at 12 and 24 months (Table 45).

Figure 35 describes this in further detail.

Patients whose scores indicated severe disabled or worse (ODI score > 40) reduced from 48.5% preoperatively to 13.6% at 6 months, 12.0% at 12 months, and 9.0% at 24 months.

Table 45: *ODI mean and median scores for L4-L5 DS patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	321	281	251	202
Mean (SD)	40.9 (17.1)	19.4 (17.5)	17.6 (17.1)	16.4 (16.6)
Median (IQR)	40.0 (28.0, 52.0)	16.0 (4.0, 30.0)	12.0 (4.0, 28.0)	12.0 (2.0, 27.0)

Figure 35: *ODI distribution for L4-L5 DS patients who completed <u>any</u> ODI at pre-op, 6, 12 and 24-months post-op*

The ten ODI domains for the L4-L5 DS patients who completed any questionnaires were analysed. Table 46 shows the mean number of ODI domain scores preoperatively and at 6, 12 and 24-months postoperatively. Mean scores across all ODI domains were lower at 6, 12 and 24-months postoperatively demonstrating that the predominant disabilities are related to walking, standing, lifting and impact on social life.

Table 46: *ODI mean scores for each domain for L4-L5 DS patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	321	281	251	202
Pain, mean (SD)	2.38 (1.07)	0.98 (1.00)	0.87 (1.00)	0.89 (1.05)
Personal Care, mean (SD)	1.07 (1.05)	0.38 (0.84)	0.35 (0.84)	0.35 (0.87)
Lifting, mean (SD)	2.53 (1.28)	1.77 (1.57)	1.47 (1.44)	1.43 (1.52)
Walking, mean (SD)	2.08 (1.24)	0.78 (1.12)	0.76 (1.13)	0.76 (1.12)
Sitting, mean (SD)	1.65 (1.16)	0.94 (0.94)	0.86 (0.96)	0.78 (0.91)
Standing, mean (SD)	2.73 (1.25)	1.28 (1.33)	1.26 (1.31)	1.22 (1.38)
Sleeping, mean (SD)	1.66 (1.10)	0.74 (0.84)	0.68 (0.81)	0.62 (0.80)
Sex Life*, mean (SD)	2.08 (1.90)	0.83 (1.49)	0.87 (1.61)	0.61 (1.30)
Social Life, mean (SD)	2.34 (1.24)	1.04 (1.32)	0.90 (1.25)	0.81 (1.15)
Traveling, mean (SD)	1.94 (1.29)	0.85 (1.16)	0.76 (1.10)	0.62 (0.92)

** Note: Sex life question is optional; lower numbers of 209, 187, 164, 141 (for each time-point, respectively).*

For the L4-L5 DS patients, 97.5% exceeded or were within the MCID for ODI at the 6-month time point (Table 47). Table 48 shows the MCID for 12-months postoperatively; 68.1% of patients showed an improvement at this time point. Table 49 shows the MCID for 24-months postoperatively, where 75.3% of patients showed an improvement.

It is interesting to note that for this group of patients, the median age of patients undergoing surgery for DS is 71 for both males and females. Despite this age profile, these patients are still benefitting from their procedures.

Table 47: *MCID for ODI from pre-op to 6-months post-op for L4-L5 DS patients*

ODI*	All TL patients (n=3,074) n (%)	L4-L5 DS patients (n=240) n (%)
Exceeding the MCID (Improved)	1,959 (63.7%)	156 (65.0%)
Within the MCID (Unchanged)	1,021 (33.2%)	78 (32.5%)
Exceeding the MCID (Worsened)	94 (3.1%)	6 (2.5%)

Table 48: *MCID for ODI from pre-op to 12-months post-op for L4-L5 DS patients*

ODI*	All TL patients (n=2,829) n (%)	L4-L5 DS patients (n=213) n (%)
Exceeding the MCID (Improved)	1,832 (64.8%)	145 (68.1%)
Within the MCID (Unchanged)	910 (32.2%)	65 (30.5%)
Exceeding the MCID (Worsened)	87 (3.1%)	3 (1.4%)

Table 49: *MCID for ODI from pre-op to 24-months post-op for L4-L5 DS patients*

ODI*	All TL patients (n=2,187) n (%)	L4-L5 DS patients (n=170) n (%)
Exceeding the MCID (Improved)	1,417 (64.8%)	128 (75.3%)
Within the MCID (Unchanged)	697 (31.9%)	36 (21.2%)
Exceeding the MCID (Worsened)	73 (3.3%)	6 (3.5%)

**Only patients that have completed both timepoint questionnaires are included.*

Low, medium and high preoperative ODI analysis

We further examined the L4-L5 DS cohort specifically looking at patients who preoperatively reported low (0 to 30), medium (30 to <61) and high (61 to 100) ODI scores. The postoperative change in ODI scores amongst these patient subsets were then analysed. Patients were selected based on ODI questionnaires being completed at both preoperative and 12-month postoperative time points. Box plots were used to analyse the data.

The three patient populations characteristics are shown in Table 50.

In the low and high ODI group, there were almost equal number of men and women compared to the medium group where they were predominantly women. The median age was very similar across all groups. When looking at the change in the ODI, each group improved however the high ODI group showed the greatest change (Figure 36 and Figure 37).

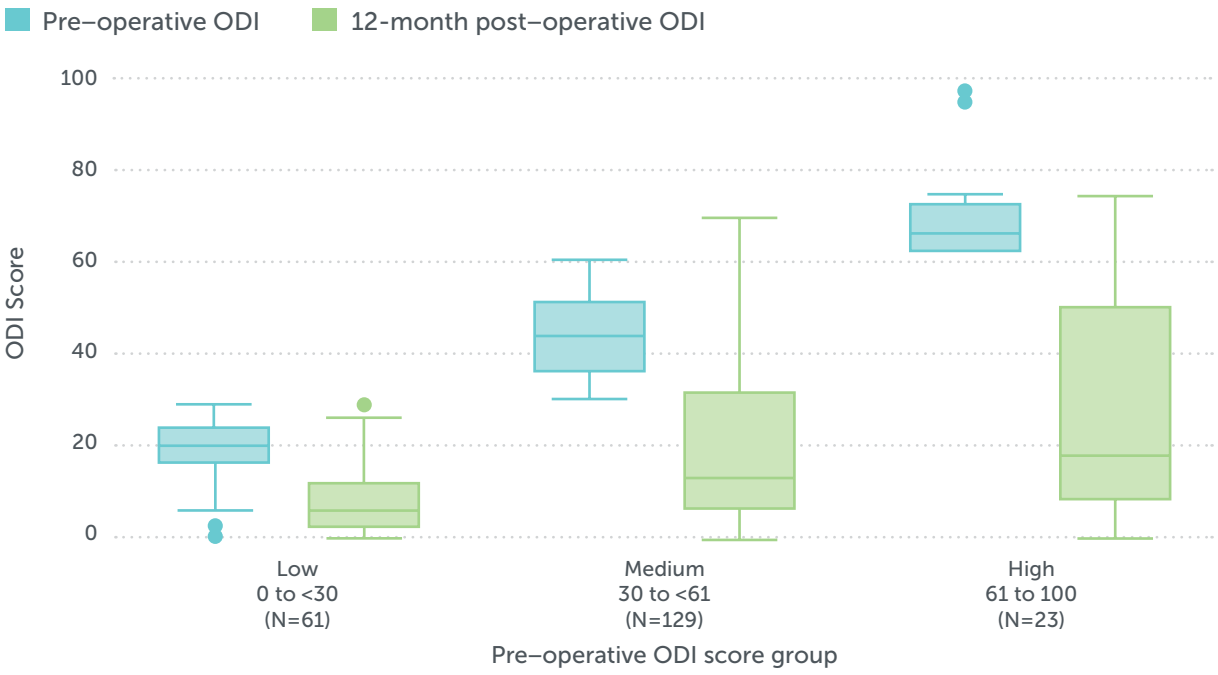
There were statistically significant differences in the 12-month ODI scores between the three different pre-operative ODI groups (<0.001). This was also the case for the absolute ODI score change between the different groups (p<0.001). Age, comorbidities, number of comorbidities and ASA classification did not differ significantly between groups (Data not shown).

Table 50: *Characteristics of the low medium and high ODI L4-L5 DS cohort*

	Low	Medium	High
N	61	129	23
Sex: Male	34 (55.7%)	37 (28.7%)	9 (39.1%)
Sex: Female	27 (44.3%)	92 (71.3%)	14 (60.9%)
Age, mean (SD)	69.4 (8.6)	68.3 (12.3)	74.4 (9.5)
Age, median (IQR)	70.0 (65.0-76.0)	70.0 (64.0-76.0)	74.0 (67.0-83.0)
Exceeding the MCID (Improved)	31 (50.8%)	96 (74.4%)	18 (78.3%)
Within the MCID (Unchanged)	29 (47.5%)	31 (24.0%)	5 (21.7%)
Exceeding the MCID (Worsened)	1 (1.6%)	2 (1.6%)	0 (0.0%)

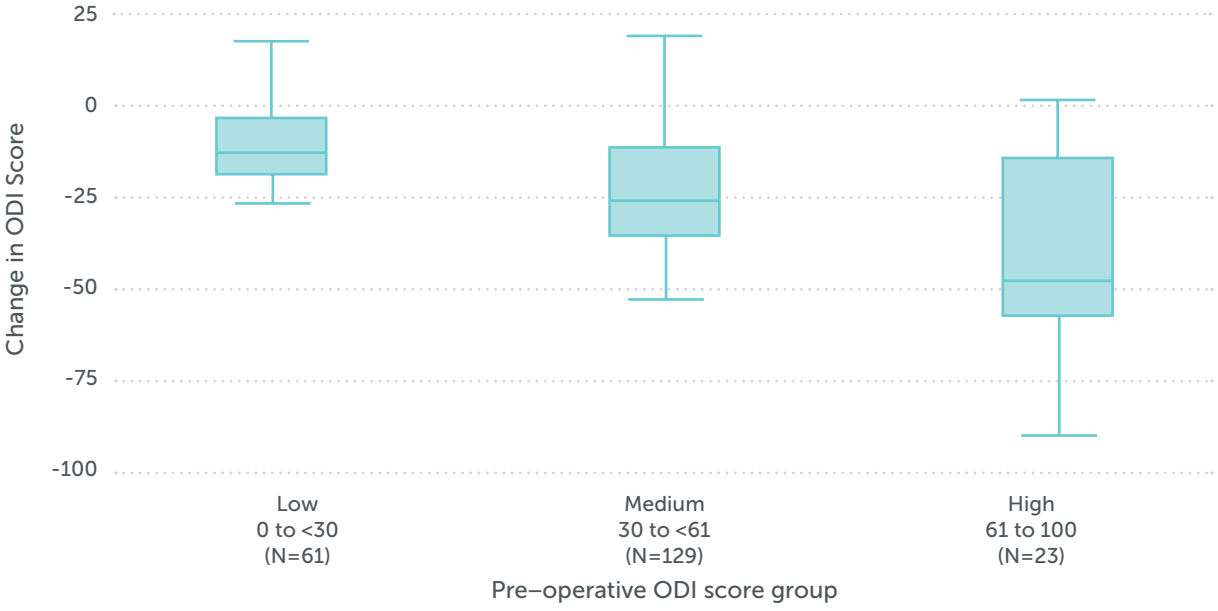
Out of the 397 L4-L5 DS patients, only 213 patients had scores at both timepoints and are included (Figure 36 and Figure 37).

Figure 36: *Preoperative and 12-month postoperative ODI scores by preoperative ODI score group*



** The boxes mark the first quartile (Q1), median and third quartile (Q3) of ODI score. Tukey values have been used for the whiskers. The lower whisker value is the smallest value that is greater or equal to Q1 - 1.5*IQR. The upper whisker value is the largest value that is less than or equal to Q3 + 1.5*IQR.*

Figure 37: *Change in ODI score by preoperative ODI score group*



** The boxes mark the first quartile (Q1), median and third quartile (Q3) of change in NDI score. Tukey values have been used for the whiskers. The lower whisker value is the smallest value that is still greater or equal to Q1 - 1.5*IQR. The upper whisker value is the largest value that is still less than or equal to Q3 + 1.5*IQR.*

The proportion that patients improve (based on MCID threshold) appears to be greater as initial severity of symptoms increases. It would appear patients with less severe symptoms would potentially obtain a lower proportional benefit after surgery.

(The ability to investigate the relationship between initial burden of disease and outcomes 12-months post-operation may be limited/confounded by sample imbalances in sex and Glassman score for symptoms. Therefore, these results should be interpreted with caution).

This analysis identified several findings:

- Patients with more severe preoperative symptoms obtained more proportional benefit from the surgery.
- Age or the frequency of comorbidities were not statistically relevant.

As indicated previously, the Minimum Clinically Important Difference (MCID) is a threshold used to measure the effect of clinical treatments and has been reported to be 12.8 for the ODI[25].

EQ-5D-3L Quality of Life

The L4-L5 DS cohort EQ-5D-3L dimension scores and the EQ-VAS were analysed (Table 51 and Figure 38). It is important to note that this group of patients have multifactorial health issues, and it is not unexpected that these patients have residual pain. In addition, this questionnaire asks about any pain, not specific pain. Therefore, pain and mobility issues, secondary to other pathologies e.g. cardiac problems, hip arthritis, vascular problems, are not separately identified.

Table 51: *EQ-VAS mean and median scores for L4-L5 DS patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

EQ-VAS	Pre-operative	6-months	12-months	24-months
n	322	282	254	203
Mean (SD)	60.1 (19.7)	74.9 (18.1)	76.7 (17.1)	78.1 (15.2)
Median (IQR)	60.0 (50.0, 75.0)	80.0 (67.0, 89.0)	80.0 (70.0, 90.0)	80.0 (70.0, 90.0)

When examining EQ-VAS a shift to the right indicates an improvement of patient perception of their general health status. As shown in Figure 38, this cohort showed improvement in their general perception of their health 6, 12 and 24-months postoperatively.

Figure 38: *EQ-VAS distribution for L4-L5 DS patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

Examination of the EQ-5D responses indicate patient improvement across all domains (Table 52). The mobility domain showed the highest improvement. 84.7% of patients reported some or extreme problems with mobility preoperatively. At 6-months post-surgery; 63.5% of patients indicated no problems with their mobility which was maintained at 12 and 24 months.

Table 52: *EQ-5D-3L scores for each domain for L4-L5 DS patients at pre-op, 6, 12 and 24-months post-op*

L4-L5 DS Patients EQ-5D-3L					
Domain	**Level of problem**	**Pre-op (%) n=322**	**6 months (%) n=282**	**12 months (%) n=254**	**24 months (%) n=203**
Mobility	1 – no problems	15.2	63.5	64.6	65.5
	2 – some problems	83.5	36.5	35.0	34.5
	3 – extreme problems	1.2	0.0	0.4	0.0
Self-Care	1 – no problems	71.7	86.9	88.2	90.6
	2 – some problems	28.0	13.1	11.8	8.9
	3 – extreme problems	0.3	0.0	0.0	0.5
Usual Activity	1 – no problems	11.2	48.6	55.5	62.6
	2 – some problems	75.5	47.5	42.5	36.0
	3 – extreme problems	13.4	3.9	2.0	1.5
Pain/ Discomfort	1 – no problems	2.2	40.8	46.9	44.8
	2 – some problems	56.5	53.9	49.6	49.3
	3 – extreme problems	41.3	5.3	3.5	5.9
Anxiety/ Depression	1 – no problems	51.2	72.7	75.2	76.4
	2 – some problems	43.8	25.9	22.4	21.7
	3 – extreme problems	5.0	1.4	2.4	2.0

L5-S1 Isthmic Spondylolisthesis (L5-S1 IS)

Spondylolisthesis is a condition where one vertebra slips forward over the vertebra below it. In isthmic spondylolisthesis, this slippage is caused by a defect or developmental abnormality in the posterior bony structures of the vertebra called the pars interarticularis. This defect is often associated with repetitive stress or trauma to the lower back, particularly during childhood or adolescence when the bones are still developing.

Studies have shown that the occurrence of isthmic spondylolisthesis varies depending on factors such as age, gender, and ethnicity. In children, it's estimated to be approximately 2.6%[28]. However, in the general adult population, the prevalence of asymptomatic isthmic spondylolisthesis ranges from 3.7% to over 25%[29-30]. This condition, along with spondylolysis, is more prevalent in males, with a male-to-female ratio of around 3:1[28].

The condition most frequently occurs at L5/S1 but can occur at all levels of the spine.

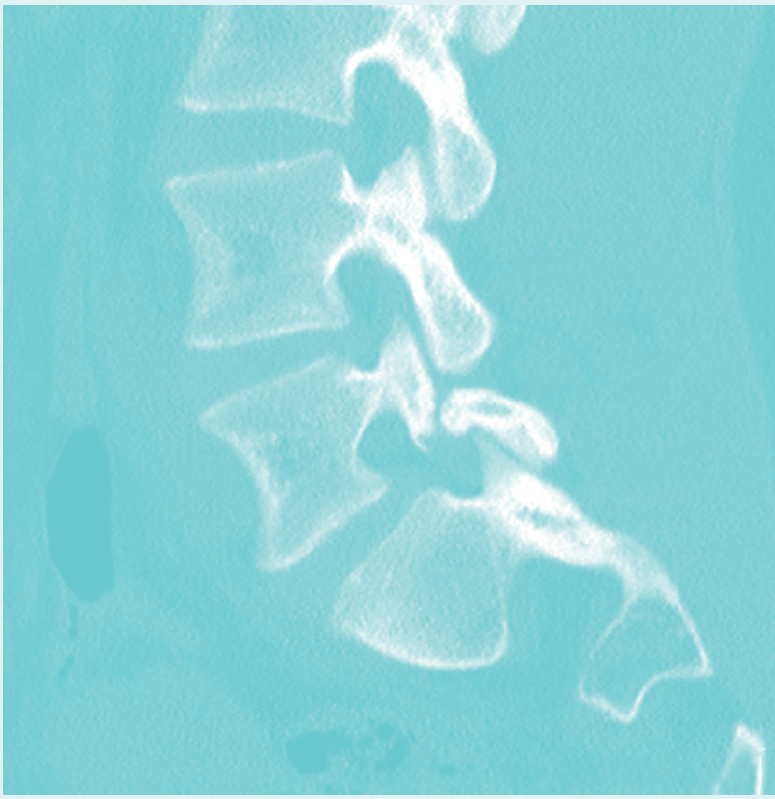
The prevalence of isthmic spondylolisthesis can be notably higher among athletes participating in sports[30] involving rotational or hyperextension movements of the lumbar spine. Such sports include gymnastics, football, rowing, weightlifting, cricket (and in particular fast bowling), and swimming[29].

There are two main subtypes of isthmic spondylolisthesis based on the underlying cause:

Lytic Spondylolysis: This subtype occurs when there is a defect or stress fracture in the pars interarticularis, being the small bony bridge that connects the facet joints at the back of the vertebra. This defect weakens the connection between the upper and lower parts of the vertebra, allowing for the slippage to occur.

Dysplastic Spondylolisthesis: This sub-type is believed to result from a congenital lack of development of the posterior vertebral structures, leading to instability and gradual forward displacement of the upper vertebra.

Symptoms of isthmic spondylolisthesis can vary greatly from no symptoms to severe pain depending on the degree of slippage and whether it causes compression of nearby nerves. Common symptoms may include lower back pain, stiffness, muscle spasms, leg pain (sciatica), and numbness and tingling. Less commonly there may be weakness in the legs or bladder and bowel disturbance.



Images courtesy of Dr Michael Johnson

For analysis, the L5-S1 IS cohort was selected using the following criteria:

Inclusions:

- Type of Spondylolisthesis - isthmic AND/OR dysplastic
- Only at the L5 – S1 level
- All grades (1-4)

Exclusions:

- Retrolisthesis
- Scoliosis
- Inflammation
- Infection
- Tumour

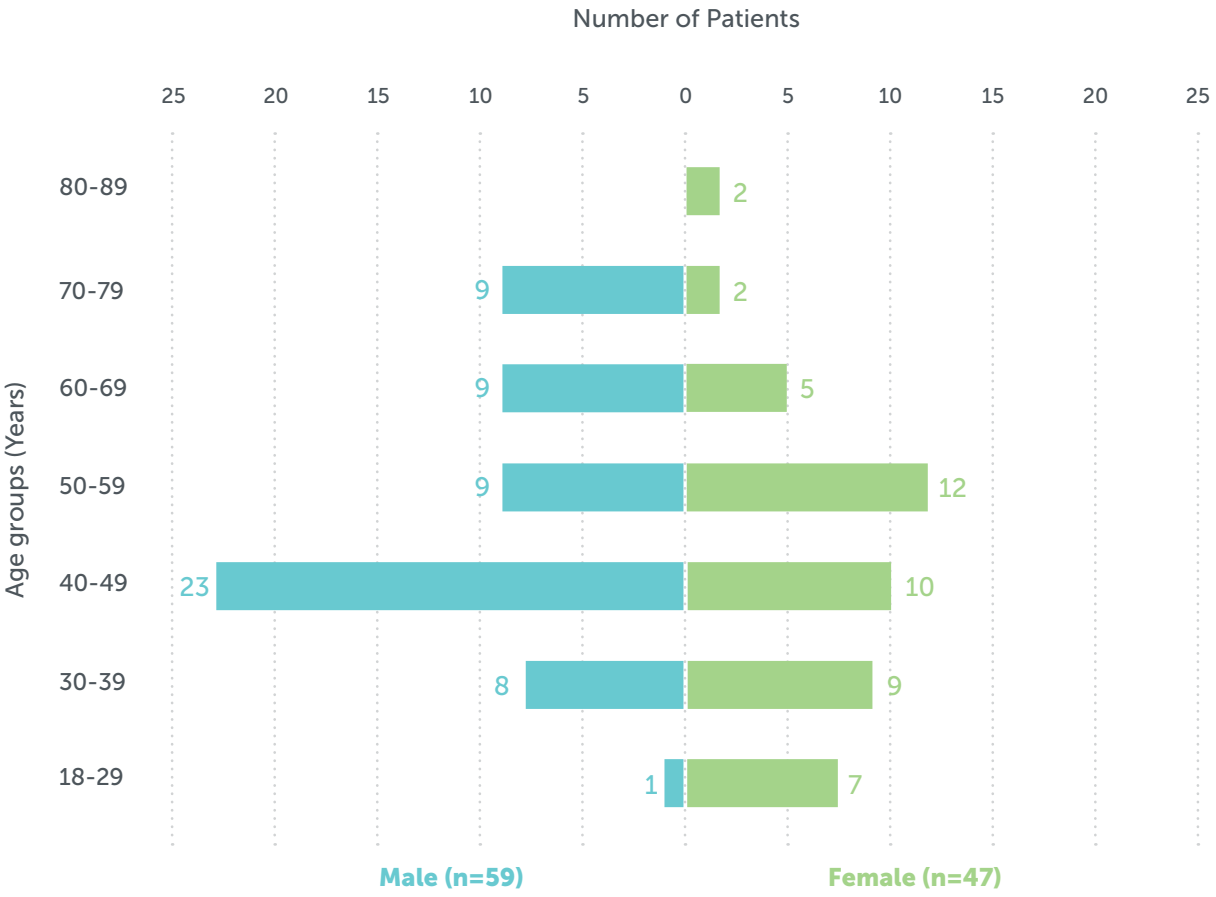
As of 31 December 2025, 106 patients met the IS cohort inclusion criteria.

Demographics

There were 59 males (55%) and 47 females (45%) who were diagnosed with L5-S1 IS as shown in Figure 39.

The median age for males was 49 years and 47 years for females, which is younger than the median patient age from the total ASR patient cohort (62 years for males and 65 years for females). The demographic data would appear to indicate that symptoms are usually more manageable in younger life but become more difficult to manage conservatively over the age of 40.

Figure 39: *L5-S1 IS cohort by patient age and gender*



Surgeon Reported Comorbidities and ASA

The number of patients who were reported to have a comorbidity is shown in Table 53. 44.2% of L5-S1 IS patients were reported to have at least one comorbidity compared to 37.4% of the total patients. Patients were then categorised into groups by the number of SRCs reported (Table 54).

Table 53: *Number of L5-S1 IS patients with any comorbidity prior to surgery compared to all patients*

Any comorbidity	All patients (n=6,679) n (%)	L4-L5 IS patients (n=106) n (%)
Yes	2,497 (37.4%)	46 (43.4%)
No	4,182 (62.6%)	60 (56.6%)

Table 54: *Number of SRCs in L5-S1 IS patients compared to all patients*

Number of reported comorbidities	All patients (n=6,679) n (%)	L4-L5 IS patients (n=106) n (%)
None	4,182 (62.6%)	60 (56.6%)
1	1,131 (16.9%)	29 (27.4%)
2	724 (10.8%)	11 (10.4%)
3	402 (6.0%)	4 (3.8%)
4	145 (2.2%)	2 (1.9%)
5+	95 (1.4%)	0 (0.0%)

Patients were further categorised by their ASA score (Table 55). For the patient who had an ASA score recorded, 78.2% were reported to have mild to severe disease.

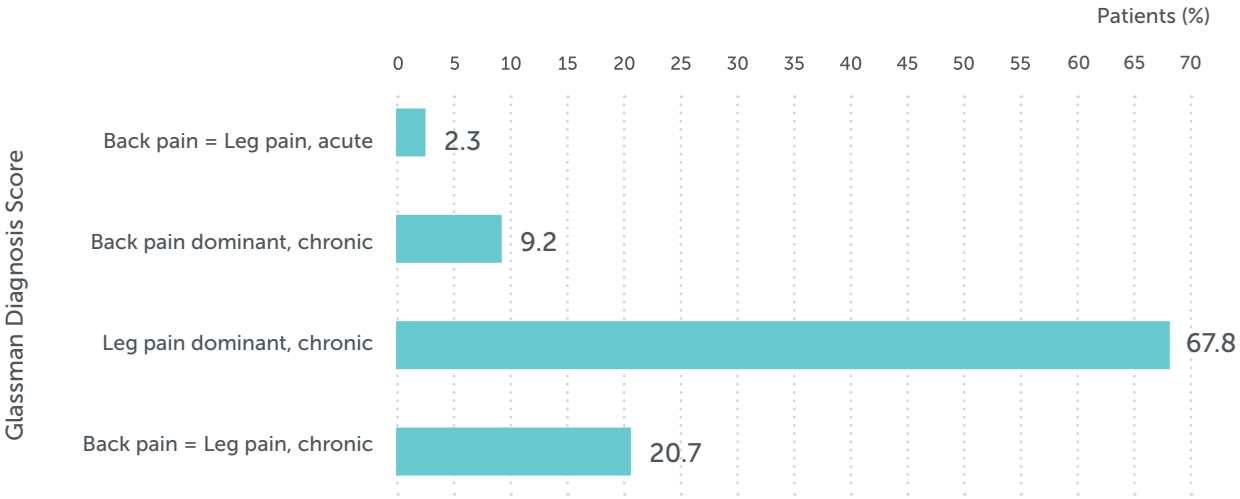
Table 55: *ASA score reported for L5-S1 IS patients compared to all patients*

ASA Classification	All patients (n=3,393) n (%)	L4-L5 IS patients (n=78) n (%)
1	712 (21.0%)	17 (21.8%)
2	1,542 (45.4%)	48 (61.5%)
3	1,096 (32.3%)	13 (16.7%)
4	43 (1.2%)	0 (0.0%)

Glassman Classification Scores

The Glassman classification scores for L5-S1 IS cohort was examined. Analysis of the "Clinical Symptoms" category indicate that for most of these patients, surgery was performed for neuro compressive pain (Figure 40).

Figure 40: *Glassman Score for 'Symptoms' among L5-S1 IS patients (n=86)*



PROMs Analysis

The Oswestry Disability Index (ODI) and the EQ-5D-3L scores were analysed for the L5-S1 IS cohort. As indicated previously, these results show unadjusted outcomes and must be interpreted with caution.

Oswestry Disability Index (ODI)

ODI median scores improved from 43.0 preoperatively to 17 at 6-months postoperatively with minimal improvement at 12 and 24 months (Table 56).

Figure 41 describes this in further detail. Patients whose scores indicated severe disabled or worse (ODI score > 40) reduced from 59.7% preoperatively to 16.0% at 6 months, 13.6% at 12 months, and 10.5% at 24 months.

However, the ODI at 24 months shows that there is small proportion of patients (11.8%) with an ODI score over 40.

Table 56: *ODI mean and median scores for L5-S1 IS patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	96	76	74	67
Mean (SD)	42.8 (16.6)	22.0 (18.2)	19.9 (17.6)	18.9 (15.7)
Median (IQR)	43.0 (32.0, 54.0)	17.0 (8.0, 35.0)	18.0 (6.0, 30.0)	16.0 (8.0, 30.0)

Figure 41: *ODI distribution for L5-S1 IS patients who completed <u>any</u> ODI at pre-op, 6, 12 and 24-months post-op*

The ten ODI domains for the L5-S1 IS patients that completed any questionnaires were analysed. Table 57 shows the mean number of ODI domain scores preoperatively and at 6, 12 and 24-months postoperatively. Mean scores across all ODI domains were lower at 6, 12 and 24-months postoperatively with standing and social life followed by lifting showing the largest improvement.

Table 57: *ODI mean scores for each domain for L5-S1 IS patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	94	75	74	67
Pain, mean (SD)	2.52 (0.96)	1.29 (1.00)	1.09 (0.92)	1.04 (0.93)
Personal Care, mean (SD)	1.15 (1.12)	0.58 (1.02)	0.50 (1.00)	0.46 (0.91)
Lifting, mean (SD)	2.59 (1.21)	1.84 (1.47)	1.53 (1.45)	1.22 (1.24)
Walking, mean (SD)	1.46 (1.20)	0.47 (0.72)	0.47 (0.73)	0.39 (0.58)
Sitting, mean (SD)	2.30 (1.07)	1.33 (1.16)	1.30 (1.08)	1.25 (1.03)
Standing, mean (SD)	2.85 (1.29)	1.22 (1.28)	1.28 (1.24)	1.30 (1.17)
Sleeping, mean (SD)	1.78 (1.00)	0.92 (0.92)	0.81 (0.89)	0.88 (0.73)
Sex Life*, mean (SD)	2.14 (1.66)	1.11 (1.47)	1.03 (1.40)	1.11 (1.55)
Social Life, mean (SD)	2.51 (1.14)	1.22 (1.35)	1.07 (1.32)	0.99 (1.16)
Traveling, mean (SD)	2.10 (1.24)	1.03 (1.11)	0.92 (1.16)	0.82 (0.94)

** Note: Sex life question is optional; lower numbers of 79, 64, 60 and 62 (for each time-point, respectively).*

MCID was examined for the L5-S1 IS patients. 95.8% were within or exceeded the MCID for ODI at the 6-month time point (Table 58). This was sustained at 12 and 24 months (Table 59, Table 60).

Table 58: *MCID for ODI from pre-op to 6-months post-op for L5-S1 IS patients*

ODI*	All TL patients (n=3,074) n (%)	L4-L5 IS patients (n=72) n (%)
Exceeding the MCID (Improved)	1,959 (63.7%)	45 (62.0%)
Within the MCID (Unchanged)	1,021 (33.2%)	24 (33.8%)
Exceeding the MCID (Worsened)	94 (3.1%)	3 (4.2%)

Table 59: *MCID for ODI from pre-op to 12-months post-op for L4-L5 DS patients*

ODI*	All TL patients (n=2,829) n (%)	L4-L5 IS patients (n=68) n (%)
Exceeding the MCID (Improved)	1,832 (64.8%)	54 (79.4%)
Within the MCID (Unchanged)	910 (32.2%)	14 (20.6%)
Exceeding the MCID (Worsened)	87 (3.1%)	0 (0.0%)

Table 60: *MCID for ODI from pre-op to 24-months post-op for L4-L5 DS patients*

ODI*	All TL patients (n=2,187) n (%)	L4-L5 IS patients (n=62) n (%)
Exceeding the MCID (Improved)	1,417 (64.8%)	50 (80.6%)
Within the MCID (Unchanged)	697 (31.9%)	11 (17.7%)
Exceeding the MCID (Worsened)	73 (3.3%)	1 (1.6%)

**Only patients that have completed both timepoint questionnaires are included.*

EQ-5D-3L Quality of Life

The L5-S1 IS cohort EQ-5D-3L dimension scores, and the EQ-VAS were analysed.

Examination of the EQ-5D responses indicate general patient improvement across most domains. For example, for the mobility domain, 83.0% of patients reported some or extreme problems with mobility preoperatively. At 6, 12 and 24 months approximately 62% of patients indicated that they had no problem with their mobility (Table 61).

Table 61: *EQ-5D-3L scores for each domain for L5-S1 IS patients at pre-op, 6, 12 and 24-months post-op*

		L5 S1 IS Patients EQ-5D-3L			
Domain	**Level of problem**	**Pre-op (%) n=94**	**6-months (%) n=77**	**12-months (%) n=75**	**24-months (%) n=67**
Mobility	1 – no problems	17.0	62.3	62.7	70.1
	2 – some problems	80.9	37.7	36.0	29.9
	3 – extreme problems	2.1	0.0	1.3	0.0
Self-Care	1 – no problems	58.5	76.6	76.0	83.6
	2 – some problems	37.2	23.4	24.0	16.4
	3 – extreme problems	4.3	0.0	0.0	0.0
Usual Activity	1 – no problems	10.6	40.3	44.0	47.8
	2 – some problems	67.0	48.1	50.7	47.8
	3 – extreme problems	22.3	11.7	5.3	4.5
Pain/ Discomfort	1 – no problems	1.1	27.3	29.3	31.3
	2 – some problems	62.8	66.2	65.3	65.7
	3 – extreme problems	36.2	6.5	5.3	3.0
Anxiety/ Depression	1 – no problems	37.2	58.4	58.7	62.7
	2 – some problems	52.1	31.2	33.3	35.8
	3 – extreme problems	10.6	10.4	8.0	1.5

When examining EQ-VAS a shift to the right indicates an improvement of patient perception of their general health status. As shown in Table 62 and in Figure 42, this cohort showed moderate improvement in their general perception of their health 6, 12 and 24-months postoperatively.

Table 62: *EQ-VAS mean and median scores for L5-S1 IS patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

EQ-VAS	**Pre-operative**	**6-months**	**12-months**	**24-months**
n	94	77	75	67
Mean (SD)	53.7 (20.4)	70.9 (20.6)	73.8 (20.4)	74.8 (18.7)
Median (IQR)	55.0 (40.0, 70.0)	75.0 (60.0, 85.0)	80.0 (61.0, 90.0)	80.0 (60.0, 91.0)

Figure 42: *EQ-VAS mean and median scores for L5-S1 IS patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

Complex Surgery

Analysis of various government and insurance databases indicates a growing amount of more complex spine surgery being performed in Australia, particularly older patients. The ASR collects data on the following defined cohort of patients in order to analyse this trend.

Inclusions:

- Age ≥60 years at time of surgery
- Degenerative diagnosis
- Surgery ≥6 motion segments (7 contiguous vertebrae)

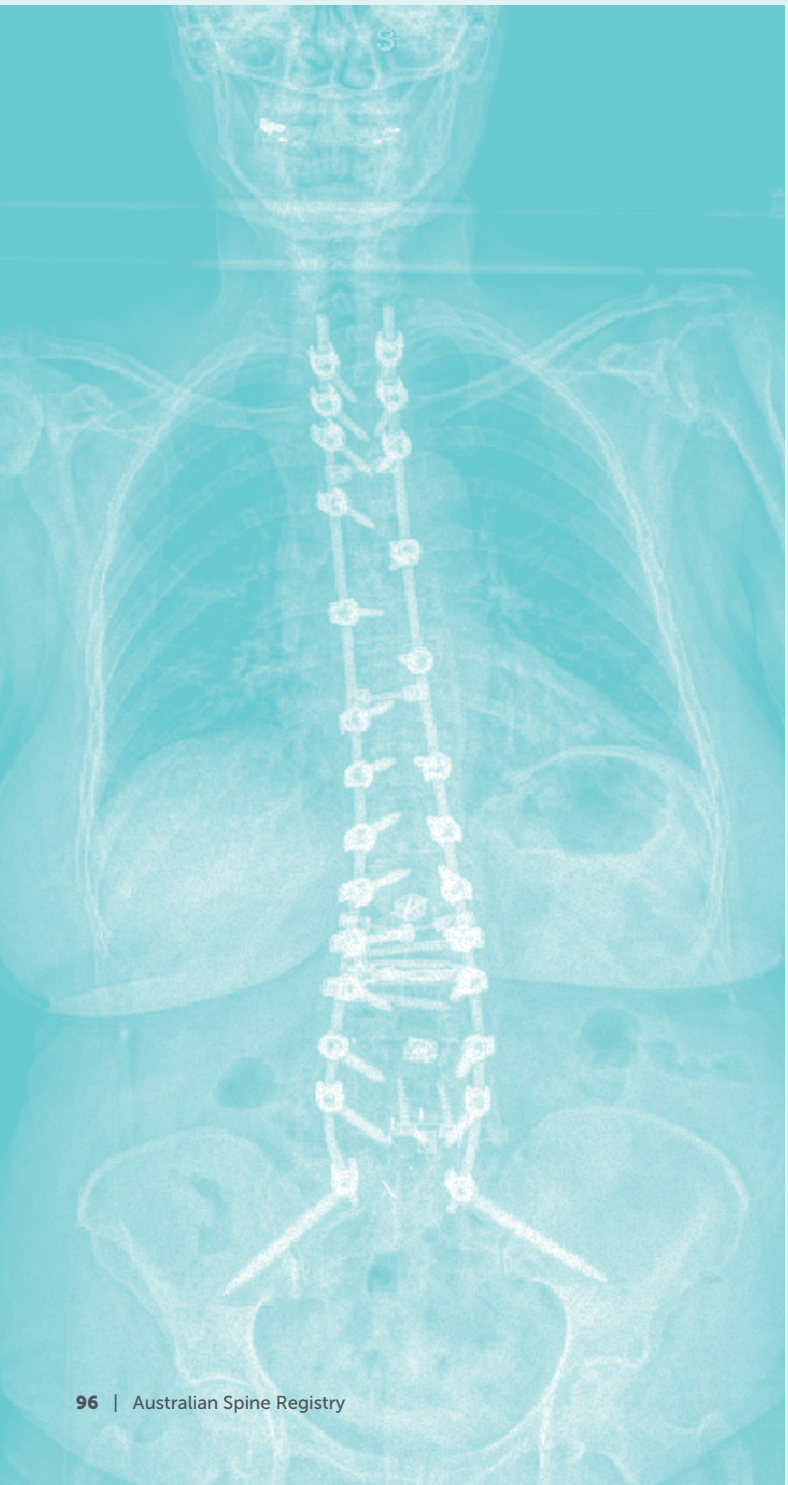
Exclusions:

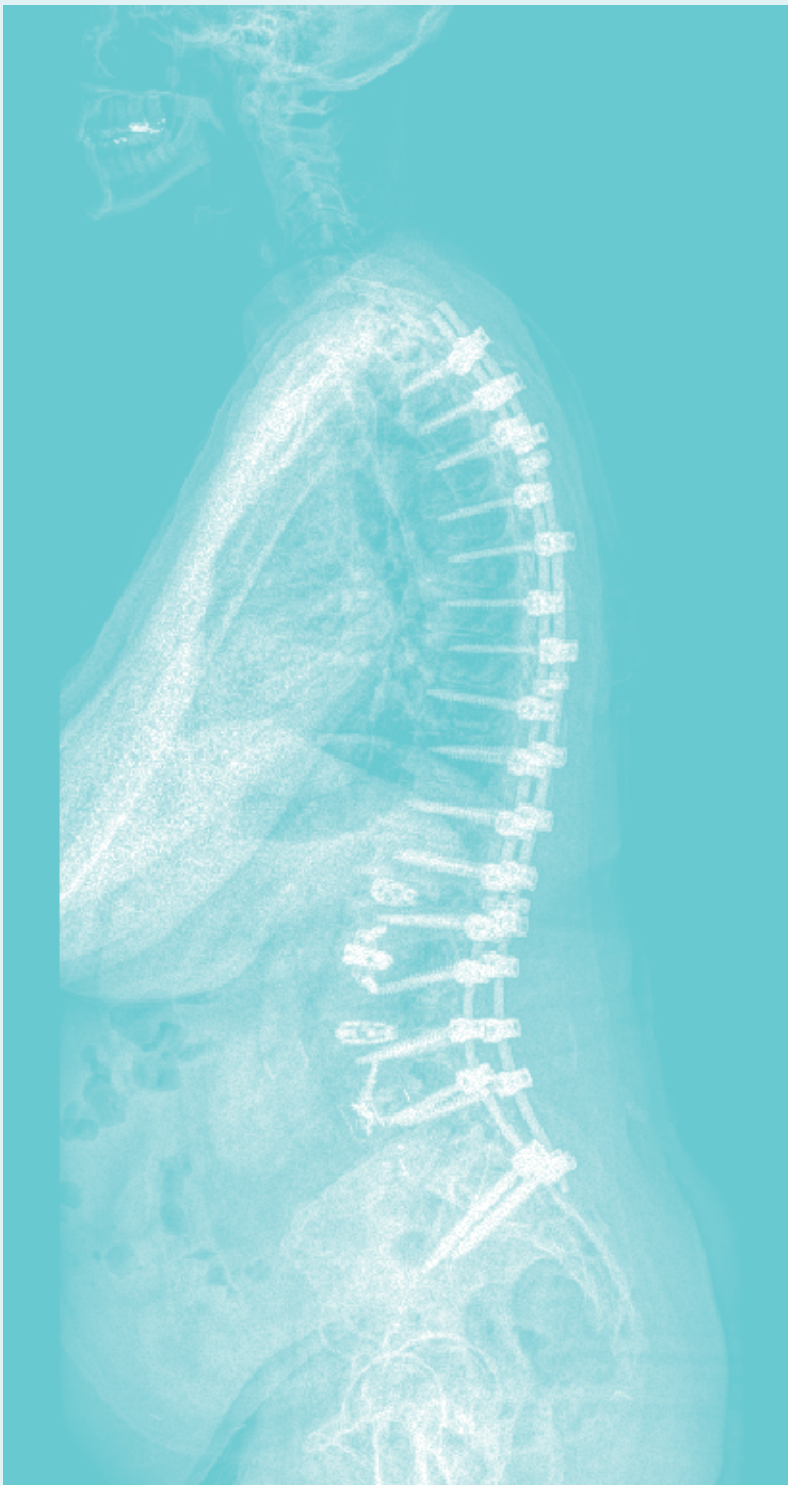
- Inflammation
- Infection
- Tumour

It is important to note that this cohort is not uniform by diagnosis or symptoms leading to some degree of cohort heterogeneity.

As of 31 December 2025, 217 patients met the complex surgery cohort inclusion criteria.

Images courtesy of A/Prof John Cunningham





Demographics

217 patients met the inclusion criteria which represents 4.0% of patients undergoing thoracolumbar procedures. The median age for males was 70 years and 69 years for females.

As indicated in Figure 43, the demographic distribution demonstrates a disproportionate number of females. This patient group has the following characteristics:

- 36.4% of patients in this cohort received planned multi-stage surgery (Figure 44).
- 53.0% of the patients had previous spine surgery (Figure 45).
- 32.5% of patients had both anterior and posterior surgery (Figure 46).

Figure 43: *Complex Surgery patients by age and gender*

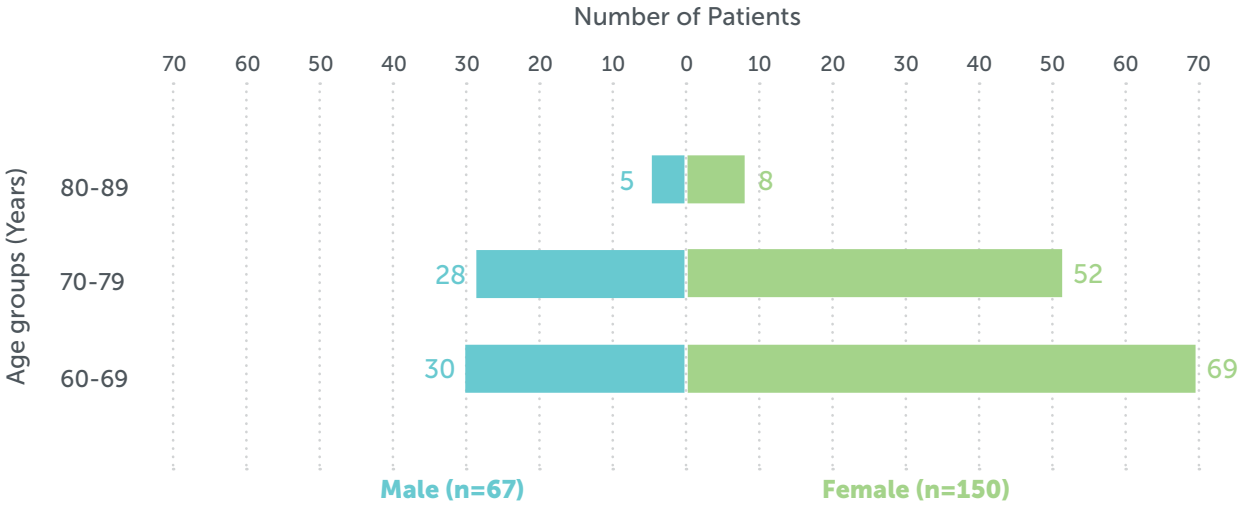


Figure 44: *Percentage of Complex Surgery patients who underwent multi-staged procedures (n=217)*

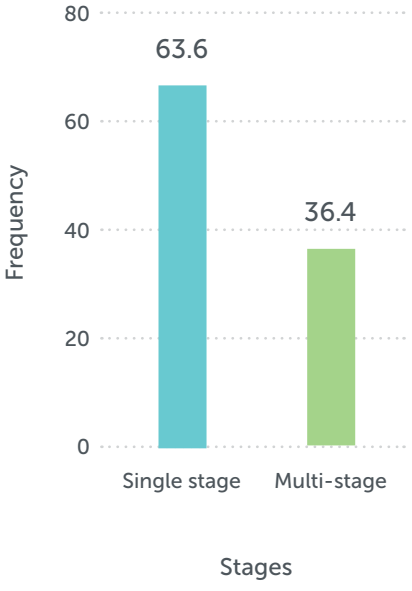


Figure 45: *Percentage of Complex Surgery patients who had previous spine surgery (n=217)*

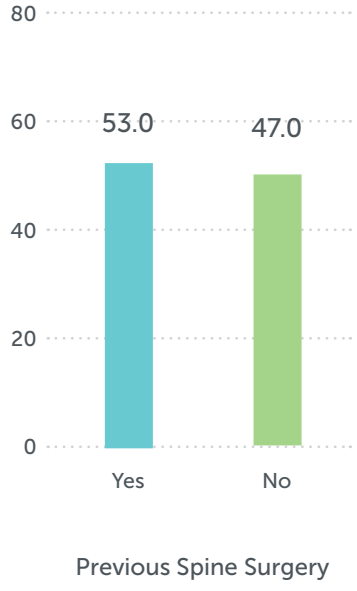
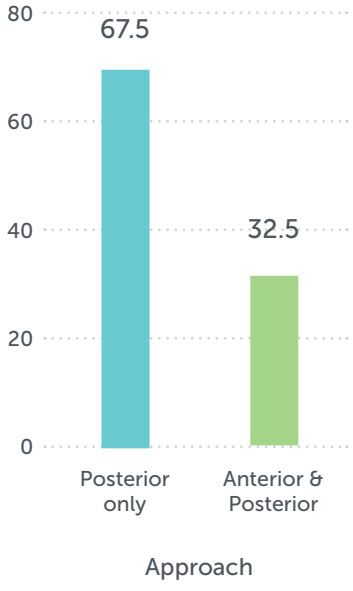


Figure 46: *Surgical approach in Complex Surgery patients (n=212)*



Patients that required revision surgery were further analysed in the attempt to determine the diagnostic reason. The following diagnoses were identified (Table 63). Note that one patient can have more than one diagnosis.

Table 63: *Reported diagnoses in non-revised and revised Complex Surgery patients*

Diagnosis	Non-revised (n=102) n (%)	Revised (n=115) n (%)	Total (n=217) n (%)
Adjacent level degeneration	0 (0.0%)	67 (58.3%)	67 (30.9%)
Pseudarthrosis	0 (0.0%)	23 (20.0%)	23 (10.6%)
Instrumentation breakage	0 (0.0%)	17 (14.8%)	17 (7.8%)
Late infection implant loosening	0 (0.0%)	6 (5.2%)	6 (2.8%)
Myelopathy	2 (2.0%)	10 (8.7%)	12 (5.5%)
Radiculopathy	23 (22.5%)	38 (33.0%)	61 (28.1%)
Deformity	61 (59.8%)	60 (52.2%)	121 (55.8%)
Scoliosis	50 (49.0%)	25 (21.7%)	75 (34.6%)
Kyphosis	14 (13.7%)	27 (23.5%)	41 (18.9%)
Global sagittal imbalance	13 (12.7%)	24 (20.9%)	37 (17.1%)
Spondylolisthesis	17 (16.7%)	20 (17.4%)	37 (17.1%)

Surgeon Reported Comorbidities and ASA

This surgical cohort suggests higher associated SRCs in comparison to the overall spine surgery population. Whilst there was a variability between SRCs and ASA score, this trend was consistent (Tables 64 - 66).

Table 64: *Number of Complex Surgery patients with any comorbidity prior to surgery*

Any comorbidity	All patients (n=6,679) n (%)	Complex Surgery patients (n=217) n (%)
Yes	2,497 (37.4%)	157 (72.4%)
No	4,182 (62.6%)	60 (27.6%)

Table 65: *Number of SRCs reported in Complex Surgery patients*

Number of reported comorbidities	All patients (n=6,679) n (%)	Complex Surgery patients (n=217) n (%)
None	4,182 (62.6%)	60 (27.6%)
1	1,131 (16.9%)	67 (30.9%)
2	724 (10.8%)	51 (23.5%)
3	402 (6.0%)	25 (11.5%)
4	145 (2.2%)	8 (3.7%)
5+	95 (1.4%)	6 (2.8%)

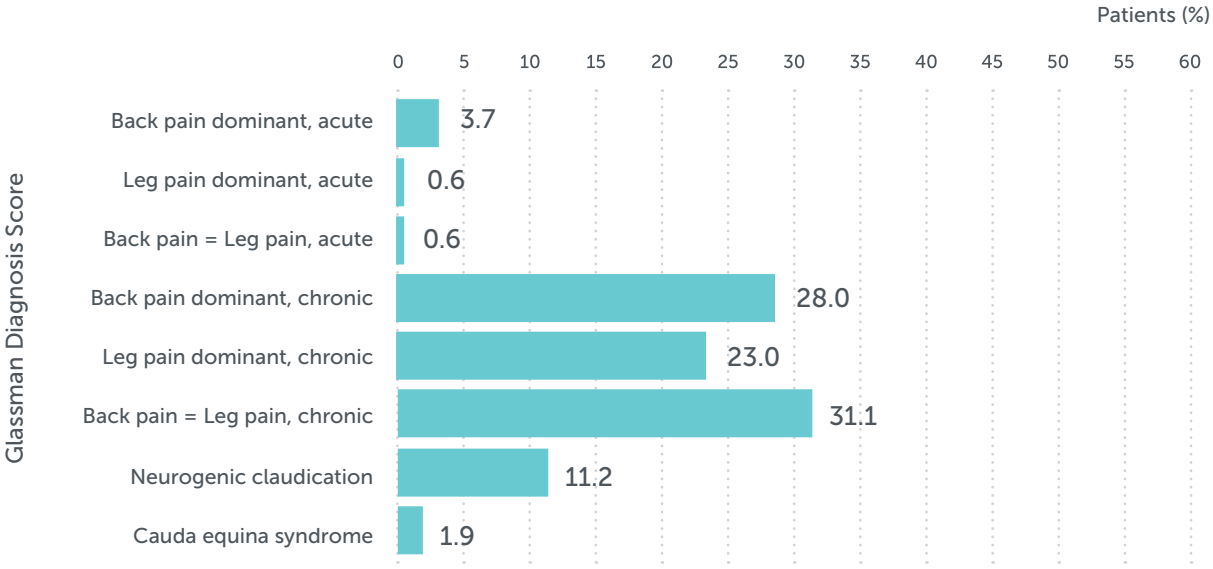
Table 66: *ASA score reported for Complex Surgery patients compared to all ASR patients*

ASA Classification	All patients (n=3,393) n (%)	Complex Surgery patients (n=178) n (%)
1	712 (21.0%)	4 (2.2%)
2	1,542 (45.4%)	58 (32.6%)
3	1,096 (32.3%)	112 (62.9%)
4	43 (1.2%)	4 (2.2%)

Glassman Score for 'Symptoms' among Complex Surgery patients

As indicated in Figure 47, these patients reported a higher proportion of back pain as their primary complaint. The Glassman classification does not describe complaints related to postural imbalance which is a frequent complaint in this patient cohort.

Figure 47: *Glassman Score for 'Symptoms' among Complex Surgery patients (n=161)*



PROMs Analysis

The Oswestry Disability Index (ODI) and the EQ-5D-3L scores were analysed for the complex surgery cohort.

As indicated previously, these results show unadjusted outcomes and must be interpreted with caution.

Oswestry Disability Index (ODI)

ODI scores for complex surgery patients were examined and analysed. Preoperatively, the ODI scores were higher than for the other cohorts.

ODI median scores improved from 49.0 preoperatively to 30 at 6-months postoperatively with minimal improvement at 12 and 24 months (Table 67).

Figure 48 describes this in further detail.

Table 67: *ODI mean and median scores for Complex Surgery patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	195	173	165	136
Mean (SD)	47.9 (15.8)	32.0 (17.6)	31.1 (18.1)	30.8 (20.0)
Median (IQR)	49.0 (38.0, 60.0)	30.0 (18.0, 46.0)	30.0 (16.0, 42.0)	29.5 (13.0, 45.0)

Patients whose scores indicated severe disabled or worse (ODI score > 40) reduced from 69.3% preoperatively to 29.1% at 6 months, 29.6% at 12 months, and 28.7% at 24 months. There was, however, a greater proportion of patients with ODI scores greater than 40 at the 24-month timepoint in comparison to other patient groups (Figure 48).

Figure 48: *ODI distribution for Complex Surgery patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

The ten ODI domains for the complex surgery patients that completed any questionnaires were analysed. Table 68 shows the mean number of ODI domain scores preoperatively and at 6, 12 and 24-months postoperatively. Mean scores across all ODI domains were lower at 6, 12 and 24-months postoperatively with pain and social life followed by standing showing the largest improvement.

Table 68: *ODI mean scores for each domain for Complex Surgery patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	195	173	165	136
Pain, mean (SD)	2.59 (1.01)	1.40 (0.93)	1.41 (0.96)	1.38 (1.08)
Personal Care, mean (SD)	1.45 (1.18)	0.98 (1.28)	0.99 (1.23)	0.99 (1.30)
Lifting, mean (SD)	3.04 (1.13)	2.69 (1.23)	2.49 (1.30)	2.38 (1.44)
Walking, mean (SD)	2.45 (1.24)	1.53 (1.38)	1.46 (1.39)	1.56 (1.44)
Sitting, mean (SD)	1.88 (1.04)	1.37 (0.94)	1.38 (1.01)	1.21 (0.90)
Standing, mean (SD)	3.15 (1.15)	1.97 (1.38)	2.01 (1.36)	2.05 (1.40)
Sleeping, mean (SD)	1.78 (1.04)	1.02 (0.92)	1.05 (0.94)	1.15 (1.00)
Sex Life*, mean (SD)	3.09 (1.86)	1.99 (2.01)	1.96 (2.05)	2.18 (1.99)
Social Life, mean (SD)	2.68 (1.14)	1.78 (1.31)	1.66 (1.31)	1.55 (1.40)
Traveling, mean (SD)	2.15 (1.24)	1.43 (1.26)	1.30 (1.18)	1.21 (1.27)

** Note: Sex life question is optional; lower numbers of 123, 96, 101 and 82 for each time-point, respectively).*

Using the ODI MCID of 12.8 for degenerative adult scoliosis[31,32], 55.6% of patients undergoing complex spine surgery have a clinically meaningful improvement at 6 months (Table 69). Unlike the other cohorts where improvements are stable at 12 months and 24 months, in this cohort, recovery appears to be more prolonged (Table 70 and Table 71). Benefit from surgery appears to be less marked and reliable.

There is a significant group where the benefit is limited. Approximately 29%, remain with an ODI greater than 40 at the 24-month time point (Figure 49).

Table 69: *MCID for ODI from pre-op to 6-months post-op for Complex Surgery patients*

ODI*	All TL patients (n=3,074) n (%)	Complex surgery patients (n=160) n (%)
Exceeding the MCID (Improved)	1,959 (63.7%)	89 (55.6%)
Within the MCID (Unchanged)	1,021 (33.2%)	66 (41.2%)
Exceeding the MCID (Worsened)	94 (3.1%)	5 (3.1%)

Table 70: *MCID for ODI from pre-op to 12-months post-op for Complex Surgery patients*

ODI*	All TL patients (n=2,829) n (%)	Complex surgery patients (n=123) n (%)
Exceeding the MCID (Improved)	1,832 (64.8%)	88 (56.8%)
Within the MCID (Unchanged)	910 (32.2%)	62 (40.0%)
Exceeding the MCID (Worsened)	87 (3.1%)	5 (3.2%)

Table 71: *MCID for ODI from pre-op to 24-months post-op for Complex Surgery patients*

ODI*	All TL patients (n=2,187) n (%)	Complex surgery patients (n=80) n (%)
Exceeding the MCID (Improved)	1,417 (64.8%)	88 (56.8%)
Within the MCID (Unchanged)	697 (31.9%)	62 (40.0%)
Exceeding the MCID (Worsened)	73 (3.3%)	5 (3.2%)

**Only patients that have completed both timepoint questionnaires are included.*

EQ-5D-3L Quality of Life

Results for the EQ-5D-3L for the Complex Surgery cohort are shown in Table 72 and Table 73. All domains of the EQ5D showed varying levels of improvements from pre-op to 24 months for this complex surgery cohort. The EQ-VAS, which indicates a patient's perception of their health state at the time of completing the questionnaire, shows a moderate level of improvement (Table 73).

Table 72: *EQ-5D-3L scores for each domain for Complex Surgery patients from pre-op to 24-months post-op*

Complex Surgery Patients EQ-5D-3L					
Domain	**Level of problem**	**Pre-op (%) n=199**	**6-months (%) n=179**	**12-months (%) n=170**	**24-months (%) n=140**
Mobility	1 – no problems	8.5	33.0	34.1	32.1
	2 – some problems	88.9	65.9	64.1	66.4
	3 – extreme problems	2.5	1.1	1.8	1.4
Self-Care	1 – no problems	52.8	62.6	58.2	62.9
	2 – some problems	45.7	36.9	40.6	35.7
	3 – extreme problems	1.5	0.6	1.2	1.4
Usual Activity	1 – no problems	6.5	16.8	26.5	25.0
	2 – some problems	71.4	75.4	65.3	67.9
	3 – extreme problems	22.1	7.8	8.2	7.1
Pain/ Discomfort	1 – no problems	0.5	15.6	20.0	19.3
	2 – some problems	47.7	80.4	74.7	70.0
	3 – extreme problems	51.8	3.9	5.3	10.7
Anxiety/ Depression	1 – no problems	41.7	63.1	68.2	62.9
	2 – some problems	50.3	35.8	30.0	32.9
	3 – extreme problems	8.0	1.1	1.8	4.3

Table 73: *EQ-VAS mean and median scores for Complex Surgery patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

EQ-VAS	**Pre-operative**	**6-months**	**12-months**	**24-months**
n	199	179	170	140
Mean (SD)	56.2 (20.0)	70.9 (18.0)	70.9 (18.9)	69.3 (20.1)
Median (IQR)	60.0 (40.0, 70.0)	71.0 (60.0, 85.0)	73.5 (60.0, 86.0)	71.0 (60.0, 85.0)

Figure 49: *EQ-VAS distribution for Complex Surgery patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

No Revision vs Revision subgroup analysis

Subgroup analysis was conducted on the complex surgery cohort looking at patients who had no prior surgery (non-revision group) versus prior surgery (revision group). Results are shown in Table 74 and Table 75.

Table 74: *ODI mean and median scores for (A) non-revised and (B) revised complex surgery patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

(A) Non-revised

ODI	Pre-operative	6-months	12-months	24-months
n	90	83	83	70
Mean (SD)	44.0 (16.1)	30.2 (16.9)	27.4 (18.0)	26.0 (17.9)
Median (IQR)	45.5 (32.0, 54.0)	29.0 (18.0, 42.0)	27.0 (13.0, 42.0)	27.0 (10.0, 38.0)

(B) Revised

ODI	Pre-operative	6-months	12-months	24-months
n	105	90	82	66
Mean (SD)	51.3 (14.8)	33.6 (18.1)	34.8 (17.4)	35.8 (20.9)
Median (IQR)	49.0 (40.0, 60.0)	31.5 (18.0, 49.0)	34.0 (20.0, 44.0)	32.0 (20.0, 52.0)

Table 75: *EQ-VAS mean and median scores for (A) non-revised and (B) revised complex surgery patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

(A) Non-revised

EQ-VAS	Pre-operative	6-months	12-months	24-months
n	92	87	87	72
Mean (SD)	55.8 (20.5)	69.4 (19.7)	72.3 (19.1)	71.9 (18.8)
Median (IQR)	57.5 (40.0, 70.0)	70.0 (60.0, 85.0)	75.0 (60.0, 90.0)	73.5 (61.0, 87.0)

(B) Revised

EQ-VAS	Pre-operative	6-months	12-months	24-months
n	107	92	83	68
Mean (SD)	56.5 (19.7)	72.3 (16.3)	69.4 (18.7)	66.5 (21.2)
Median (IQR)	60.0 (44.0, 70.0)	74.0 (60.5, 82.0)	73.0 (60.0, 84.0)	70.0 (53.0, 81.5)

Complex Surgery Deformity (CSD) Subgroup

This subgroup was identified as an important group within the complex surgery cohort. Whilst international data indicated a high and probably increasing prevalence of scoliosis in older individuals [33,34], there is a paucity of data in Australia. This highlights the value of the ASR data for the collection and analysis of this specific subgroup.

Adult spinal deformity (ASD) is an often debilitating condition with a disease burden comparable to severe chronic illnesses such as diabetes, heart failure, chronic lung disease and arthritis. Nonoperative management often produces limited improvement in health related quality of life (HRQOL), whereas surgery can produce significant HRQOL gains. This type of surgery however is often associated with significant risk of both spinal and general medical complications. With population ageing, high ASD prevalence and a growing expectation of independence in later life, surgical demand has risen sharply. This is consistent with changes in MBS spinal surgery item number usage. Consequently, ASD is increasingly viewed as a condition with the potential to reach epidemic proportions in aging societies[35].

This cohort of patients has been selected using all the following inclusion criteria:

Inclusions:

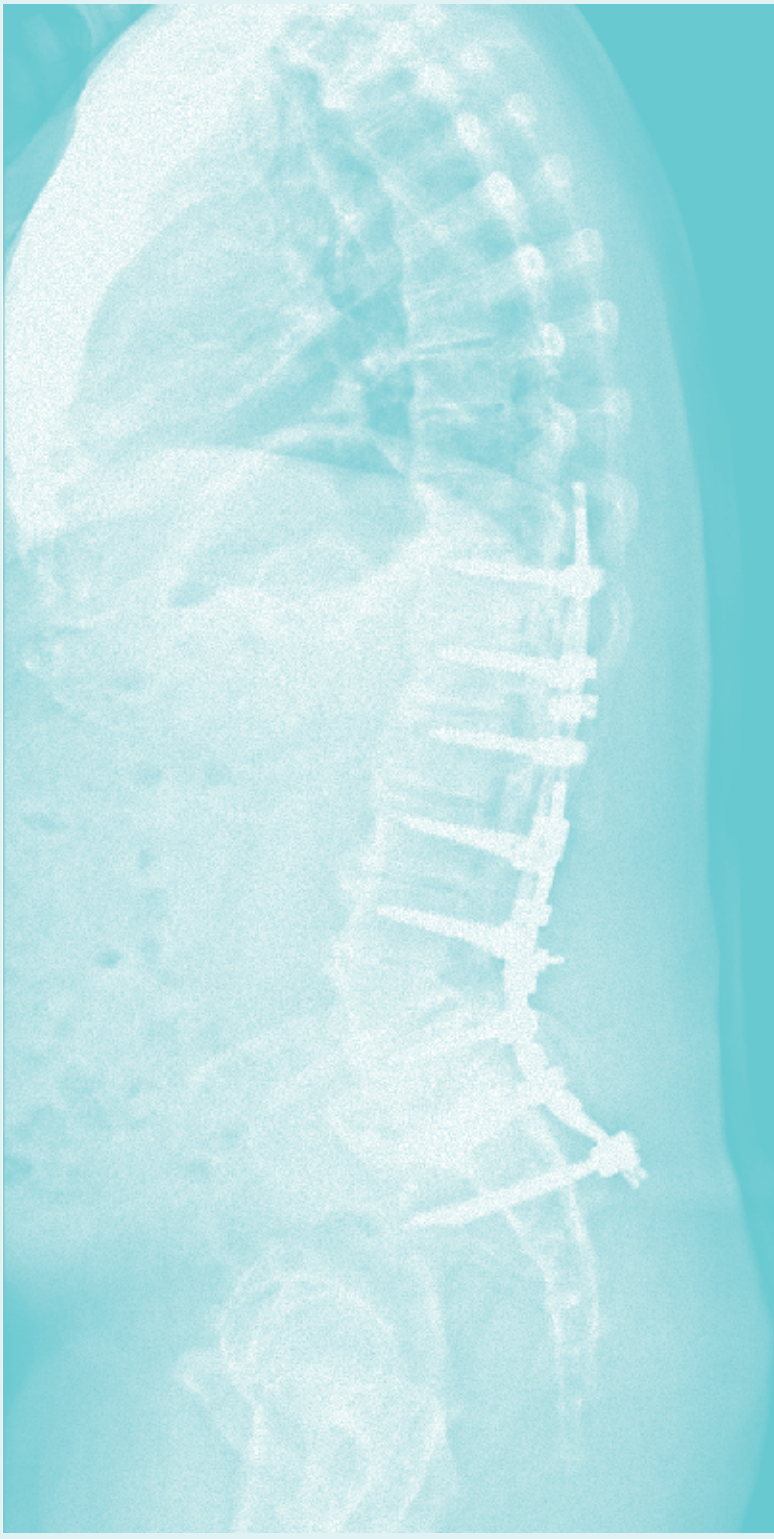
- Age ≥60 years at time of surgery
- Degenerative diagnosis
- Surgery ≥6 motion segments (7 contiguous vertebrae)
- Deformity diagnosis

Exclusions:

- Inflammation
- Infection
- Tumour

It is important to note that this cohort is not uniform by diagnosis or symptoms leading to some degree of cohort heterogeneity.

As of 31 December 2025, 121 patients met the Complex Surgery Deformity cohort inclusion criteria.



Images courtesy of Dr Michael Johnson

Demographics

121 patients met the inclusion criteria which represents 56% of complex surgery cohort. The median age for males was 68 years and 67 years for females. As indicated in Figure 50, the demographic distribution demonstrates a disproportionate number of females in comparison to that total ASR cohort. This patient group has the following characteristics:

- 50.4% of patients in this cohort received planned multi-stage surgery (Figure 51).
- 49.6% of the patients had previous spine surgery (Figure 52).
- 45.0% of patients had both anterior and posterior surgery (Figure 53).

Figure 50: *CSD patients by age and gender*

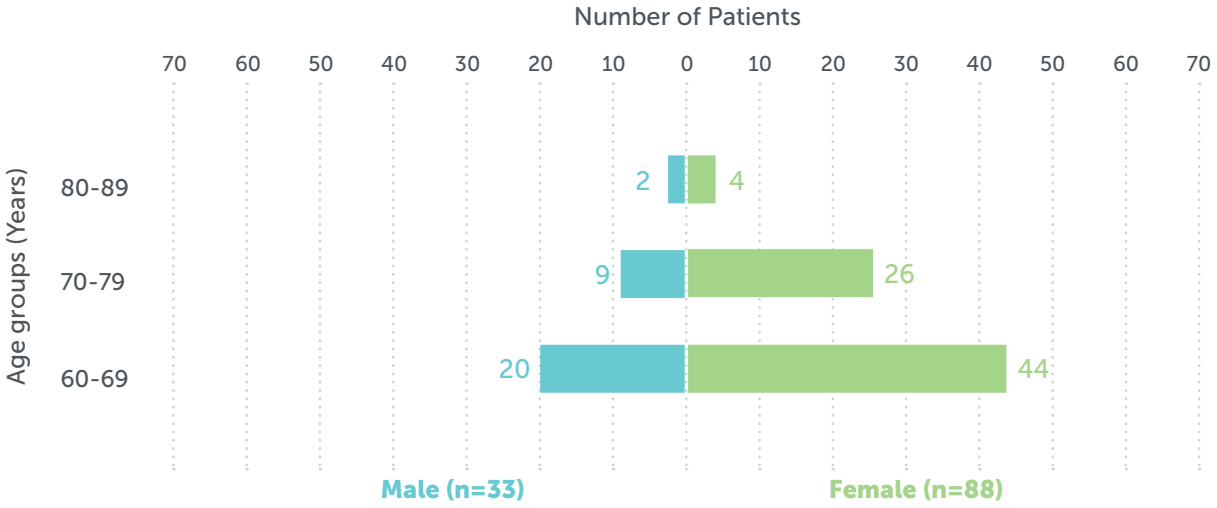
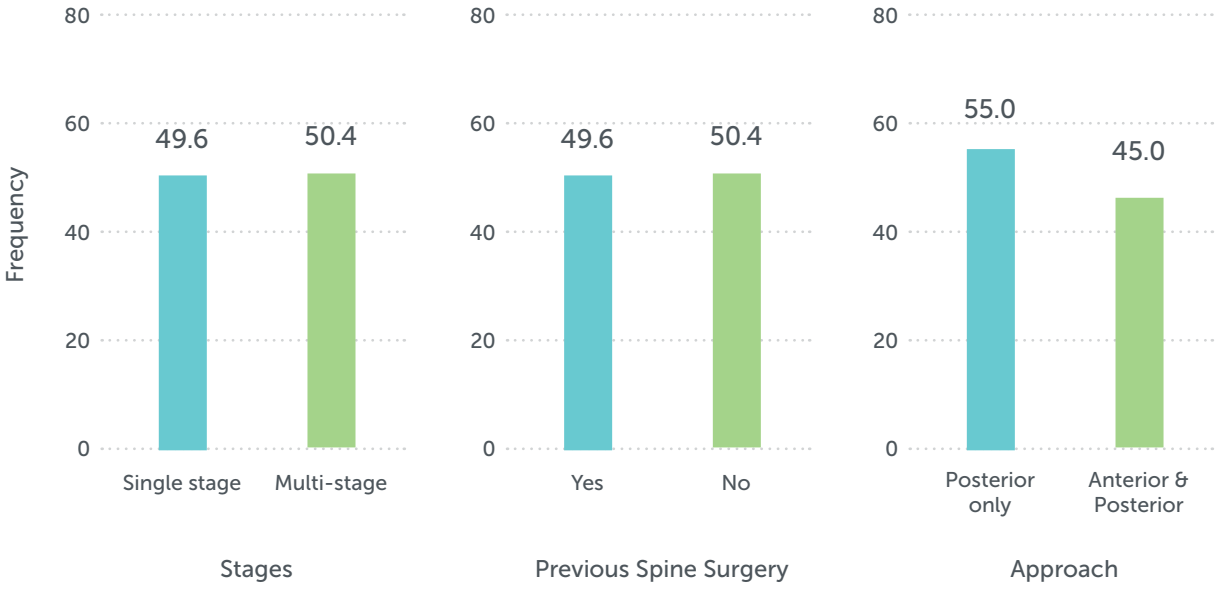


Figure 51: *Percentage of CSD patients who underwent multi-staged procedures (n=121)*

Figure 52: *Percentage of CSD patients who had previous spine surgery (n=121)*

Figure 53: *Surgical approach in CSD patients (n=120)*



Surgeon Reported Comorbidities and ASA

This surgical cohort suggests higher associated SRCs in comparison to the overall spine surgery population. Whilst there was a variability between SRCs and ASA score, this trend was consistent (Tables 76 - 78).

Table 76: *Number of CSD patients with any comorbidity prior to surgery compared to all patients*

Any comorbidity	All patients (n=6,679) n (%)	CSD patients (n=121) n (%)
Yes	2,497 (37.4%)	98 (81.0%)
No	4,182 (62.6%)	23 (19.0%)

Table 77: *Number of SRCs reported in CSD patients compared to all patients*

Number of reported comorbidities	All patients (n=6,679) n (%)	CSD patients (n=121) n (%)
None	4,182 (62.6%)	23 (19.0%)
1	1,131 (16.9%)	44 (36.4%)
2	724 (10s.8%)	29 (24.0%)
3	402 (6.0%)	16 (13.2%)
4	145 (2.2%)	5 (4.1%)
5+	95 (1.4%)	4 (3.3%)

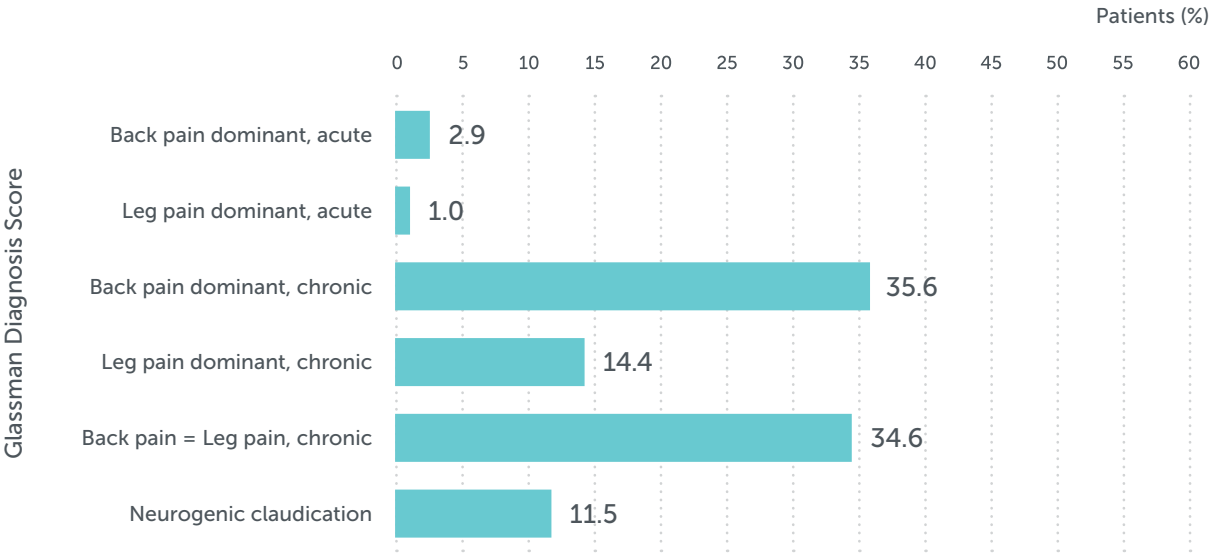
Table 78: *ASA score reported for CSD patients compared to all patients*

ASA Classification	All patients (n=3,393) n (%)	CSD patients (n=100) n (%)
1	712 (21.0%)	2 (2.0%)
2	1,542 (45.4%)	29 (29.0%)
3	1,096 (32.3%)	67 (67.0%)
4	43 (1.2%)	2 (2.0%)

Glassman Classification Scores

As indicated in Figure 54, these patients reported a combination of back and leg pain as their primary complaint prior to surgery.

Figure 54: *Glassman Score for 'Symptoms' among CSD patients (n=104)*



PROMs Analysis

The Oswestry Disability Index (ODI) and the EQ-5D-3L scores were analysed for the CSD cohort. As indicated previously, these results show unadjusted outcomes and must be interpreted with caution.

Oswestry Disability Index (ODI)

ODI median scores improved from 48.0 preoperatively to 30 at 6-months postoperatively with minimal improvement at 12 and 24 months (Table 79).

Figure 55 describes this in further detail.

Patients whose scores indicated severe disabled or worse (ODI score > 40) reduced from 66.3% preoperatively to 25.5% at 6 months, 32.0% at 12 months, and 29.2% at 24 months.

Table 79: *ODI mean and median scores for CSD patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	115	94	94	79
Mean (SD)	47.8 (16.8)	31.1 (16.5)	31.1 (17.2)	30.5 (20.1)
Median (IQR)	48.0 (38.0, 60.0)	29.5 (18.0, 42.0)	29.5 (16.0, 44.0)	29.0 (12.0, 46.0)

Figure 55: *ODI distribution for CSD patients who completed <u>any</u> ODI at pre-op, 6, 12 and 24-months post-op*

The ten ODI domains for the CSD patients that completed any questionnaires were analysed. Table 80 shows the mean number of ODI domain scores preoperatively and at 6, 12 and 24-months postoperatively. Mean scores across all ODI domains were lower at 6, 12 and 24-months postoperatively with pain and social life followed by standing showing the largest improvement.

Table 80: *ODI mean scores for each domain for CSD patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	115	94	94	79
Pain, mean (SD)	2.56 (1.04)	1.37 (0.94)	1.51 (0.88)	1.43 (1.07)
Personal Care, mean (SD)	1.47 (1.24)	0.88 (1.23)	1.05 (1.23)	0.97 (1.33)
Lifting, mean (SD)	2.97 (1.18)	2.70 (1.19)	2.48 (1.21)	2.35 (1.44)
Walking, mean (SD)	2.42 (1.28)	1.27 (1.26)	1.31 (1.37)	1.42 (1.36)
Sitting, mean (SD)	1.85 (1.00)	1.47 (0.92)	1.38 (0.96)	1.29 (0.85)
Standing, mean (SD)	3.17 (1.14)	1.74 (1.34)	1.81 (1.35)	2.00 (1.41)
Sleeping, mean (SD)	1.85 (1.08)	1.05 (0.90)	1.14 (0.89)	1.18 (1.01)
Sex Life*, mean (SD)	3.05 (1.85)	1.90 (1.98)	2.03 (2.01)	2.16 (1.99)
Social Life, mean (SD)	2.68 (1.15)	1.80 (1.31)	1.68 (1.31)	1.46 (1.39)
Traveling, mean (SD)	2.15 (1.32)	1.47 (1.27)	1.31 (1.12)	1.23 (1.26)

** Note: Sex life question is optional; lower numbers of 73, 52, 60 and 51 for each time-point, respectively).*

MCID was examined for the CSD patients (Tables 81 - 83). 61.3% exceeded the MCID for ODI at the 24-month time point (Table 83).

Table 81: *MCID for ODI from pre-op to 6-months post-op for CSD patients*

ODI*	All TL patients (n=3,074) n (%)	CSD patients (n=91) n (%)
Exceeding the MCID (Improved)	1,959 (63.7%)	53 (58.2%)
Within the MCID (Unchanged)	1,021 (33.2%)	37 (40.7%)
Exceeding the MCID (Worsened)	94 (3.1%)	1 (1.1%)

Table 82: *MCID for ODI from pre-op to 12-months post-op for CSD patients*

ODI*	All TL patients (n=2,829) n (%)	CSD patients (n=90) n (%)
Exceeding the MCID (Improved)	1,832 (64.8%)	52 (57.8%)
Within the MCID (Unchanged)	910 (32.2%)	36 (40.0%)
Exceeding the MCID (Worsened)	87 (3.1%)	2 (2.2%)

Table 83: *MCID for ODI from pre-op to 24-months post-op for CSD patients*

ODI*	All TL patients (n=2,187) n (%)	CSD patients (n=75) n (%)
Exceeding the MCID (Improved)	1,417 (64.8%)	46 (61.3%)
Within the MCID (Unchanged)	697 (31.9%)	27 (36.0%)
Exceeding the MCID (Worsened)	73 (3.3%)	2 (2.7%)

**Only patients that have completed both timepoint questionnaires are included.*

EQ-5D-3L Quality of Life

The CSD cohort EQ-5D-3L dimension scores, and the EQ-VAS were analysed.

Examination of the EQ-5D responses indicate general patient improvement across most domains. For example, for the mobility domain, 91.3% of patients reported some or extreme problems with mobility preoperatively. At 6, 12 and 24 months approximately 35.0% of patients indicated that they had no problem with their mobility (Table 84).

Table 84: *EQ-5D-3L scores for each domain for CSD patients at pre-op, 6, 12 and 24-months post-op*

		CSD Patients EQ-5D-3L			
Domain	**Level of problem**	**Pre-op (%) n=115**	**6 months (%) n=95**	**12 months (%) n=95**	**24 months (%) n=80**
Mobility	1 – no problems	8.7	37.9	33.7	35.0
	2 – some problems	87.8	61.1	65.3	62.5
	3 – extreme problems	3.5	1.1	1.1	2.5
Self-Care	1 – no problems	55.7	61.1	54.7	61.3
	2 – some problems	43.5	38.9	45.3	36.3
	3 – extreme problems	0.9	0.0	0.0	2.5
Usual Activity	1 – no problems	7.0	16.8	27.4	25.0
	2 – some problems	70.4	75.8	66.3	65.0
	3 – extreme problems	22.6	7.4	6.3	10.0
Pain/ Discomfort	1 – no problems	0.9	13.7	14.7	15.0
	2 – some problems	49.6	83.2	81.1	75.0
	3 – extreme problems	49.6	3.2	4.2	10.0
Anxiety/ Depression	1 – no problems	44.3	65.3	67.4	65.0
	2 – some problems	45.2	32.6	30.5	31.2
	3 – extreme problems	10.4	2.1	2.1	3.8

When examining EQ-VAS a shift to the right indicates an improvement of patient perception of their general health status. As shown in Table 85 and in Figure 56, this cohort showed moderate improvement in their general perception of their health 6, 12 and 24-months postoperatively.

Table 85: *EQ-VAS mean and median scores for CSD patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

EQ-VAS	**Pre-operative**	**6-months**	**12-months**	**24-months**
n	115	95	95	80
Mean (SD)	57.0 (17.9)	72.6 (16.6)	69.9 (18.2)	68.7 (19.8)
Median (IQR)	60.0 (44.0, 70.0)	74.0 (61.0, 85.0)	72.0 (60.0, 84.0)	70.5 (58.5, 85.0)

Figure 56: *EQ-VAS mean and median scores for CSD patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

No Revision vs Revision subgroup analysis

Sub-group analysis was conducted on the CSD cohort looking at patients who had no prior surgery (non-revision group) versus prior surgery (revision group). Results are shown in Table 86 and Table 87.

Table 86: *ODI mean and median scores for (A) non-revised and (B) revised CSD patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

(A) Non-revised

ODI	Pre-operative	6-months	12-months	24-months
n	59	51	52	42
Mean (SD)	43.7 (17.1)	29.2 (15.2)	27.0 (16.2)	25.3 (17.2)
Median (IQR)	47.0 (32.0, 54.0)	27.0 (18.0, 40.0)	25.5 (16.0, 42.0)	27.0 (10.0, 36.0)

(B) Revised

ODI	Pre-operative	6-months	12-months	24-months
n	56	43	42	37
Mean (SD)	52.0 (15.4)	33.2 (17.9)	36.2 (17.3)	36.4 (21.7)
Median (IQR)	50.0 (40.0, 62.0)	31.0 (18.0, 48.0)	36.0 (26.0, 46.0)	33.0 (20.0, 51.0)

Table 87: *EQ-VAS mean and median scores for (A) non-revised and (B) revised CSD patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

(A) Non-revised

EQ-VAS	Pre-operative	6-months	12-months	24-months
n	59	52	53	43
Mean (SD)	56.0 (18.0)	70.9 (16.6)	71.7 (18.5)	70.7 (18.2)
Median (IQR)	55.0 (40.0, 70.0)	70.5 (60.0, 85.0)	75.0 (60.0, 88.0)	71.0 (60.0, 85.0)

(B) Revised

EQ-VAS	Pre-operative	6-months	12-months	24-months
n	56	43	42	37
Mean (SD)	58.0 (17.8)	74.7 (16.5)	67.6 (17.9)	66.4 (21.6)
Median (IQR)	60.0 (45.0, 70.0)	78.0 (69.0, 85.0)	70.0 (55.0, 80.0)	70.0 (52.0, 85.0)

1-2 Level Anterior Interbody Fusion (1-2 ALIF)

Anterior Lumbar Interbody Fusion (ALIF) is one of the methods of performing lumbar spinal fusion. The procedure involves approaching the spine from the front of the body through an incision on the anterior wall of the abdomen.The surgeon then accesses the spine through the abdomen. This is usually done by mobilizing the intact peritoneal sac, although on occasions it may be necessary to do the exposure through the peritoneal sac. To see the disc, the surgeon must mobilise the large vessels on the front of the spine. Once this is done, most of the disc material can be removed with effective cleaning of the vertebral end plates. Once completed, bone graft, usually within a fusion cage is inserted and secured.

This operation has several advantages:

- Direct access to the front of the spine,
- Minimal disruption to back muscles,
- Better visualisation of the disc space,
- Potential for disc height and spinal curvature correction,
- Lower infection rate (as compared to posterior surgery).

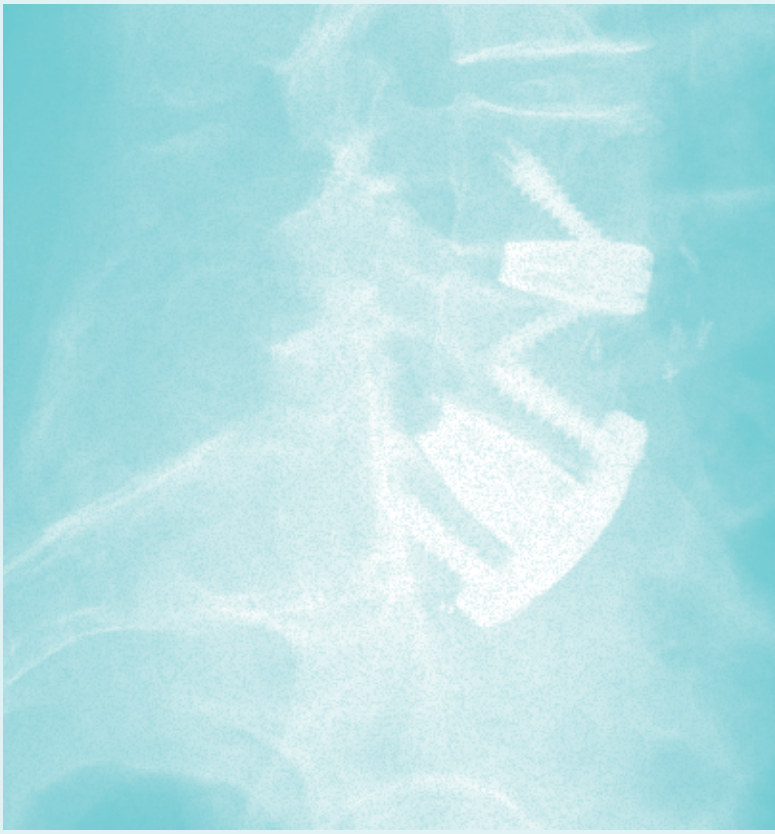
For analysis, the 1-2 ALIF cohort patients were selected based on the following criteria:

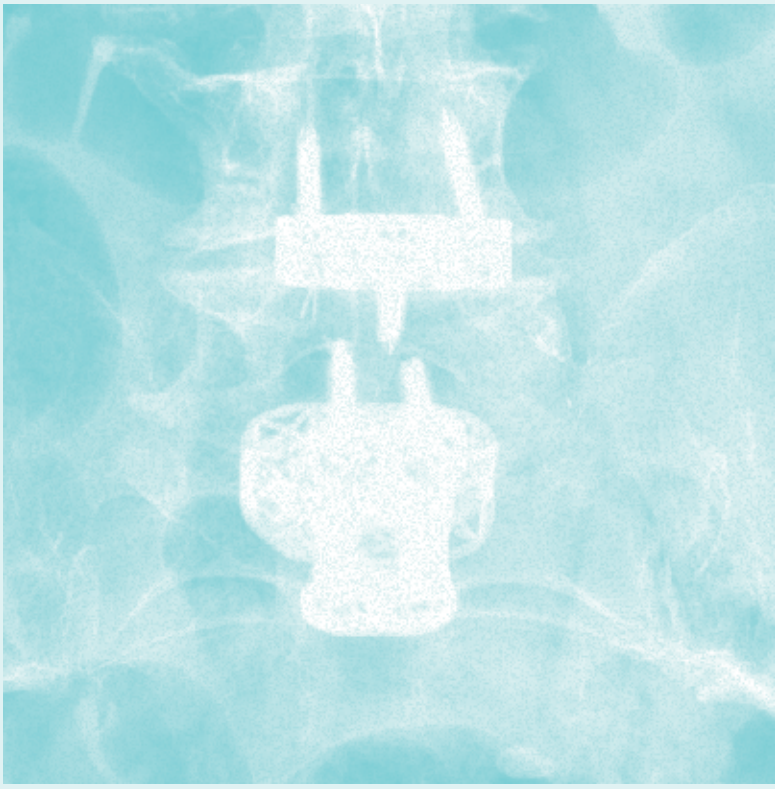
ALIF inclusion criteria (single procedure anterior fusion)

- All ages
- Surgery type: anterior lumbar fusion
- Number of levels: ≤2
- Lumbar region: L3 - S1 levels only

Exclusion criteria:

- The surgery was staged
- They had posterior surgery
- Decompression
- Scoliosis
- Inflammation
- Infection
- Tumour





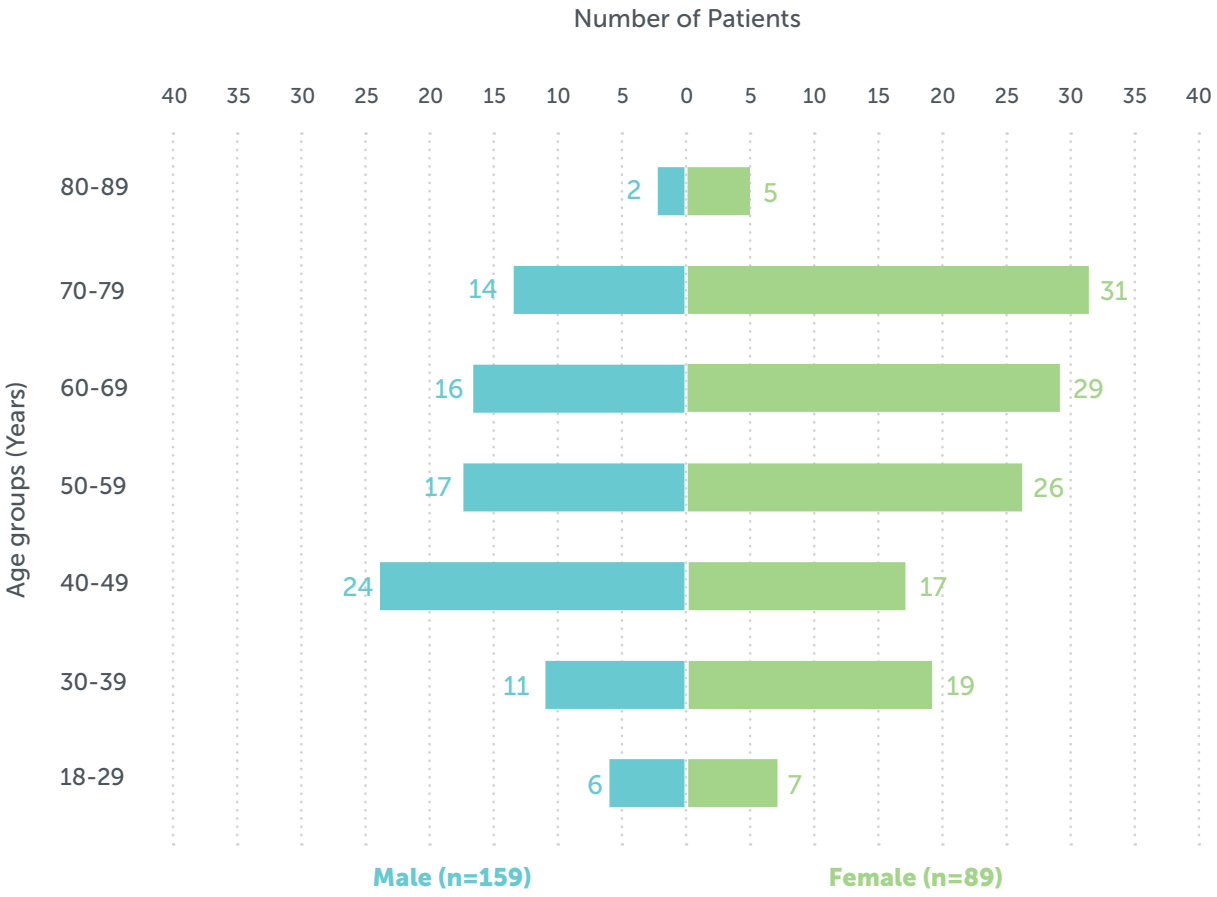
Images courtesy of Dr Radek Kindl

Demographics

248 patients met the 1-2 ALIF cohort inclusion criteria which represents 4.6% of patients undergoing thoracolumbar procedures.

The ALIF procedure was performed predominately on male patients. There were 159 males (64%) and 89 females (36%) in this group as shown in Figure 57. The median age were 49 years for both males and females, which is younger than the median patient age from the total ASR patient cohort (62 years for males and 65 years for females).

Figure 57: *1-2 ALIF procedures by patient age and gender*



Surgeon Reported Comorbidities and ASA

The number of patients that were reported with a comorbidity is shown in Table 88 below. Examination of SRCs in this group identified that 1-2 ALIF patients had approximately the same frequency of comorbidities when compared to all patients in the registry. 38.6% of 1-2 ALIF patients were reported to have at least one comorbidity; 37.4% of the entire registry patient population were reported to have at least one comorbidity. Patients were further categorised into groups by the number of SRCs reported (Table 89).

Table 88: *Number of 1-2 ALIF patients diagnosed with any comorbidity prior to surgery compared to all patients*

Any reported comorbidity	All patients (n=6,679) n (%)	1-2 ALIF patients (n=249) n (%)
Yes	2,497 (37.4%)	96 (38.6%)
No	4,182 (62.6%)	153 (61.4%)

Table 89: *Number of SRCs reported in 1-2 ALIF patients compared to all patients*

Number of reported comorbidities	All patients (n=6,679) n (%)	1-2 ALIF patients (n=249) n (%)
None	4,182 (62.6%)	153 (61.4%)
1	1,131 (16.9%)	65 (26.1%)
2	724 (10s.8%)	22 (8.8%)
3	402 (6.0%)	8 (3.2%)
4	145 (2.2%)	1 (0.4%)
5+	95 (1.4%)	0 (0.0%)

72.3% of 1-2 ALIF patients had ASA data recorded. When ASA scores were examined, 20.6 % of patients were scored with an ASA of 1 indicating that these patients were 'normal', healthy patients without acute or chronic disease, overweight or obesity. An additional 59.4% of patients had mild disease without significant limitations. 20.0% of patients had severe disease (Table 90).

Table 90: *ASA score reported for 1-2 ALIF patients compared to all ASR patients*

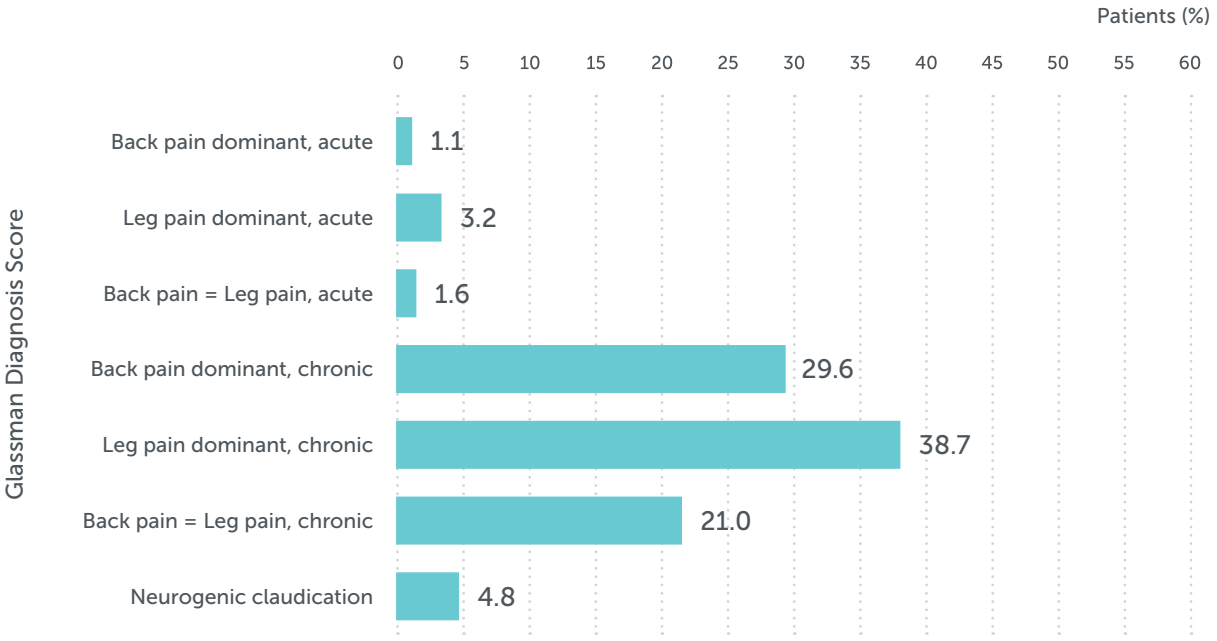
ASA Classification	All patients (n=3,393) n (%)	1-2 ALIF patients (n=180) n (%)
1	712 (21.0%)	37 (20.6%)
2	1,542 (45.4%)	107 (59.4%)
3	1,096 (32.3%)	36 (20.0%)
4	43 (1.2%)	0 (0.0%)

Glassman Classification Scores

Glassman scores were reported in 75.0% of the 1-2 ALIF cohort.

Chronic back pain and chronic leg pain were the most reported symptoms by these patients. Acute back pain and neurogenic claudication was infrequently reported (Figure 58).

Figure 58: *Glassman Score for 'Symptoms' among 1-2 ALIF patients (n=186)*



PROMs Analysis

The Oswestry Disability Index (ODI) and the EQ-5D-3L scores were evaluated for the 1-2 ALIF cohort preoperatively and at 6-months, 12-months and 24-months postoperatively.

It must be noted that these results show unadjusted outcomes and must be interpreted with caution.

Adjustments for known predictors of outcomes after this form of spine surgery such as underlying diagnosis, age, sex and severity of a patient's condition at baseline have not been performed at the time of this publication and may account for some of the differences seen in the figures presented below.

Oswestry Disability Index (ODI)

A lower ODI score indicates improved relief in pain and disability (Table 6)[21]. ODI mean, median and overall scores for any questionnaires completed at each time point are shown in Table 91 and Figure 59 respectively. As shown in Table 91 median ODI scores improved from 44 preoperatively to 20 at 6-months postoperatively and showed a further decrease to 12 by 24 months.

Table 91: *ODI mean and median scores for 1-2 ALIF patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	212	176	158	117
Mean (SD)	42.8 (15.7)	24.2 (19.6)	21.3 (18.2)	19.3 (19.2)
Median (IQR)	44.0 (31.0, 54.0)	20.0 (8.0, 35.0)	18.0 (6.0, 32.0)	12.0 (4.0, 28.0)

Figure 59 shows that for the 1-2 ALIF cohort there is a shift to the left (lower scores) in the overall ODI from 44 preoperatively to 20 at the 6-month follow up time point. This was maintained at both 12 and 24 months.

1-2 ALIF patients whose scores indicated severe disabled or worse (ODI score > 40) reduced from 57.9% preoperatively to 17.6% at 6 months, 14.6% at 12 months, and 15.4% at 24 months.

Figure 59: *ODI distribution for 1-2 ALIF patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

Analysis of the ten ODI domains for the 1-2 ALIF patient cohort is shown in Table 92.

Mean scores across all domains were lower at 6, 12 and 24-months postoperatively compared to preoperatively. A lower ODI score indicates an improvement for that domain. The domains of the ODI indicated all aspects of life are improved by the surgery.

Table 92: *ODI mean scores for each domain for 1-2 ALIF patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	212	176	158	117
Pain, mean (SD)	2.46 (0.85)	1.27 (1.09)	1.10 (0.99)	1.03 (1.02)
Personal Care, mean (SD)	1.32 (1.06)	0.62 (1.07)	0.47 (0.94)	0.43 (0.94)
Lifting, mean (SD)	2.67 (1.22)	1.95 (1.53)	1.63 (1.40)	1.44 (1.43)
Walking, mean (SD)	1.31 (1.07)	0.51 (0.93)	0.42 (0.70)	0.39 (0.73)
Sitting, mean (SD)	2.33 (1.14)	1.53 (1.16)	1.45 (1.13)	1.30 (1.09)
Standing, mean (SD)	2.64 (1.22)	1.38 (1.25)	1.25 (1.19)	1.14 (1.16)
Sleeping, mean (SD)	1.93 (0.98)	1.09 (1.00)	1.02 (0.99)	0.99 (0.96)
Sex Life*, mean (SD)	2.09 (1.53)	1.19 (1.46)	0.96 (1.36)	0.90 (1.38)
Social Life, mean (SD)	2.52 (1.10)	1.35 (1.35)	1.20 (1.29)	1.07 (1.30)
Traveling, mean (SD)	2.14 (1.23)	1.19 (1.17)	1.09 (1.10)	0.96 (1.11)

** Note: Sex life question is optional; lower numbers of 196, 158, 140 and 105 (for each time-point, respectively).*

The MCID value of 12.8 for ODI[25] was used to define MCID for this patient cohort.

By 24-months postoperatively, 82.4% of patients undergoing a 1-2 level ALIF exceeded this MCID (improved), as shown by ODI scores (Tables 93 - 95).

Table 93: *MCID for ODI from pre-op to 6-months post-op for 1-2 ALIF patients*

ODI*	All TL patients (n=3,074) n (%)	1-2 ALIF patients (n=154) n (%)
Exceeding the MCID (Improved)	1,959 (63.7%)	98 (63.6%)
Within the MCID (Unchanged)	1,021 (33.2%)	52 (33.8%)
Exceeding the MCID (Worsened)	94 (3.1%)	4 (2.6%)

Table 94: *MCID for ODI from pre-op to 12-months post-op for 1-2 ALIF patients*

ODI*	All TL patients (n=2,829) n (%)	1-2 ALIF patients (n=137) n (%)
Exceeding the MCID (Improved)	1,832 (64.8%)	102 (73.9%)
Within the MCID (Unchanged)	910 (32.2%)	36 (26.1%)
Exceeding the MCID (Worsened)	87 (3.1%)	0 (0.0%)

Table 95: *MCID for ODI from pre-op to 24-months post-op for 1-2 ALIF patients*

ODI*	All TL patients (n=2,188) n (%)	1-2 ALIF patients (n=102) n (%)
Exceeding the MCID (Improved)	1,417 (64.8%)	84 (82.4%)
Within the MCID (Unchanged)	697 (31.9%)	17 (16.7%)
Exceeding the MCID (Worsened)	73 (3.3%)	1 (1.0%)

**Only patients that have completed both timepoint questionnaires are included.*

EQ-5D-3L Quality of Life

The 1-2 ALIF cohort EQ-5D-3L dimension scores and the EQ-VAS were analysed (Table 96). It is important to note that this group of patients have multifactorial health issues, and it is not unexpected to have a wide treatment effect. In addition, this questionnaire asks about any pain, not specific pain.

Examination of the EQ-5D responses indicate general patient improvement across 4 out of 5 domains (Table 96).

Table 96: *EQ-5D-3L scores for each domain for 1-2 ALIF patients at pre-op, 6, 12 and 24-months post-op*

1-2 ALIF Patients EQ-5D-3L					
Domain	**Level of problem**	**Pre-op (%) n=215**	**6-months (%) n=176**	**12-months (%) n=158**	**24-months (%) n=117**
Mobility	1 – no problems	22.8	63.6	69.6	72.6
	2 – some problems	76.7	36.4	30.4	27.4
	3 – extreme problems	0.5	0.0	0.0	0.0
Self-Care	1 – no problems	56.7	79.0	78.5	80.3
	2 – some problems	42.8	20.5	21.5	19.7
	3 – extreme problems	0.5	0.6	0.0	0.0
Usual Activity	1 – no problems	6.0	33.0	47.5	52.1
	2 – some problems	75.3	56.2	44.9	41.0
	3 – extreme problems	18.6	10.8	7.6	6.8
Pain/ Discomfort	1 – no problems	1.4	28.4	34.8	39.3
	2 – some problems	58.1	66.5	57.6	53.8
	3 – extreme problems	40.5	5.1	7.6	6.8
Anxiety/ Depression	1 – no problems	38.6	59.1	62.7	68.4
	2 – some problems	52.6	30.7	31.0	26.5
	3 – extreme problems	8.8	10.2	6.3	5.1

When examining EQ-VAS, a shift to the right indicates an improvement of patient perception of their general health status. As shown in Table 97 and in Figure 60, this cohort showed improvement in their general perception of their health 6, 12 and 24-months postoperatively.

Table 97: *EQ-VAS mean and median scores for 1-2 ALIF patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

EQ-VAS	**Pre-operative**	**6-months**	**12-months**	**24-months**
n	215	176	158	117
Mean (SD)	56.3 (19.3)	71.2 (19.3)	74.0 (18.9)	75.8 (19.8)
Median (IQR)	60.0 (40.0, 70.0)	75.0 (64.5, 85.0)	75.5 (64.0, 90.0)	80.0 (66.0, 90.0)

Figure 60: *EQ-VAS distribution for 1-2 ALIF patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

Back Pain Dominant Cohort (BPD)

Lower back pain is common especially as people age. Non-surgical measures, such as exercise and weight loss, are first-line treatment for most people[6]. However, surgery has a role in treating a carefully selected small number of people with certain degenerative conditions.

Demographics

224 patients met the BPD inclusion criteria which represents 4.1% of patients undergoing thoracolumbar procedures. The BPD cohort included predominately of female patients. There were 90 males (36%) and 134 females (64%) in this group as shown in Figure 61. The median age for males was 52 years and females was 59 years, which is younger than the median patient age from the total ASR patient cohort (62 years for males and 65 years for females).

It is important to note that the BPD group is heterogeneous both in the surgical diagnosis and the surgery performed.

Figure 61: *BPD cohort by patient age and gender*

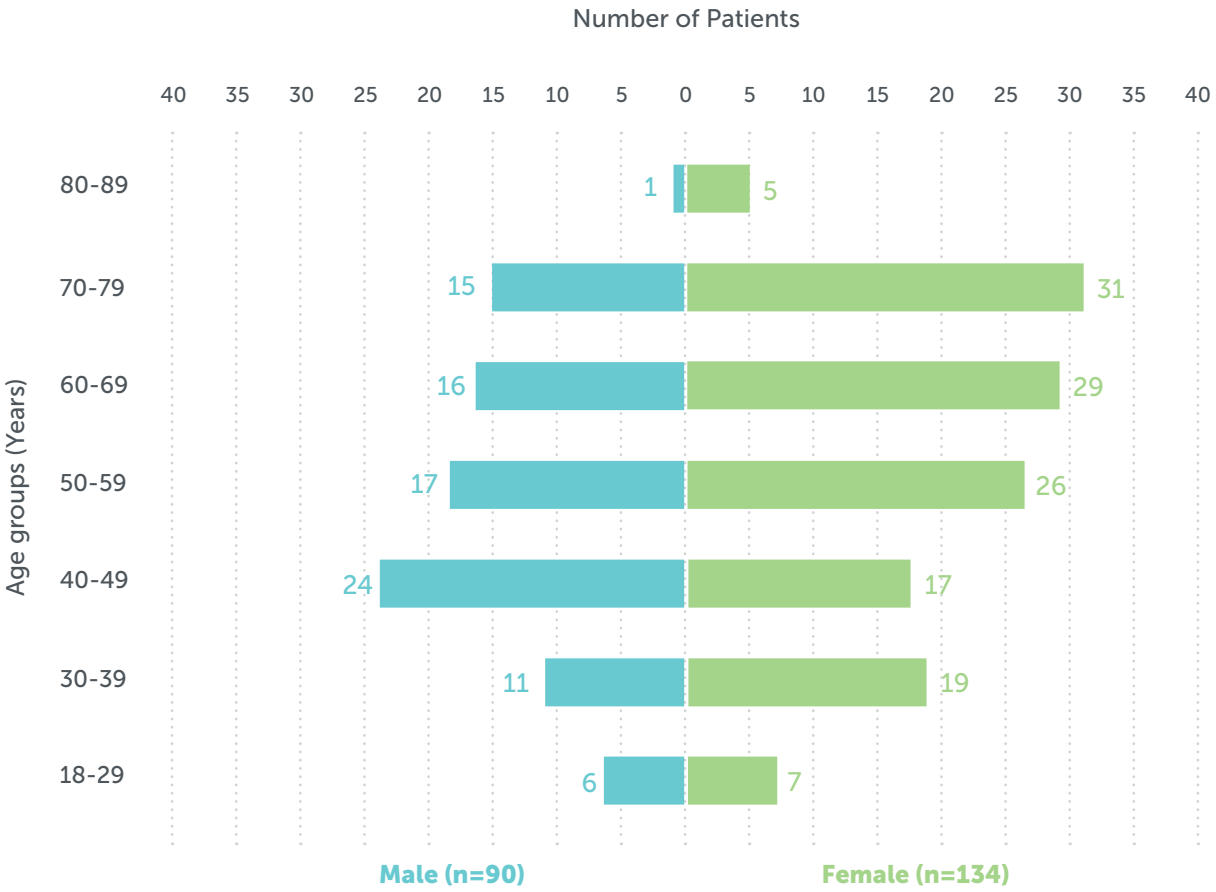


Figure 62: *Frequency of number of surgical motion segments in BPD patients*

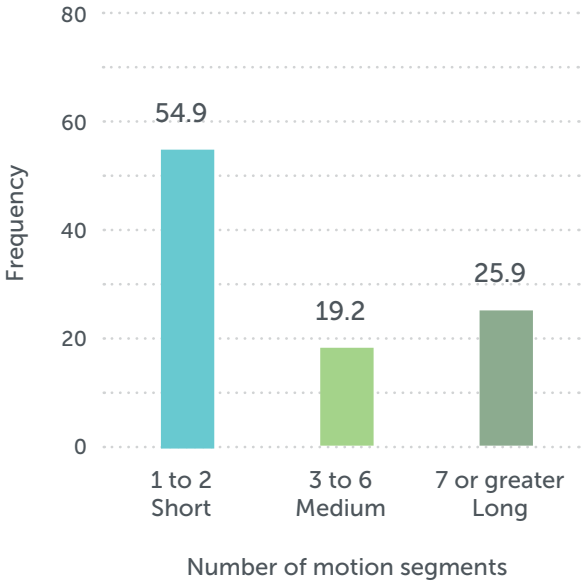


Figure 63: *Frequency of surgical approaches in BPD patients*

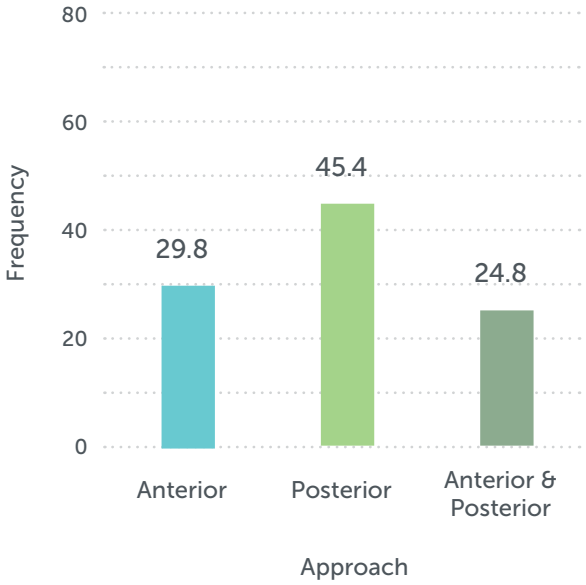


Table 98: *Reported diagnoses in BPD patients*

Diagnosis category	Short fusion	Medium fusion	Long fusion
n	106	37	50
Revision surgery	32 (30.2%)	21 (56.8%)	25 (50.0%)
Degenerative disease	86 (81.1%)	15 (40.5%)	19 (38.0%)
Neurology	23 (21.7%)	5 (13.5%)	4 (8.0%)
Deformity	9 (8.5%)	22 (59.5%)	39 (78.0%)
Spondylolisthesis	21 (19.8%)	7 (18.9%)	4 (8.0%)
Inflammation	0 (0.0%)	0 (0.0%)	0 (0.0%)
Infection	0 (0.0%)	0 (0.0%)	0 (0.0%)
Tumour	1 (0.9%)	0 (0.0%)	1 (2.0%)

Surgeon Reported Comorbidities and ASA

The number of patients that were reported with a comorbidity is shown in Table 99 below.

Examination of SRCs in this group identified that BPD patients had approximately the same frequency of comorbidities when compared to all patients in the registry. 55.4% of BDP patients were reported to have at least one comorbidity; 37.4% of the entire registry patient population were reported to have at least one comorbidity. Patients were further categorised into groups by the number of SRCs reported (Table 100).

Table 99: *Number of BPD patients diagnosed with any comorbidity prior to surgery compared to all patients*

Any comorbidity	All patients (n=6,679) n (%)	BPD patients (n=224) n (%)
Yes	2,497 (37.4%)	124 (55.4%)
No	4,182 (62.6%)	100 (44.6%)

Table 100: *Number of SRCs reported in BPD patients compared to all patients*

Number of reported comorbidities	All patients (n=6,679) n (%)	BPD patients (n=224) n (%)
None	4,182 (62.6%)	100 (44.6%)
1	1,131 (16.9%)	67 (29.9%)
2	724 (10.8%)	30 (13.4%)
3	402 (6.0%)	15 (6.7%)
4	145 (2.2%)	8 (3.6%)
5+	95 (1.4%)	4 (1.8%)

81.3% of BPD patients had ASA data recorded. When ASA scores were examined, 20.9 % of patients were scored with an ASA of 1 indicating that these patients were 'normal', healthy patients without acute or chronic disease, overweight or obesity. An additional 48.9% of patients had mild disease without significant limitations. 29.7% of patients had severe disease (Table 101).

Table 101: *ASA score reported for BPD patients compared to all patients*

ASA Classification	All patients (n=3,393) n (%)	BPD patients (n=182) n (%)
1	712 (21.0%)	38 (20.9%)
2	1,542 (45.4%)	89 (48.9%)
3	1,096 (32.3%)	54 (29.7%)
4	43 (1.2%)	1 (0.5%)

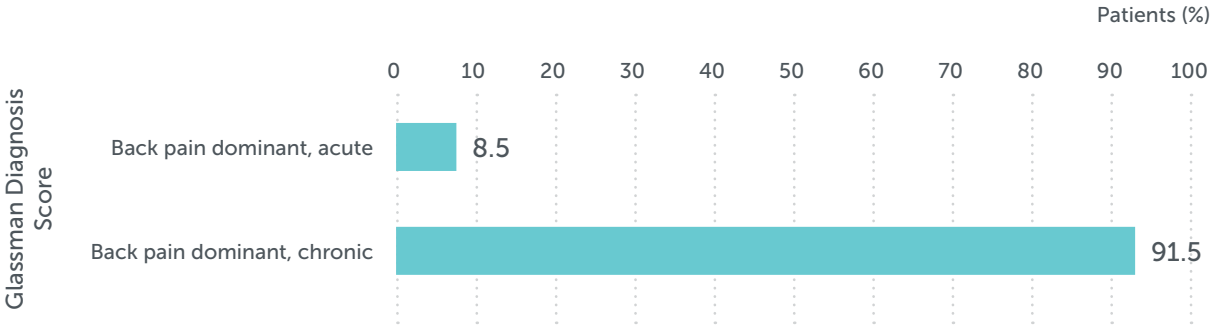
Glassman Classification Scores

The ASR has used the Glassman Index which is based on 3 parameters: Clinical symptoms, structural pathology and compressive pathology for the lumbar spine. Using the Clinical Symptoms parameter, it has identified patients with a dominant complaint of lower back pain (Figure 64).

It should be emphasised that the primary common factor in this cohort is the presence of dominant lower back pain. There is considerable heterogeneity in this group based on demographics, diagnosis and surgery. This heterogeneity means that further analysis will need to be undertaken in the future to identify specific patient sub cohorts where surgical treatment may be an appropriate. It should also be noted that the numbers in this cohort are relatively small, suggestive of a caution by surgeons in recommending surgical treatment in this group.

The data collected to date suggests that the back pain of a small, selected group of patients benefits from surgical intervention (Table 102, Figure 65).

Figure 64: *BPD Glassman Score (n=224)*



PROMs Analysis

The Oswestry Disability Index (ODI) and the EQ-5D-3L scores were evaluated for the BPDF cohort preoperatively and at 6-months, 12-months and 24-months postoperatively.

It must be noted that these results show unadjusted outcomes and must be interpreted with caution.

Adjustments for known predictors of outcomes after spine surgery such as age, sex and severity of a patient's condition at baseline have not been performed at the time of this publication and may account for some of the differences seen in the figures presented below.

Oswestry Disability Index (ODI)

A lower ODI score indicates improved relief in pain and disability (Table 6)[21]. ODI mean, median and overall scores for any questionnaires completed at each time point are shown in Table 102 and Figure 65 respectively. As shown in Table 102 median ODI scores improved from 44 preoperatively to 20 at 6-months postoperatively and showed a further decrease to 12 by 24 months.

Table 102: *ODI mean and median scores for BPD patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	203	176	161	127
Mean (SD)	45.6 (15.6)	29.7 (18.1)	28.4 (17.9)	25.6 (19.4)
Median (IQR)	46.0 (33.0, 56.0)	27.5 (14.0, 42.0)	27.0 (14.0, 42.0)	22.0 (11.0, 38.0)

Figure 65 shows that for the BPD cohort there is a shift to the left (lower scores) in the overall ODI from 44 preoperatively to 20 at the 6-month follow up time point. This was maintained at both 12 and 24 months.

BPD patients whose scores indicated severe disabled or worse (ODI score > 40) reduced from 57.9% preoperatively to 17.6% at 6 months, 14.6% at 12 months, and 15.4% at 24 months.

Figure 65: *ODI distribution for BPD patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

Analysis of the ten ODI domains for the BPD patient cohort is shown in Table 103.

Mean scores across all domains were lower at 6, 12 and 24-months postoperatively compared to preoperatively. A lower ODI score indicates an improvement for that domain. The domains of the ODI indicated all aspects of life are improved by the surgery.

Table 103: *ODI mean scores for each domain for BPD patients who completed any ODI at pre-op, 6, 12 and 24-months post-op*

ODI	Pre-operative	6-months	12-months	24-months
n	203	176	161	127
Pain, mean (SD)	2.63 (0.83)	1.41 (1.02)	1.43 (1.09)	1.24 (1.04)
Personal Care, mean (SD)	1.36 (1.06)	0.77 (1.15)	0.74 (1.08)	0.63 (1.17)
Lifting, mean (SD)	2.73 (1.23)	2.43 (1.42)	2.16 (1.38)	1.91 (1.47)
Walking, mean (SD)	1.68 (1.21)	0.97 (1.22)	0.88 (1.18)	0.94 (1.31)
Sitting, mean (SD)	2.28 (1.07)	1.70 (1.09)	1.72 (1.09)	1.39 (1.00)
Standing, mean (SD)	2.73 (1.15)	1.79 (1.34)	1.76 (1.32)	1.69 (1.43)
Sleeping, mean (SD)	1.96 (1.03)	1.06 (0.92)	1.12 (0.99)	1.01 (0.84)
Sex Life*, mean (SD)	2.51 (1.70)	1.52 (1.63)	1.46 (1.71)	1.33 (1.74)
Social Life, mean (SD)	2.70 (1.10)	1.70 (1.30)	1.49 (1.36)	1.38 (1.44)
Traveling, mean (SD)	2.26 (1.21)	1.46 (1.21)	1.36 (1.07)	1.24 (1.18)

** Note: Sex life question is optional; lower numbers of 165, 134, 124 and 97 (for each time-point, respectively).*

The MCID value of 12.8 for ODI[25] was used to define MCID for this patient cohort.

By 24-months postoperatively, 64.2% of BPD patients exceeded this MCID (improved), as shown by ODI scores (Tables 104 - 106).

Table 104: *MCID for ODI from pre-op to 6-months post-op for BPD patients*

ODI*	All TL patients (n=3,074) n (%)	BPD patients (n=164) n (%)
Exceeding the MCID (Improved)	1,959 (63.7%)	99 (60.4%)
Within the MCID (Unchanged)	1,021 (33.2%)	58 (35.4%)
Exceeding the MCID (Worsened)	94 (3.1%)	7 (4.3%)

Table 105: *MCID for ODI from pre-op to 12-months post-op for BPD patients*

ODI*	All TL patients (n=2,829) n (%)	BPD patients (n=164) n (%)
Exceeding the MCID (Improved)	1,832 (64.8%)	89 (59.7%)
Within the MCID (Unchanged)	910 (32.2%)	58 (38.9%)
Exceeding the MCID (Worsened)	87 (3.1%)	2 (1.3%)

Table 106: *MCID for ODI from pre-op to 24-months post-op for BPD patients*

ODI*	All TL patients (n=2,187) n (%)	BPD patients (n=164) n (%)
Exceeding the MCID (Improved)	1,417 (64.8%)	77 (64.2%)
Within the MCID (Unchanged)	697 (31.9%)	39 (32.5%)
Exceeding the MCID (Worsened)	73 (3.3%)	4 (3.3%)

**Only patients that have completed both timepoint questionnaires are included.*

EQ-5D-3L Quality of Life

The BDP cohort EQ-5D-3L dimension scores and the EQ-VAS were analysed (Table 107, Figure 66). It is important to note that this group of patients have multifactorial health issues, and it is not unexpected to have a wide treatment effect. In addition, this questionnaire asks about any pain, not specific pain.

Examination of the EQ-5D responses indicate general patient improvement across 4 out of 5 domains (Table 107).

Table 107: *EQ-5D-3L scores for each domain for BPD patients at pre-op, 6, 12 and 24-months post-op*

		BPD Patients EQ-5D-3L			
Domain	**Level of problem**	**Pre-op (%) n=204**	**6-months (%) n=177**	**12-months (%) n=161**	**24-months (%) n=127**
Mobility	1 – no problems	17.6	49.7	57.1	59.8
	2 – some problems	81.4	50.3	42.2	39.4
	3 – extreme problems	1.0	0.0	0.6	0.8
Self-Care	1 – no problems	58.3	72.3	72.7	71.7
	2 – some problems	40.7	27.1	26.7	27.6
	3 – extreme problems	1.0	0.6	0.6	0.8
Usual Activity	1 – no problems	5.4	21.5	34.2	41.7
	2 – some problems	65.2	66.7	59.0	50.4
	3 – extreme problems	29.4	11.9	6.8	7.9
Pain/ Discomfort	1 – no problems	0.5	18.1	23.0	26.0
	2 – some problems	49.5	74.6	67.1	66.9
	3 – extreme problems	50.0	7.3	9.9	7.1
Anxiety/ Depression	1 – no problems	33.3	57.6	54.7	62.2
	2 – some problems	57.8	35.0	40.4	33.1
	3 – extreme problems	8.8	7.3	5.0	4.7

Table 108: *EQ-VAS mean and median scores for BPD patients who completed <u>any</u> EQ-VAS at pre-op, 6, 12 and 24-months post-op*

EQ-VAS	**Pre-operative**	**6-months**	**12-months**	**24-months**
n	204	177	161	127
Mean (SD)	55.5 (19.8)	68.7 (19.9)	70.5 (18.5)	72.8 (20.3)
Median (IQR)	56.5 (40.0, 70.0)	70.0 (60.0, 84.0)	75.0 (60.0, 85.0)	80.0 (65.0, 89.0)

Figure 66: *EQ-VAS distribution for BPD patients who completed any EQ-VAS at pre-op, 6, 12 and 24-months post-op*

Section 4

Paediatric ASR

Paediatric Australian Spine Registry (pASR)

The end of the pilot trial study of the Paediatric Australian Spine Registry at the Queensland Children's Hospital is quickly approaching, marking this as an important milestone in its establishment journey. Throughout the year, the pASR team has been again focused on high quality data collection, but also began preparations for future expansion to other sites and sharing findings gained from pilot study analyses.

The pASR pilot cohort was selected based on the following inclusion criteria:

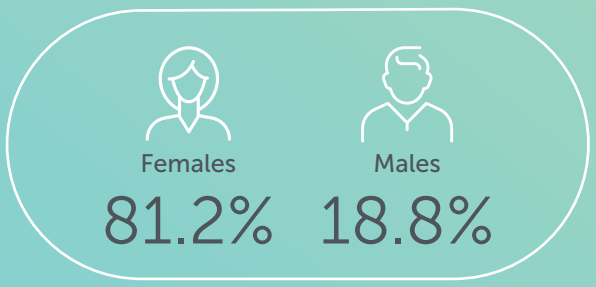
- Patients aged 9 – 17 years
- Diagnosed with idiopathic or congenital scoliosis
- Presented at Queensland Children's Hospital
- Had a single surgical intervention such as an instrumented scoliosis spinal fusion (anterior or posterior approach) or vertebral body tethering

Implementation of a smaller subset of patients has been essential in evaluating the feasibility of a large-scale data collection project using minimal staffing resources. Over the last year, the pilot has demonstrated stable workflows, excellent data completion, and strong follow-up results. This signifies its abilities and its potential to collect more information from more patient groups.

The pASR has been represented at several conferences this year with both podium presentations and poster presentations. These opportunities allow the team to disseminate early lessons learnt from starting a paediatric spine registry and interesting findings that have emerged from the pilot cohort. This visibility in rigorously peer-reviewed scholarly conferences reinforces the value of clinical registries and has strengthened clinician engagement and awareness.

A major focus for the pASR this year has been forward planning for the national expansion. An ethics application for the full study protocol has been submitted and is currently under review at the principal site Children's Health Queensland Hospital and Health Service for use at multiple sites. Given the success and stability of the pilot protocol, it is expected that this will progress smoothly to approval. The pASR is positioned well for increased data capture, national collaborations, and contributions to paediatric spine research and ultimately improvements in paediatric spine care.

Demographics



Aetiology

96.0% Idiopathic Scoliosis

4.0% Congenital Scoliosis

85.5% Posterior Spinal Instrumented Fusion

1.4% Vertebral Body Tethering

10.1% Thoracoscopic Anterior Fusion

1.4% Open Anterior Fusion

1.4% Anterior Release + Posterior Fusion

Average age

14.2 +/- 1.5 years
Mean Age at Consent

14.2 +/- 1.5 years
Mean Age at Surgical Treatment

Clinical Data Entry Completion

100% Diagnosis

100% Surgical Treatment

100% Complication

PROMs Completion

PROMs (SRS-22) completion	Pre-op	6Wk	6Mth	12Mth	24Mth
Patients eligible (n)	69	69	57	42	24
Complete with data (n)	69	36	37	32	13
Complete with data (%)	100%	52%	65%	78%	54%

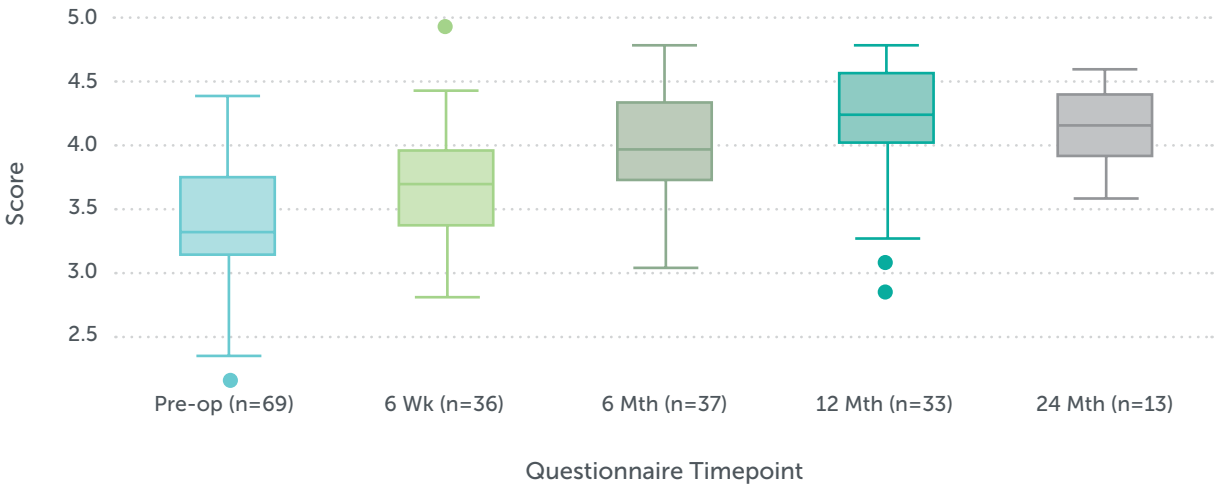
SRS-22

In the SRS-22 questionnaire, a higher score indicates the patient was feeling better at that timepoint. The questionnaire evaluates 5 domains: pain, function and activity, self-image, mental health, and satisfaction with management. When viewing the pASR cohort as a whole, a consistent trend shows patients generally reported an improved wellbeing following surgery with the most notable change at 12 months post-op (Figure 67).

Completion rates for the 6-week and 24-month timepoints are lower than the other cohorts.

The reduced response rate at 6-weeks is likely a reflection of the early postoperative recovery period where families are managing increased demands in caring for the child and completing a questionnaire may not be a priority. The QCH outpatient clinic appointment typically occurs at the 8-week timepoint meaning families may not receive an in-person reminder to complete the questionnaires on time. By 24 months post-surgery, patients may be discharged from care or may feel less compelled and engaged to complete questionnaires, resulting in a lower completion rate.

Figure 67: *Boxplot of pASR cohort's scored SRS-22 questionnaires for all domains*



Note: Unanswered questions are accounted for based on the average of the answered questions.

Cohort Analysis

Idiopathic Scoliosis Patients Who Reported Pain Before Surgery

Idiopathic scoliosis is a three-dimensional deformation of the spine with its cause currently unknown[36]. Adolescent idiopathic scoliosis (AIS) is often referred to as a painless and asymptomatic condition with pain rarely reported as the primary factor for receiving treatment[37,38]. Recent studies have demonstrated the prevalence of back pain in AIS patients[36,39,40,41]. Using data collected from the pASR, this study aimed to explore how subjective preoperative pain may affect post-operative outcomes. Using the SRS-22 quality of life questionnaire, patients were retrospectively stratified into subgroups based on their self-reported pain at the pre-op timepoint. Differences in the groups were explored for the five domains of the SRS-22 including pain, function, self-image, mental health, and satisfaction with management.

Data for this analysis was extracted from the pASR pilot up until 31st December 2025. All the patient data included in this study was collected as part of the pASR pilot study at the single pilot site the Queensland Children's Hospital. Patients were filtered for an idiopathic diagnosis and subsequently divided into 2 subgroups based on their pre-operative SRS-22 quality of life questionnaire pain domain score. The pain score given ranged from 1 to 5, corresponding to severe, moderate to severe, moderate, mild, and none, respectively. Patients with a mean pain score of 3.5 or higher were categorised into the none–mild pain subgroup, while those with a score below 3.5 were classified as having moderate–severe pain.

The SRS-22 pain domain comprises five questions that assess pain characteristics:

- Question 1: Which one of the following best describes the amount of pain you have experienced during the past 6 months?
- Question 2: Which one of the following best describes the amount of pain you have experienced over the last month?
- Question 8: Do you experience back pain when at rest?
- Question 11: Which one of the following best describes your pain medication use for back pain?
- Question 17: In the last 3 months have you taken any days off of work, including household work, or school because of back pain?

A pain threshold of 3.5 was selected as it represents the midpoint between the standard scoring categories of mild (4) and moderate (3). Borderline responses would be meaningfully grouped based on their overall pre-operative pain experience.

PROMs Analysis

A total of 66 unique patients were included in the analysis. More than half (56%) of the AIS pASR cohort reported a moderate-severe pain at the pre-operative timepoint. The mean age at surgery was comparable and not statistically significant ($p>0.05$) between the none-mild pain group (14.2 ± 1.5 years) and moderate-severe pain group (14.1 ± 1.5 years, p-value=0.81) (Table 109). The pre-operative SRS-22 domain scores showed significant differences between the two groups in the pain, function and mental health domains (Table 110). A meaningful difference in pain between the two groups was essential to observe distinct post-op questionnaire outcomes. Patients reporting more pain pre-op also reported lower levels of function, which is consistent with expectations. Increased pain may limit physical activities which may contribute to a lower mental health score. In contrast, both pre-op pain subgroups reported similar self-image and satisfaction with management scores at the pre-op timepoint.

Linear mixed-effects models were fitted to assess the changes in each SRS-22 domain across post-operative timepoints within each pre-op pain subgroup. The timepoint was a fixed effect, while patient ID was a random effect to account for the repeated questionnaires responses at each timepoint from the same individuals.

Table 109: *pASR patient subgroup numbers and mean age at surgery*

Pre-op Timepoint Subgroup	n (%)	Mean (SD) age at surgery (years)
Moderate-severe pain	37 (56%)	14.12 (1.55)
None-mild pain	29 (44%)	14.21 (1.54)
p-value		0.81

Note: The p-value was calculated using Welch Two Sample t-test.

Table 110: *pASR patient subgroup comparison of SRS-22 questionnaire domains; pain, function, self-image, mental health, and satisfaction with management domain scores*

Pre-op Timepoint Subgroup	Domain (Mean (SD))				
	Pain	Function	Self-image	Mental Health	Satisfaction with Management
Moderate-severe pain	2.76 (0.49)	3.73 (0.73)	2.78 (0.59)	3.28 (0.62)	3.46 (1.32)
None-mild pain	4.05 (0.40)	4.26 (0.53)	2.98 (0.65)	3.63 (0.75)	3.78 (0.93)
p-value	<0.001	<0.01	0.21	<0.05	0.26

Both pre-op pain subgroups demonstrated statistically significant improvements at all timepoints post-op in the SRS-22 domains of self-image (Figure 70) and satisfaction with management (Figure 72) when compared with their respective pre-op scores. The moderate-severe subgroup additionally showed significant improvements in the pain domain at all timepoints (Figure 68), whereas those who reported none-mild pain at pre-op demonstrated a significant improvement only at the 12-month timepoint. Function scores declined at 6-weeks post-op, which is consistent whilst recovering from spinal deformity surgery (Figure 69). In the moderate-severe subgroup, function returned to baseline and improved beyond pre-op levels. A similar pattern was observed for the none-mild subgroup, however the scores returned to baseline and remained stable. Mental health scores improved from the 6-month timepoint, and this was seen in both subgroups (Figure 71).

These results align with findings from Hwang et al. (2020), who reported that low pre-operative SRS pain scores (≤ 3) are the most consistent predictors of post-operative pain for all curve types[42]. In the pASR, patients who reported moderate-severe pain at pre-op (mean score of 2.76), showed early post-op improvement at 6-weeks but with a relatively small mean estimated positive change of 0.43 (Data not shown). Faster improvements in pain and function were observed for this subgroup with all post-op pain domain timepoints significantly different from pre-operative values and function scores improved significantly above baseline at 12 months. This pattern is likely due to a lower initially reported baseline, providing greater capacity for post-operative improvement in the moderate-severe group.

Many studies have explored AIS patients as a single cohort. In contrast, this analysis provides a more granular perspective by examining post-op trajectories based on their self-reported pre-operative pain severity. Literature has previously shown that significant improvements are seen in pain domain scores at 24-months following surgical correction of AIS patients[38,43,44,45]. Merola et al., reported an average improvement of 0.95 points between baseline and postoperative time points in their adolescent scoliosis population[44]. This is comparable to the moderate-severe subgroup reported in this pASR study which demonstrated a significant 1.36-point improvement at 24-months post-op. However, this change was not observed for the none-mild subgroup where only the 12-month timepoint showed significant improvement with 0.37 points, and all other timepoints remained similar to pre-op scores (Data not shown).

Pain is a subjective experience. There are unmeasured and unknown confounding factors that may influence patient self-reported pain. The SRS pain domain questions are specific to back pain, however psychosocial factors cannot be fully accounted for. A key limitation of this study is the sample size, particularly the reduced number of responses at the 24-month timepoint. Additionally, these findings are specific to the pASR pilot cohort which collects data from AIS patients with a surgical severity of scoliosis aged 9-17 years and cannot be generalised to less severe AIS populations.

Overall, the findings from this study highlight the importance of recognising and addressing pre-op pain in AIS patients. Stratifying patients by their reported preoperative pain levels reveals meaningful differences in postoperative recovery patterns. These insights help guide expectations for pain, function, self-image, mental health, and overall quality of life outcomes in AIS patients following surgery.

Figure 68: *Boxplot of SRS-22 pain domain scores*

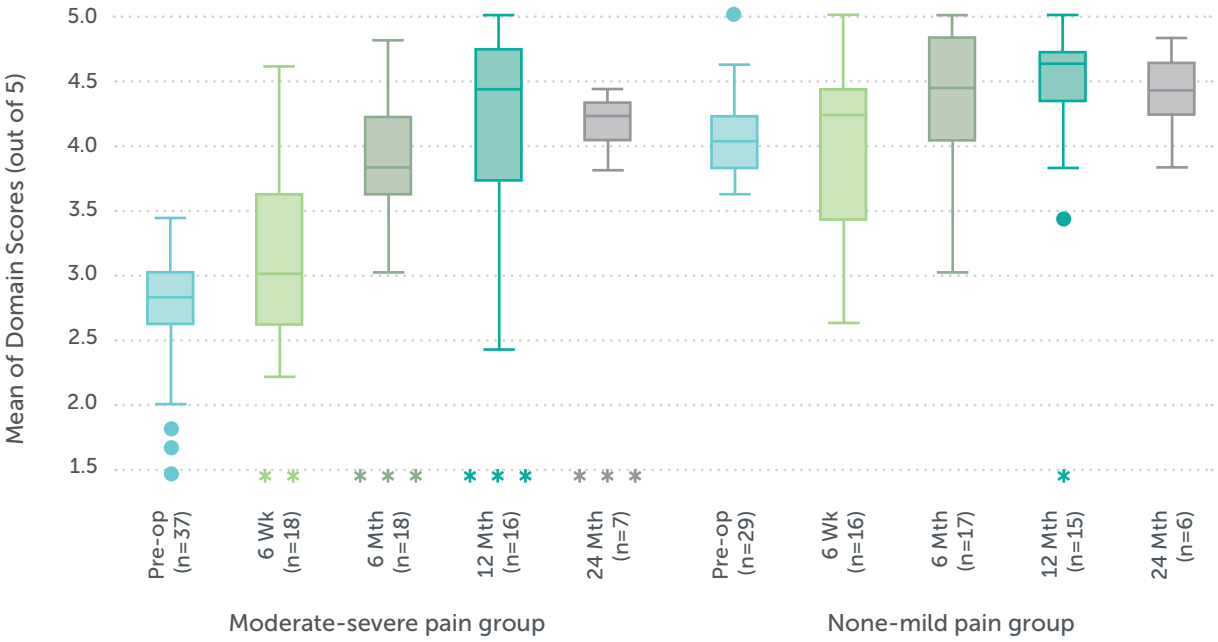


Figure 69: *Boxplot of SRS-22 function and activity domain scores*

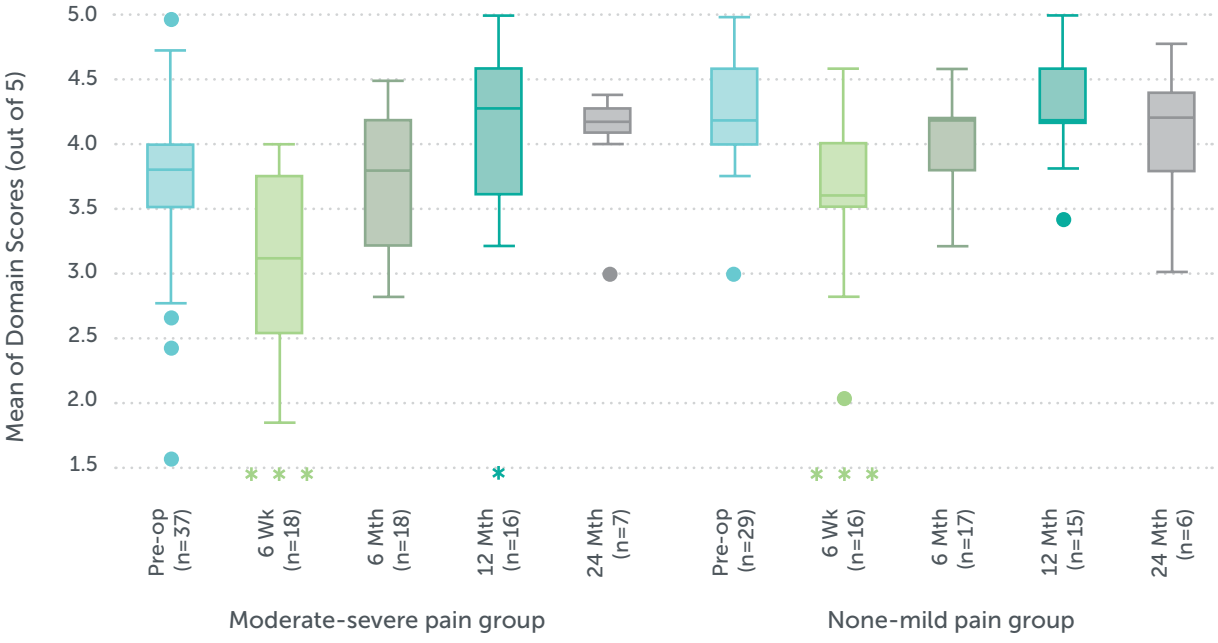


Figure 70: *Boxplot of SRS-22 self-image domain scores*

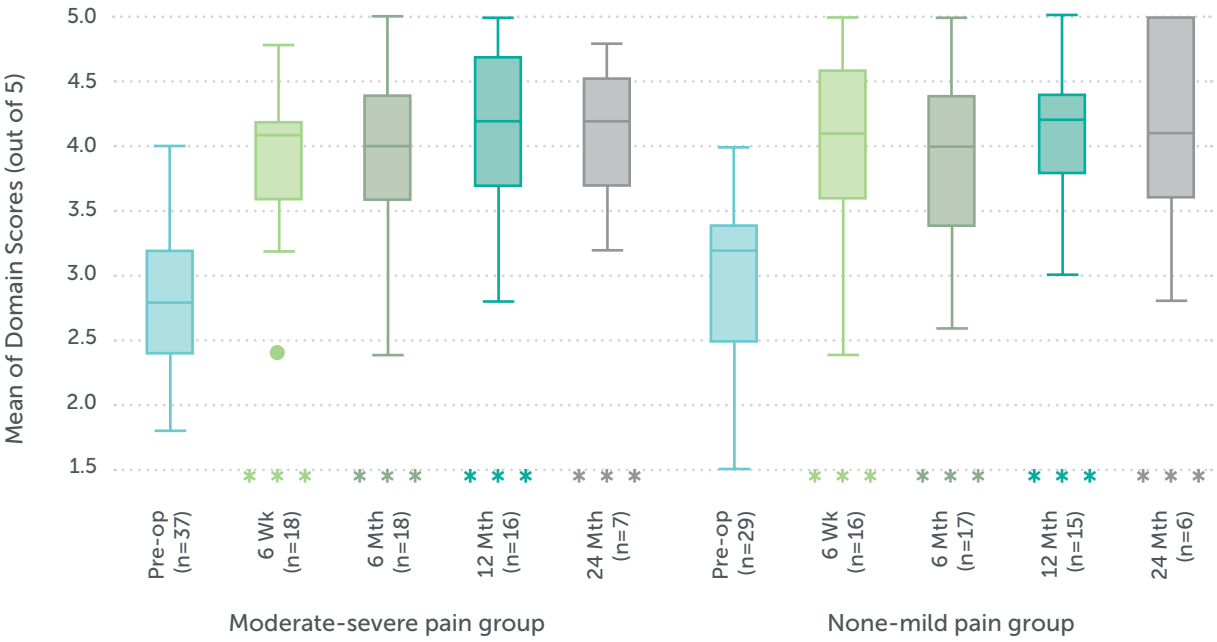


Figure 71: *Boxplot of SRS-22 mental health domain scores*

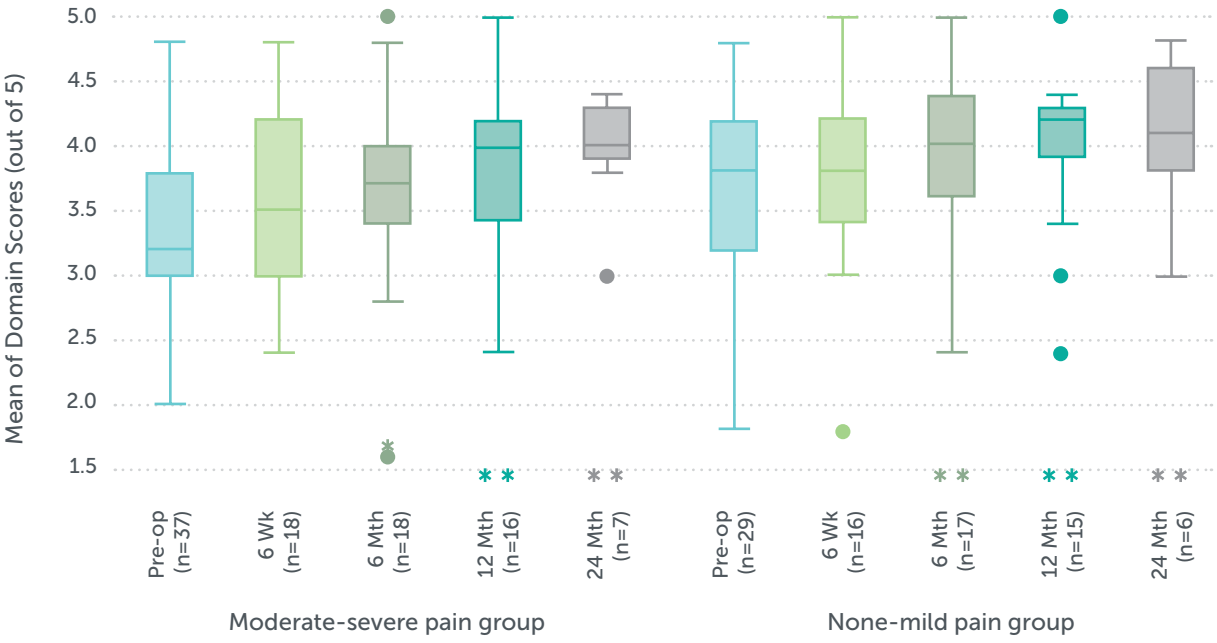
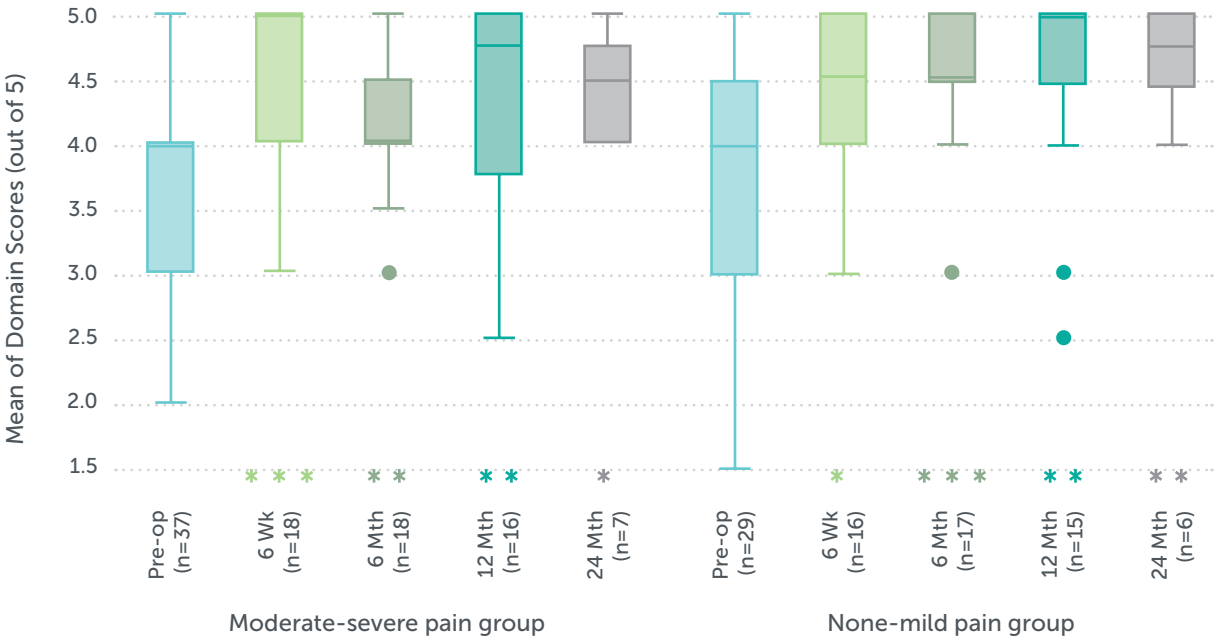
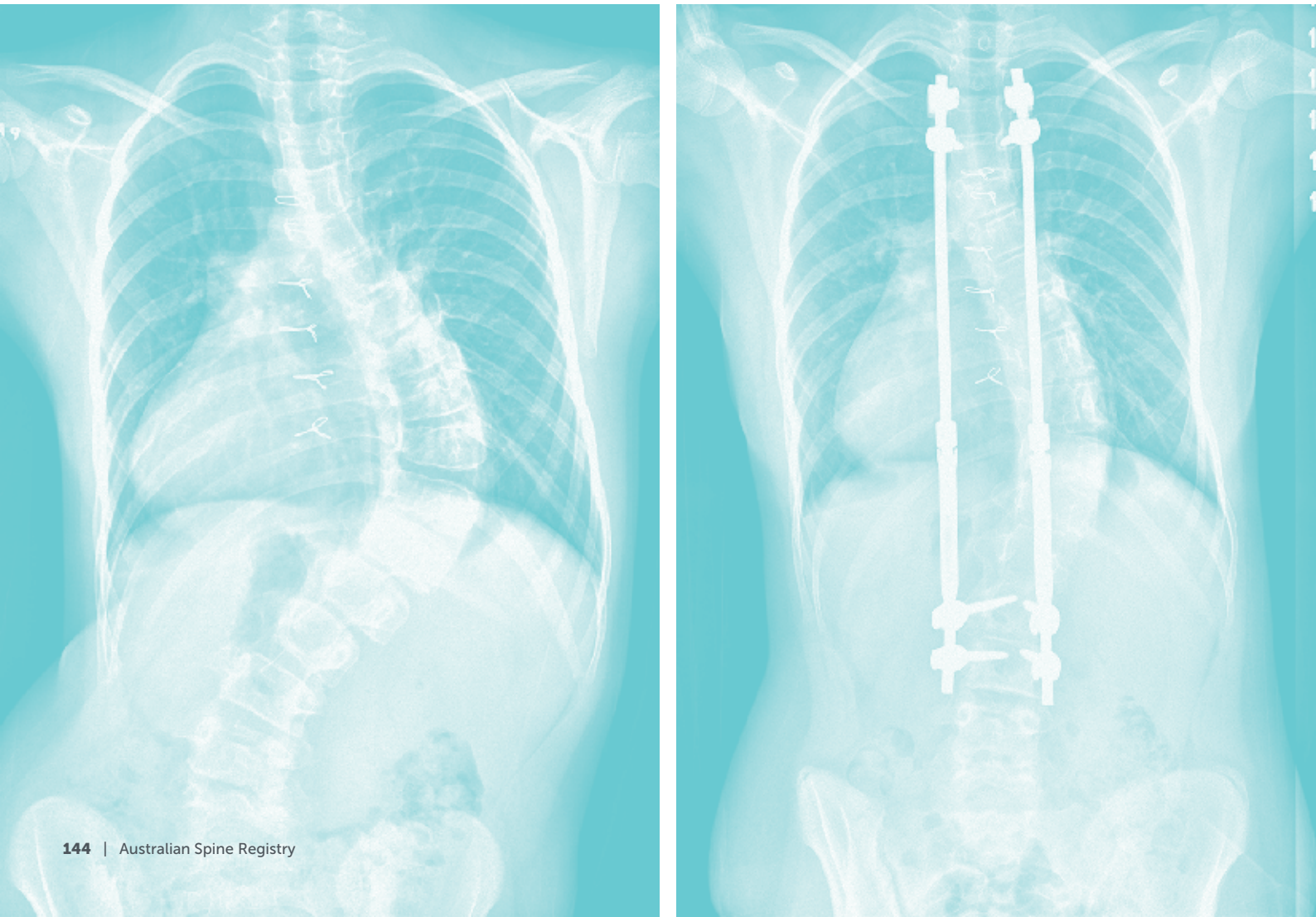


Figure 72: *Boxplot of SRS-22 satisfaction domain scores*



*Note: Significance is denoted from the linear mixed-effects models (*p<0.05), **(p<0.01), ***p<0.001).*



Future Directions

2025 was a year of transition, but 2026 will be a year of growth and new ventures.

1. National expansion of the ASR
The ASR, through the strategic employment of territory recruitment managers, has been able to double patient recruitment in the last six months. The ASR is now considering adding another recruitment specialist to accelerate hospital and surgeon recruitment. The increase in collected data will provide opportunities for expanded and more in-depth data analysis.

To support our increased number of users and larger dataset, we will be exploring innovative ways to improve our support for surgeons and their practices, to ensure robust data entry and compliance.

2. User and Community Engagement
One of the core purposes of the registry is to provide information about the role of spine surgery to clinicians, patients and the community. Whilst the Annual Report is a valuable resource, the information is not necessarily in the best format for all readers. We are considering a simplified summary section to make the key findings easier to locate and understand. In addition, the ASR will be publishing patient facing infographics to help patients understand their surgery and the likely outcomes.

We have also been very fortunate to have Ms Helen Jentz, CEO of Musculoskeletal Health Australia, join both our Steering Committee and MRFF Grant team. It is essential that our information both reaches patients and is easy to understand, and there is no doubt that Helen will be of enormous assistance in achieving this.

3. Data Linkage
Through the involvement of data linkage experts in the ASPIRE project, the ASR will be investigating how external data could be collected to enable more comprehensive analysis of the ASR dataset. Data sets from PBS, MBS and state hospitalisation records, etc., will be examined, and applications will be made to determine what data is available, how it will be collected and how it will fit with the current ASR minimal data set.

4. Paediatric Australian Spine Registry
With the success of the pilot, the pASR will be applying for new ethics approval for a national registry. However, the complicated nature of data collection from surgically and non surgically treated patients in this very diverse patient group means that this national registry will be expanded in a staged manner to ensure that data collection is well managed and that compliance by surgeons, hospitals and patients remains high.

5. New projects
The ASR is also exploring a pilot neuromodulation data collection stream. Working with the Pain Faculty, the ASR will begin collecting data on spinal stimulators, which were reported as “expensive controversial devices” by the media in 2025.

6. Research
Another core function of any registry is to facilitate research. We feel that our dataset is now reaching a level of maturity where this is an increasing possibility, both for individual surgeons and within the registry itself.

7. International Collaboration
The ASR, through its involvement in the International Spine Registry Group, will collaborate in the first direct comparison of discectomy patients from around the world. Using aggregated data, the ASR will be able to compare the outcomes of Australian patients with those from other countries.

With each year, the ASR’s activities and future become more exciting. We hope that you will continue to follow the journey and share in the success of the ASR

Publications

Backer HC, Turner P, Johnson MA, Apos E, Cunningham J. (2024) The clinical and radiographic degenerative spondylolisthesis classification and its predictive value. Arch Orthop Trauma Surg 144(4):1597-601.

Quigley M, Apos E, Truong T-A, Ahern S, Johnson MA. (2023) Comorbidity data collection across different spine registries: an evidence map. European Spine Journal 32(3):753-77

Ahern S, Apos E, McNeil JJ, Cunningham J, Johnson M. Monitoring outcomes in spine surgery: rationale behind the Australian Spine Registry. ANZ J Surg. 2018 Oct;88(10): 950-951. doi: 10.1111/ans.14562.

Registry Presentations in 2025

Presentations at the SSA Annual Scientific Meeting April 2025

- Society Session: Update on the Australian Spine Registry
- Development of the Paediatric Australian Spine Registry (pASR)
- Australian spine registry stakeholder presentation

Australian Paediatric Orthopaedic Society (APOS) & Paediatric Orthopaedic Society of New Zealand (POSNZ), Annual Scientific Meeting, Brisbane, QLD August 2025

Tracking Progress of the Paediatric Australian Spine Registry (pASR)

EUROSPINE Annual Meeting, Copenhagen, Denmark October 2025

Creating a common language on outcome for surgeries.

Section 5

Appendices

Appendices

Appendix 1 - ASR Committees

ASR Registry Committee

Dr Michael Johnson	ASR Clinical Lead, Steering Committee Chair
Adjunct A/Prof John Cunningham	Orthopaedic Spine Surgeon
Dr Rob Kuru	Orthopaedic Spine Surgeon
Dr Ralph Stanford	Orthopaedic Spine Surgeon
Dr Gordon Dandie	Neurosurgeon
A/Prof Mitchell Hansen	Neurosurgeon
Ms Maree Izatt	Project Coordinator, QUT Biomechanics & Spine Research Group (BSRG)

ASR Management Team

Dr Michael Johnson	Clinical Lead
Dr Esther Apos	Executive Registry Manager
Mr Raj Khatri	Finance Officer

ASR Operations Team

Dr Esther Apos	Executive Manager
Dr Linda De Melis	Manager, Operations and Compliance
Ms Trieu-Anh Truong	Data Manager
Ms Jenny Wilson	Recruitment and Business Development
Ms Katherine Kindl	Recruitment and Business Development
Ms Laura Busk	Research Assistant
Mr Patrick Garduce	Data Analyst
Dr Ahmad Reza Pourghaderi	Principal Data Science Lead

pASR Management Team

Dr Michael Johnson	Clinical Lead
Dr Esther Apos	Executive Registry Manager
Dr Geoff Askin	Clinical Lead and Principal Investigator
Ms Maree Izatt	Project Coordinator

pASR Operations Team

Ms Maree Izatt	Project Coordinator
Ms Selina Ho	pASR Integration Coordinator, Research Engineer
Ms Rebecca Bruce	RN, Clinical Nurse Case Manager, Scoliosis and Spinal Deformity Service

Appendix 2 - ASR Approved Hospitals*

State	Hospital
Victoria	Epworth Richmond
	Royal Melbourne Hospital
	Epworth Eastern
	Warringal Private Hospital
	Epworth Geelong
	The Avenue Hospital
	St John of God Ballarat Hospital
	Ballarat Base Hospital
	Mulgrave Private Hospital
	Peninsula Hospital
	Knox Private Hospital
New South Wales	John Hunter Hospital
	Newcastle Private Hospital
	Nepean Public Hospital
	Lake Macquarie Private Hospital
	Macquarie University Hospital
	Nepean Private Hospital
	Prince of Wales Hospital
	Prince of Wales Private Hospital
	St George Private Hospital
	St George Public Hospital
	North Shore Private Hospital
	Sydney Adventist Hospital
	Norwest Private Hospital
	Westmead Private Hospital
Queensland	Princess Alexandra Hospital
	Royal Brisbane and Women's Hospital
	Mater Public Hospital Brisbane
	Mater Private Hospital Brisbane
	Mater Private Hospital Redlands
Tasmania	Calvary Private Hospital – Lenah Valley
Western Australia	St John of God Subiaco Hospital
	Royal Perth Hospital
	Hollywood Private Hospital
South Australia	Royal Adelaide Hospital
	The Memorial Hospital

**Approved by Melbourne Health Ethics and all relevant research governance offices.*

Appendix 3 – Governance Overview

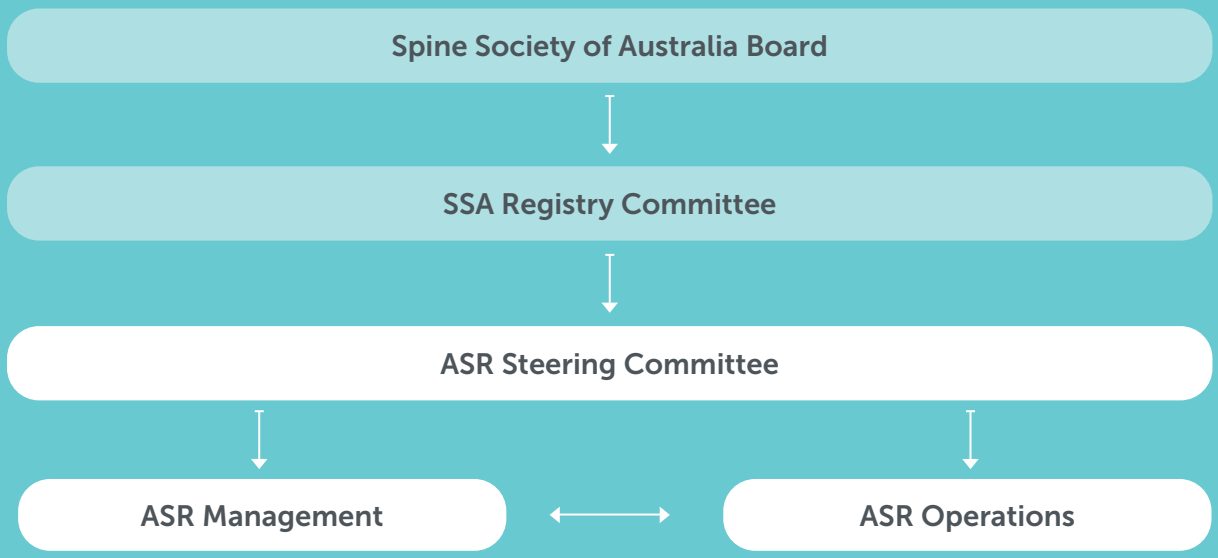
The ASR reports directly to the Spine Society of Australia which is the legal entity that owns the ASR.

SSA Registry Committee

The SSA Registry Committee is responsible for overall direction and financial management of the Spine Registry.

ASR Steering Committee

The ASR Steering Committee Membership comprises a multidisciplinary group of experts that are responsible for the governance of the ASR whose focus is on providing strategic direction and ensuring deliverables are met by the ASR.



Data Custodian

From 1 April 2025, data custodianship vested entirely with the SSA, which includes accountability of the privacy, security and integrity of patient information held within the registry.

Research Ethics and Governance

The ASR received ethics approval under the National Mutual Acceptance (NMA) scheme through Melbourne Health, Victoria, in August 2016 (HREC approval number: 2016-165). All participating public and private hospitals have site specific governance approvals.

Registry Methodology

ASR Registry Population

The registry population includes any person undergoing elective surgery at participating private and public hospitals in Australia that involves the spine.

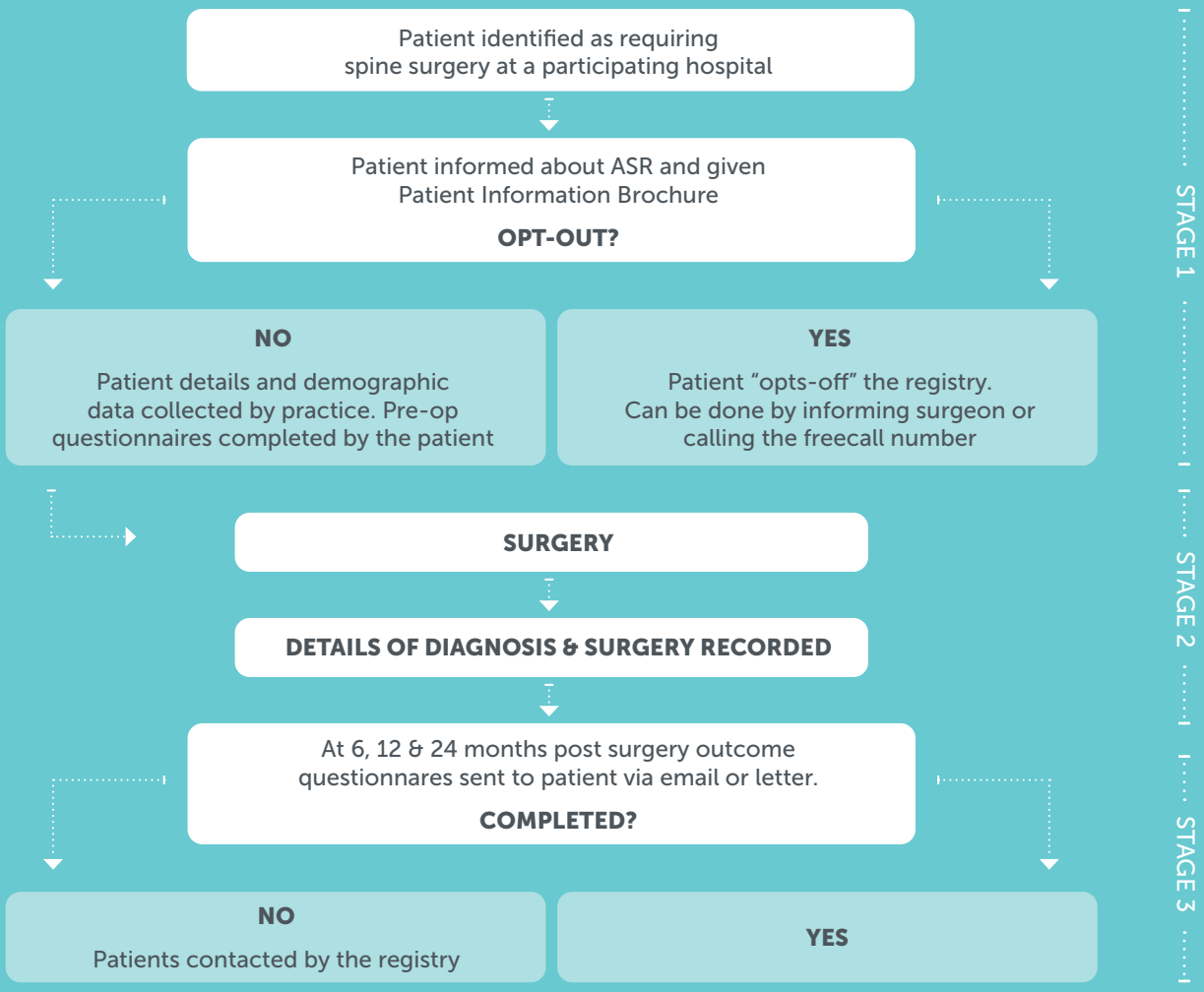
Inclusion Criteria

- Patients 18 years of age and older with surgery date which falls within the time frame specified for inclusion. This date will vary per institution/surgeon.
- Patients willing and able to provide informed consent and willing to accept the registry requirements.

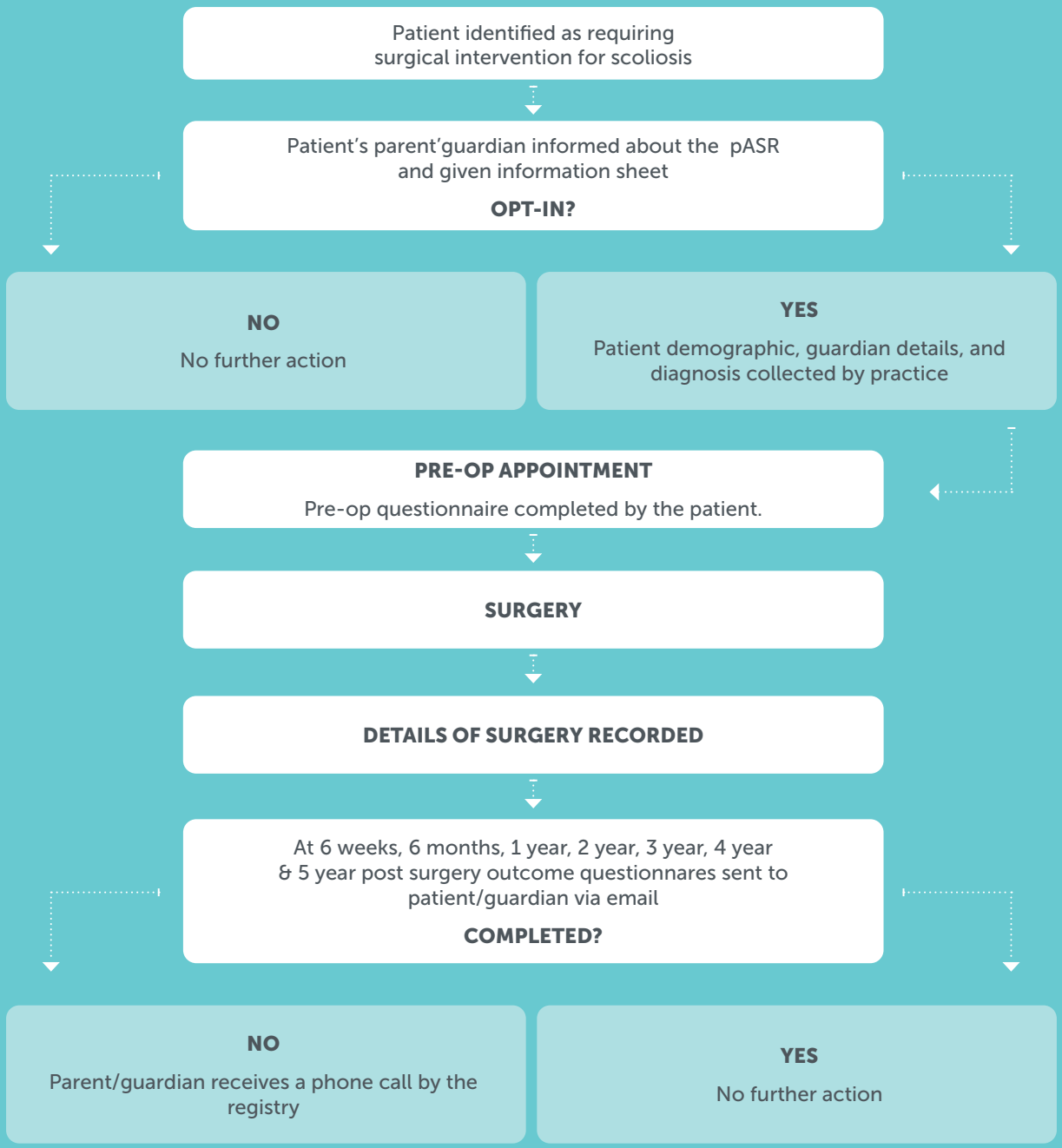
Exclusion Criteria

- Patients under 18 years of age
- Trauma patients
- People whose primary language is other than English
- People with a cognitive impairment, an intellectual disability, or a mental illness

Registry Process



pASR Pilot Process



Appendix 4 - Data for the Degenerative Cervical Myelopathy (DCM) cohort

Data for the DCM cohort low, medium and high ODI analysis.

p-values were calculated using Fisher's exact and Kruskal-Wallis tests for categorical variables and continuous variables respectively.

	Low pre-operative NDI (0 to <15)	**Moderate pre-operative NDI (15 to <25)**	**High pre-operative NDI (25 to 50)**	**p-value**
n	32	22	21	
Pre-operative NDI score				
mean (SD)	7.3 (4.1)	19.1 (2.9)	29.9 (5.2)	
median (IQR)	6.5 (4.5, 11.0)	19.0 (17.0, 22.0)	28.0 (27.0, 31.0)	N/A
12-month post-operative NDI score				
mean (SD)	5.0 (5.3)	13.8 (8.6)	18.9 (9.0)	
median (IQR)	4.0 (0.0, 7.0)	14.0 (7.0, 19.0)	19.0 (14.0, 23.0)	<0.001
NDI score change				
mean (SD)	-2.3 (6.9)	-5.3 (8.3)	-11.1 (7.9)	
median (IQR)	-3.0 (-7.0, 0.5)	-4.5 (-14.0, 0.0)	-10.0 (-16.0, -6.0)	0.002
Improved				0.002
(NDI decreased by at least 17.3% or 8.65 out of 50)				
Yes	6 (18.8%)	8 (36.4%)	14 (66.7%)	
No	26 (81.2%)	14 (63.6%)	7 (33.3%)	
Age				
mean (SD)	62.9 (12.3)	64.2 (12.4)	63.0 (13.9)	
median (IQR)	64.0 (56.0, 71.0)	66.5 (60.0, 69.0)	65.0 (50.0, 74.0)	0.88
Sex				0.016
Male	22 (68.8%)	10 (45.5%)	10 (47.6%)	
Female	10 (31.2%)	12 (54.5%)	11 (52.4%)	

Comorbidities reported				0.28
Yes	14 (43.8%)	14 (63.6%)	13 (61.9%)	
No	18 (56.2%)	8 (36.4%)	8 (38.1%)	
Number of Comorbidities reported				0.31
0	18 (56.2%)	8 (36.4%)	8 (38.1%)	
1	8 (25.0%)	5 (22.7%)	5 (23.8%)	
2	4 (12.5%)	6 (27.3%)	5 (23.8%)	
3	2 (6.2%)	1 (4.5%)	0 (0.0%)	
4	0 (0.0%)	2 (9.1%)	1 (4.8%)	
5+	0 (0.0%)	0 (0.0%)	2 (9.5%)	
ASA Classification				0.44
1	8 (25.0%)	1 (4.5%)	4 (19.0%)	
2	9 (28.1%)	9 (40.9%)	5 (23.8%)	
3	7 (21.9%)	7 (31.8%)	8 (38.1%)	
4	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Not stated	8 (25.0%)	5 (22.7%)	4 (19.0%)	

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