Degenerative Cervical Spondylolisthesis: A Comprehensive Systematic Review in Diagnosis, Management, and Outcomes

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Received: 8 January 2025

Accepted: 10 June 2025

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DOI 10.5001/omj.2026.43

Abstract

Background: Cervical spondylolisthesis can be described as traumatic, pathological, and dysplastic of the cervical spine. DCS is reported as an important cause of spinal canal stenosis, even though it is sometimes poorly understood dynamically on MRI, in the supine and neutral positions. It was reported in 1986, but with little attention compared to degenerative lumbar spondylolisthesis in young people in 19% of cases.

Objectives: The aim of this study is to evaluate the management of degenerative cervical spondylolisthesis by frequency, the affected levels, and the possible results and treatment for this pathology with slipping measure of the displacement.

Methods: A systematic review was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The review focused on surgical outcomes and treatment modalities related to Degenerative Cervical Spondylolisthesis. The comprehensive search involved several databases, including Science Direct and PubMed/MEDLINE, and was performed using PRISMA guidelines, IBM SPSS Statistics for Windows (Version 26.0, released 2020).

Results: In this systematic review we focused on 2,367 patients with degeneration cervical spondylolisthesis, Table 1. Figure1-2, table 2, figure3 and table 3, Figures 4,5,6, not without first mentioning that the records identified through the database included 179 studies, so it was decided to remove some records before screening; for example, 16 duplicates were eliminated, 14 records marked as ineligible and other files a number of 10 were removed for other reasons.

Conclusions: This study shows that cervical degeneration, spondylolisthesis, is less frequent in young people and is associated with trauma in this population, while the aging population presents due to wear and tear or degeneration of the vertebra. Therefore, we recommend MRI and CT imaging studies; the displacement measurements in flexion-extension to consider surgery should be more than 2 mm to consider the level of instability.

Keywords: Degenerative cervical Spondylolisthesis, Stenosis, anterolisthesis, retrolisthesis, instability, ACDF.

Introduction

Its main affectation is the degeneration of the disc with osteoarthritis of the facet joints, which, however, in the cervical spine, can be caused by trauma, which can be the cause of an anterior displacement of a vertebral body in the underlying vertebra. There are lesions that produce this deformity of the axis, producing traumatic spondylolisthesis. Cervical spondylolisthesis can be described as traumatic, pathological, and dysplastic of the cervical spine. [1]. DCS is reported as an important cause of spinal canal stenosis, even though it is sometimes poorly understood dynamically on MRI, in the supine and neutral positions. It was reported in 1986, but with little attention compared to degenerative lumbar spondylolisthesis in young people in 19% of cases. [2]. DCS, by its mechanism, is analogous compared to DLS, where there is weakening of the core muscles causing neck or low back pain. It shows a greater relevance in the sagittal orientation of the facet joints of cervical degenerative spondylolisthesis. Also, a notable hypertrophic degeneration of these facet joints as a result of altered cervical mechanics with a secondary type of spondylolisthesis. [3]. For a reliable diagnosis, we should assess facet osteoarthritis on both CT and MRI, as the assessment is moderate but more substantial on CT, whereas on MRI, it is also reliable in the degree of facet tropism during its scan but not in facet osteoarthritis. Therefore, it is advisable to use both studies in degenerative cervical spondylolisthesis. [4]. Cervical degeneration spondylolisthesis is a factor in 98% of cases of cervical myelopathy. Therefore, 7 factors of spinal cord compression were described, such as developmental stenosis, dynamic stenosis, as well as disc herniation, segmental ossification of the posterior longitudinal ligament, which continues, posterior spur, and calcification of the ligamentum flavum. [5]. Unstable degenerative cervical spondylolisthesis is rare but may include slippage at the C3-C4-C5 levels, superiorly and inferiorly to these rigid levels. Therefore, there are clinical and neurological patterns affecting or causing cervicobrachial pain with myelopathy or simple neck pain alone. Diagnosis is made by flexion or extension x-ray of the cervical spine. [6].

Methods

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards were followed in conducting a systematic review. The review concentrated on surgical results and degenerative cervical spondylolisthesis treatment approaches. A thorough search was conducted using PRISMA guidelines, IBM SPSS Statistics for Windows (version 26.0, published in 2020), and "degenerative cervical spondylolisthesis," along with surgical techniques, outcomes, and treatment terms that specify related pathologies, in databases, including ScienceDirect and PubMed/MEDLINE. The inclusion criteria focused on cervical approaches with fixation and stabilization, and patients aged 18 to 85 years were included. Pathologies unrelated to spondylolisthesis and research published in English prior to April 2024 were not included.

The PICO (Population, Intervention, Comparison, Outcome) framework was employed to define the study population, focusing on patients aged 18 to 85 years with traumatic spinal cord injury (Figure 1).

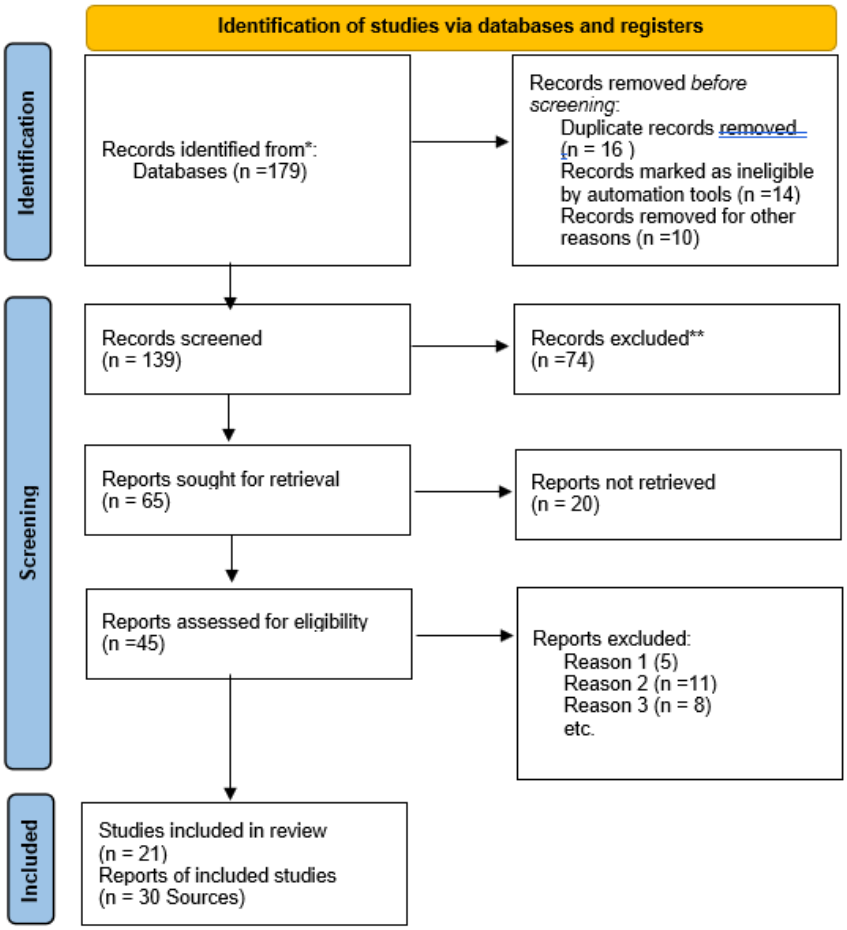

Figure 1: Flowchart systematic review [DCS].

Search Strategy and Mesh Terms; The search strategy incorporated MeSH (Medical Subject Headings) terms related to **Degenerative Cervical Spondylolisthesis**.

Search Strategy Development

Comprehensive Search Strategy Keywords

The comprehensive search strategy incorporated the following MeSH terms:

- "Degenerative Cervical Spondylolisthesis./cerebrospinal fluid"[Mesh]
- "Degenerative Cervical Spondylolisthesis./diagnostic imaging"[Mesh]
- "Degenerative Cervical Spondylolisthesis./diet therapy"[Mesh]
- "Degenerative Cervical Spondylolisthesis./drug therapy"[Mesh]
- "Degenerative Cervical Spondylolisthesis./epidemiology"[Mesh]
- "Degenerative Cervical Spondylolisthesis.etiology"[Mesh]
- "Degenerative Cervical Spondylolisthesis./mortality"[Mesh]
- "Degenerative Cervical Spondylolisthesis./pathology"[Mesh]
- "Degenerative Cervical Spondylolisthesis./physiopathology"[Mesh]
- "Degenerative Cervical Spondylolisthesis./radiotherapy"[Mesh]
- "Degenerative Cervical Spondylolisthesis.s/rehabilitation"[Mesh]
- "Degenerative Cervical Spondylolisthesis./surgery"[Mesh]
- "Degenerative Cervical Spondylolisthesis./therapy"[Mesh]

("Spine/abnormalities"[Mesh] OR "Spine/anatomy and histology"[Mesh] OR "Spine/diagnostic imaging"[Mesh] OR "Spine/growth and development"[Mesh] OR "Spine/pathology"[Mesh] OR "Spine/physiology"[Mesh] OR "Spine/physiopathology"[Mesh] OR "Spine/radiation effects"[Mesh] OR "Spine/surgery"[Mesh])

Keywords, Additional keywords included "Degenerative cervical spondylolisthesis," "Degenerative," "anterolithesis," "retrolisthesis," "myelopathy," "Fracture stabilization," "Surgical approaches," and "Restorative rehabilitation.".

Inclusion criteria

Age range: 18 to 85 years

Approaches Cervical spine stabilization, ACDF, control, and prevention pertaining rehabilitation after healing, repairs and regeneration of the spine

Use of magnetic resonance imaging strategies for cervical spine flexion and extension for accurate diagnosis.

Facet orientation indicators for cervical spine stabilization

Postoperative neurologic outcomes for cervical spine prevalence, correction, and stabilization in pain control.

Exclusion criteria

Patients ruled out by imaging for osteochondrosis or vertebral slippage by a space-occupying mass.

Patients with trauma and destruction of the vertebra without classification for spondylolisthesis.

Patient with lumbar spondylolisthesis without cervical involvement in adults or adolescents.

Data collection

Data were collected from the included studies covering various aspects of cervical spine degeneration including diagnosis, management and treatment. hypertrophic degeneration of these facet joints, together with details on surgical or conservative techniques such as decompression, stabilisation factors of spinal cord compression developmental stenosis, dynamic stenosis, as well as disc herniation, also segmental ossification of the posterior longitudinal ligament. Techniques for recovery and rehabilitation in degenerative cervical spondylolisthesis injuries including myelopathy were also reviewed.

Data extraction and analysis

Data extraction was performed using standardized systems and a rigorous search margin of Pubmed/Medline, Science direct and Cochrane, relevant research manuscripts. Information was collected from the studies in question for relevant research, including demographic characteristics, interventions, control parameters in comparative studies, authorship, year of publication and study design for each research.

Results

In this systematic review we focused on 2,367 patients with degeneration cervical spondylolisthesis, Table 1. Figure1-2, table 2, figure3 and table 3, Figures 4,5, 6, not without first mentioning that the records identified through the database included 179 studies, so it was decided to remove some records before screening; for example, 16 duplicates were eliminated, 14 records marked as ineligible and other files a number of 10 were removed for other reasons. Then the screening record went to 139, and from those files we excluded about 74, some records searched for retrieval 65 and reports not searched about 20, other selected reports about 45 and reports excluded for other reasons No. 1. 5, No. 2, 11 and No. 3, 8, so there were only 21 studies in this research. A systematic review of degenerative cervical spondylolisthesis was conducted between 1947-2010 in 102 patients with this pathology, of which 52 patients, 51%, had occipital and neck pain, while 23 (22.5%) had radiculopathy and 65 patients (63.7%) had myelopathy and myeloradiculopathy. DCS was most frequent at C3-C5, and in 81 other patients it was frequent at C3-C4 levels (46%) and in 87 patients it was at C4-C5 level (49.4%).

Disc degeneration with facet hypertrophy were the main causes of the presenting clinical manifestations. In 57 patients, 46.3% of the patients presented segmental instability, as previously shown on lateral flexion-extension projection radiographs. With two classification systems for degenerative cervical spondylolisthesis. Indicated in the surgery of patients with degenerative cervical spondylolisthesis with instability and spinal cord compression confirmed by imaging. Jiang S. et al. [1].

Table 1: Degenerative cervical spondylolisthesis: comparative studies with myelopathy and most frequently operated levels.

Authors	**Year**	**Study**	**No. Patients**	**Range of age**	**Levels**	**Myelopathy/ radiculopathy**	**P-value**
Kawasaki et al. [7].	2007	N/A	79	65	2	yes	N/A
Tani et al. [8].	3003	Clinical trial	47	elderly	31	yes	N/A
Dean et al.[9].	2009	Retrospective	58	, 2-24	72	yes	N/A
Woiciechowsky et al. [10].	2004	N/A	16	N/A	2	yes	N/A
Wang Z. et al. [11].	2021	Retrospective	50	N/A	2	yes	0.001
Alvarez A. et al. [12].	2022	Retrospective	111	N/A	20	yes	P =0.02
Murakami K. et al. [13].	2020	cross-sectional observational study	959	66.4 years	N/A	yes	p < 0.001
Shigematsu et al. [14].	2010	Retrospective	49	>65 years	N/A	yes	*p* < 0.01
Goyal D. et al. [15].	2021	Retrospective cohort study	202	Over 18	2	yes	*P* = 0.024
Kulkarni A. et al. [16].		Retrospective	17	65.8 years (49-79)	N/A	Yes	N/A
Tran K. et al. [17].	2022	Retrospective	157	60.4 ± 12.0 years		yes	*P* = 0.003
Aoyama R. et al. [18].	2023	Retrospective	83	66.0±11.4	124	YES	0.439
Lee Y. et al. [19].	2024	Retrospective cohort study	154	≥18 years	149	yes	p <0.001
Bunmaprasert T. et al.[20].	2024	retrospective cohort study	15	65.22±9.39 years	2.6±0.986 levels	yes	0.025
Kumamaru H. et al. [21].	2021	Retrospective	103	40-94 years		yes	P<0.001
Park M. et al. [22].	2018	Retrospective radiographic study	193	Over 18	C3-C5	yes	p<0.001

According to another study that explored the presence of degenerative spondylolisthesis in a study showing alterations in patient-reported outcomes, that compared anterior cervical discectomy and fusion at 1-2 levels in 202 patients with spondylolisthesis at cervical levels C2-T1 in the comparison group without spondylolisthesis and the second group with spondylolisthesis preoperatively and postoperatively, in two groups univariately with multivariately. The scores were assessed on the physical components of the Short Form-12, PCS-12, with the mental components of the Short Form-12, MCS-12; and with the neck capacity index (NDI); with the visual analogue scale (VAS, arm-neck). While in two cohorts of 154 patients postoperatively, NDI of VAS-arm-neck; 48 patients had MCS-12 delta scores, 8.3 vs 1.3, with a P = 0. 024 in the NS group, after the ACDF procedure, which showed a significant improvement in the groups. [15].

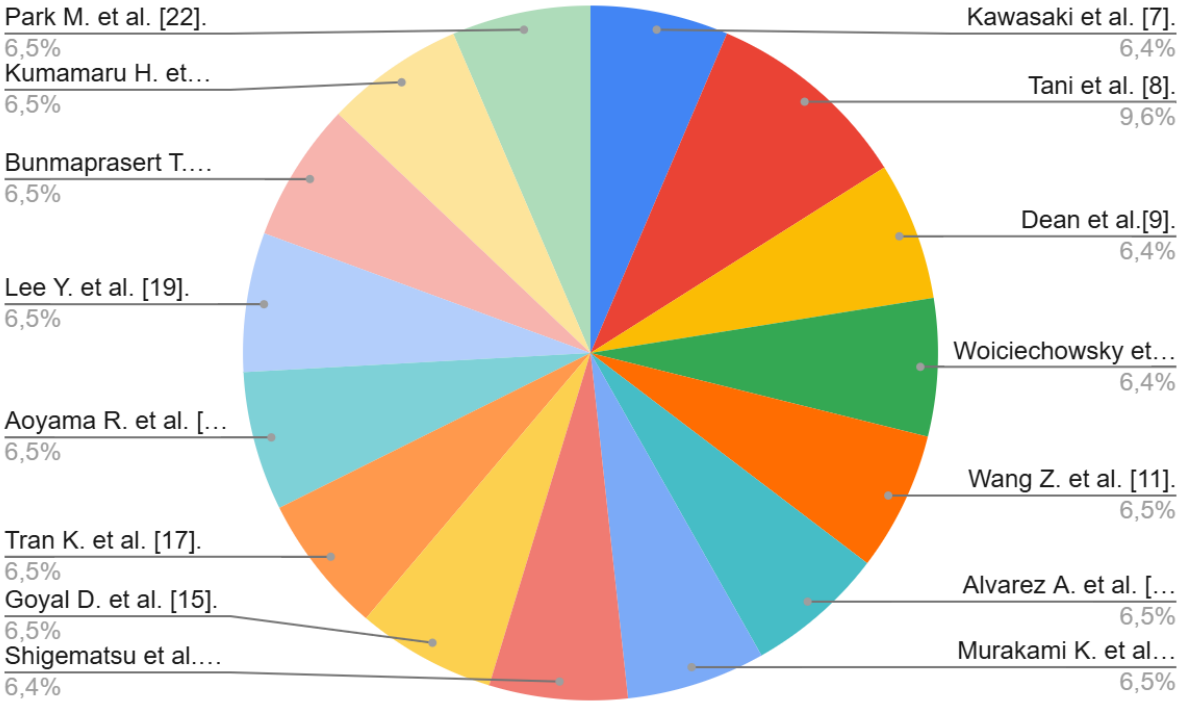

Figure 2: Degenerative Cervical Spondylolisthesis, with myelopathy, provided comparative studies with associated pathologies and clinical manifestations.

Table 2: Degenerative cervical spondylolisthesis: comparative studies with affected cervical levels and degrees of displacement for possible surgical intervention of the vertebrae.

Authors	Year	No. Patients	displacement vertebral	Levels	Treatment	Follow up
Kawasaki et al. [7].	2007	79	2.0-3.4 mm	C3-C5	Surgical	N/A
Tani et al. [8].	3003	47	3.1 +/- 0.9 mm; range, 2-6 mm	C1-C7	spinal-evoked potentials	N/A
Dean et al.[9].	2009	58	N/A	C4-C5	anterior cervical decompression and fusion	6.9 years
Woiciechowsky et al. [10].	2004	16	N/A	C3-C6	dorsal decompression / ventral fusion	6–52 month
Wang Z. et al. [11].	2021	50	N/A	C7	Surgical	N/A
Alvarez A. et al. [12].	2022	111	1-3.5mm	C3-C7	teral flexion and extension radiographs/Surgical	N/A
Murakami K. et al. [13].	2020	959	≥2 mm	C5	cervical surgery	N/A
Shigematsu et al. [14].	2010	49	2.5 mm	C3–C7	Laminoplasty double-door (midsagittal spinous-splitting) technique	11.4 ± 3.0
Goyal D. et al. [15].	2021	202	N/A	C2-T1	ACDF surgery	less than 1 year
Kulkarni A. et al. [16].	2022	17	1.6 mm to 4.7 mm	C3-C6	ACDF	1 year

Tran K. et al. [17].	2022	157	0.19 ± 0.07 mm vs. 0.16 ± 0.07 mm vs. 0.16 ± 0.06 mm vs. 0.14 ± 0.04 mm,	C4-C5	cervical surgery	90-day readmission
Aoyama R. et al. [18].	2023	83	2 mm	C2–C7	cervical surgery+ Fusion	N/A
Lee Y. et al. [19].	2024	154	>3.5 mm	C3-C6	ACDF	>1 year
Bunmaprasert T. et al.[20].	2024	15	<15° and C2-C7 SVA <40 mm	C2–C7	ACDF	24.50±1.50
Kumamaru H. et al. [21].	2021	103	>3.5 mm	C2-C6	open-door laminoplasty	N/A

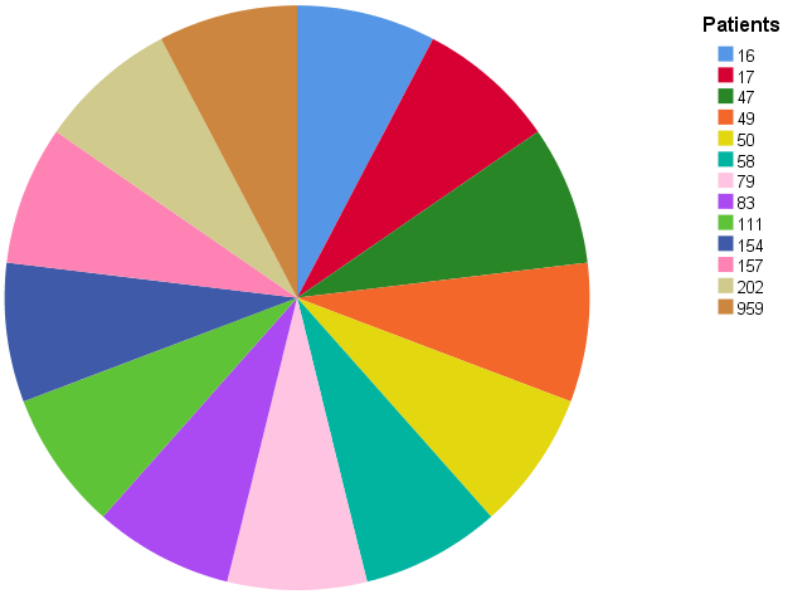

Figure 3: Degenerative Cervical Spondylolisthesis, with vertebral displacement comparative foot of various studies and respective affected levels see table 2.

Table 3: Degenerative cervical spondylolisthesis: comparative studies with the most frequent cervical levels in anterolithesis vs retrolisthesis.

Reference	Year	Study	Patients	Level	Anterolithesis	Retrolisthesis	followed up
[23].	2022	Retrospective analysis of prospectively collected observational data.	29/178	-	9	15	2 years
[24]	2015	Retrospective analysis	45	C2-C7	45	N/A	N/A
[7].	2007	N/A	79	C3-C5	14	10	
[18].	2023	Retrospective	83		52	31	N/A
[21].	2021	Retrospective	103	C2-C6	10	5	N/A

A retrospective cohort study conducted in the current year 2024, by Lee Y. et al. in 154 patients, seeking to correlate the characteristics of the cervical facet fluid with radiographic degenerative spondylolisthesis. Which is associated with the instability of cervical degenerative spondylolisthesis, among which 149 levels entered spondylolisthesis and 206 were declassified. The study showed that the index of the facet fluid was sharply higher in patients with spondylolisthesis of 0.26 ± 0.07 versus 0.23 ± 0.08. $p < 0.001$, as well as the width of the fluid and the facet were

incredibly greater in patients with spondylolisthesis with a $p < 0.001$; the facet index was higher in constructive cervical levels with fusions with a greater predisposition to unstable spondylolisthesis than the stable one itself with a $p < 0.001$, in both. [19].

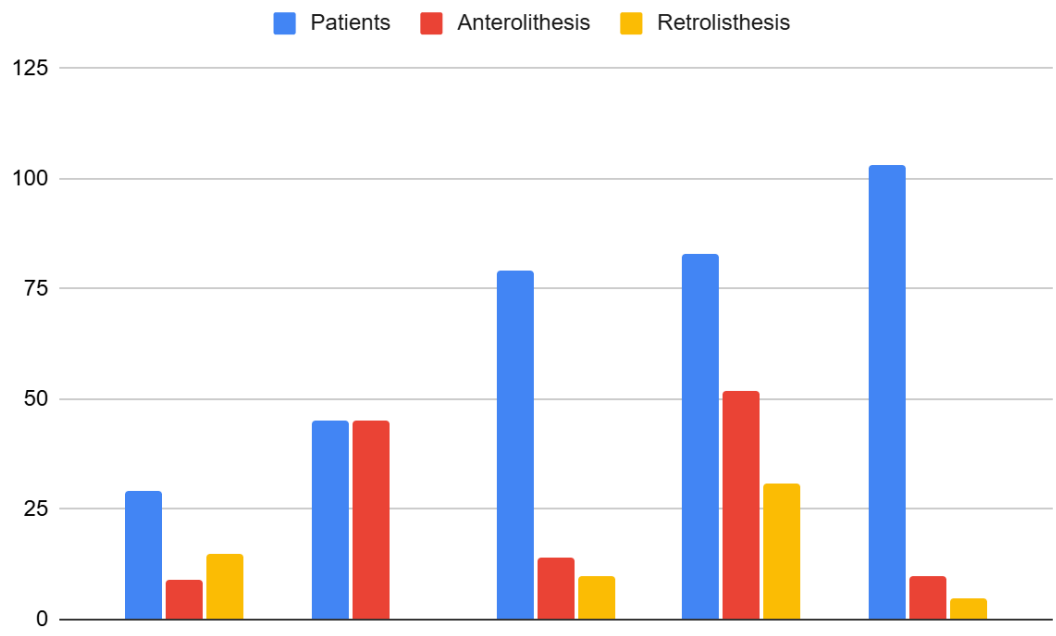

Figure 4: Degenerative Cervical Spondylolisthesis, frequent signs of displacement of the vertebrae with anterolisthesis and retrolithesis affecting the cervical spine.

This analysis review the radiographic examinations and medical records of 30 patients with degenerative cervical spondylolisthesis, 15 of them had degenerative cervical kyphosis between 2010 and 2020 and underwent anterior cervical discectomy and fusion. In the sagittal vertical axis of C2-C7, the inclination angle in T1, the neck, and the thoracic angle, [ACDF] is seeking to determine the relationship between cervical sagittal characteristics both before and after surgery in angles C0-C2-C1-C2-C2-C7. Patients with degenerative cervical kyphosis had a smaller angle at the C2-C7 level than those in the degenerative cervical spondylolitheis group (-14.88 ± 7.32 vs. 9.60 ± 13.60), which was categorized as a mismatch at the T1 level with the angle of C2-C7 than in the kyphotic group or hyperlordosis at the angles of C0-C2-C1-C2; 31.13 ± 7.68. 37.88 ± 5.08, in comparison to those with degenerative cervical spondylolisthesis SVA, C2-C7; 13 ± 10.20, 24.60 ± 10.70; in the degenerative cervical spondylolisthesis group; SVA C2-C7 (33.22 ± 13.8). 92, and was 13.70 ± 13.60 with kyphosis; following the surgical period, there was a notable enhancement at the C2-C7 level in this group. After surgery, all patients fell within normal threshold criteria with a T1 tilt with less lordosis at C2-C7 level <15° and SVA C2-C7 <40 mm, indicating that there was no significant change in spondylolisthesis.20].

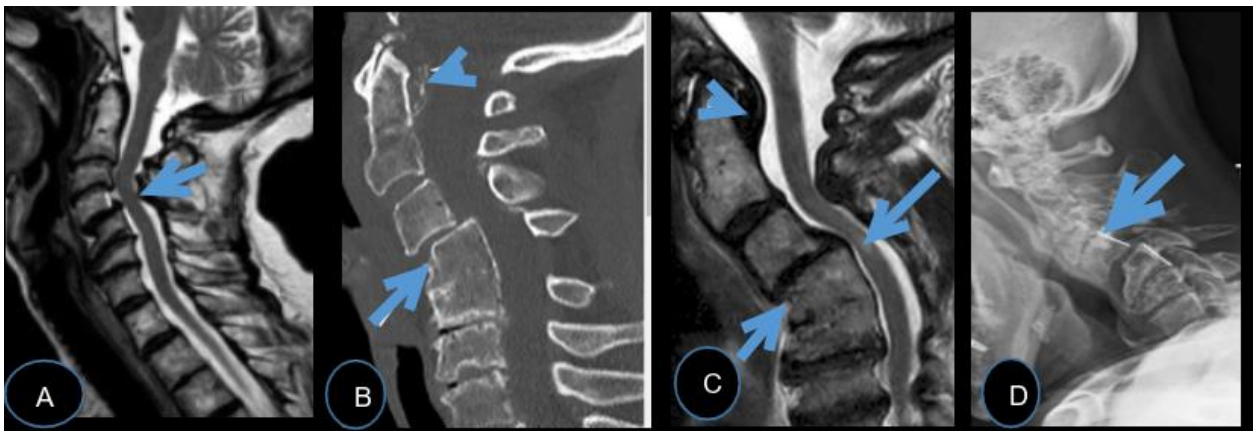

Figure 5: a) Degenerative cervical spondylolisthesis, with stenosis of the spinal canal, C3-C5, b) Vertebral slipp at the level C3-C4, c) arrow in blue showing spinal cord compression, d) instability anteriorly, C4-C5.

Computed tomography (CT)

The CT was intended to evaluate the direction of the facet joints in each of the patients at the same time as it was evaluated for the reconstruction of the cervical spine of each patient. After evaluating the axial images in the planes parallel to the upper terminal plate of the vertebral bodies. Coronal images of the plane perpendicular to the axial and sagittal planes were made, to then obtain sagittal images of the planes that bisect the vertebral bodies. Therefore, in the axial, both angles were measured in the tangential line to the posterior wall to the line that is responsible for connecting the medial and lateral edges of the articular surfaces with that of the facets. There was also a medial calculation of the facet rings for each segment according to its right or left inclination in the axial facet joint as postmedial defined as > 0 and postlateral < 0 according to research. [21].

Surgical Procedures

Surgery is performed with the patient in the prone position via a posterior approach. First, the holes for screw placement are drilled, and, after performing the laminectomy or laminoplasty, the screws are inserted. We will use the CT scan as a reference point and insert the screws using the navigation system. After correctly evaluating the preoperative images, we will perform an autologous bone graft on the immobile facet joint and use a cervical collar for about 2–3 months.[25].

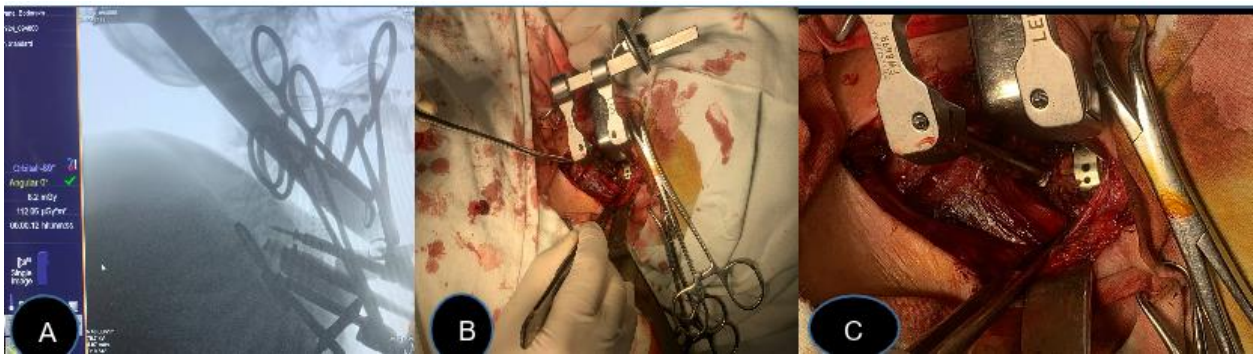

Figure 6: a) ACDF; for example, fluoroscope instrumentation C5-C6 levels; b) Procedure to the cervical levels; and c) dissection of muscles and cage in place after performing the laminectomy.

Discussion

The Ames-International Spine Study Group states that they are predicated on several sagittal deformity classifications. concentrated on where the cervical or craniovertebral deformity is located, or localized with the thoracic spine or cervico-thoracic junction. As a result, myelopathy and central stenosis are linked to cervical sagittal misalignment, particularly cervical kyphosis, which increases longitudinal spinal stress. Furthermore, the following surgical plan is implemented by the Cervical Spine Research Society, Europe, which depends on both regional and worldwide balance. [20]. Patients with caudal listhesis and degenerative cervical spondylolisthesis had more displacement at the cephalad

level. Because they have a larger physiological range of motion at the cervical spine level, C4–C6 are the most affected or implicated levels. [26]. While disc degeneration and osteoarthritis in the facet joints are contributing factors to lumbar spondylolisthesis, trauma may be the main cause of anterior displacement of the vertebral body with respect to the underlying vertebral body in degenerative lumbar spondylolisthesis. Subluxation, joint erosions, or the neoformation of marginal osteophytes may occur if the facet joints experience an anterior displacement as a result of increasing hypertrophy. [27]. A study of 202 patients who had ACDF because of myelopathy and radiculopathy found that individuals without listhesis had a higher baseline VAS arm than those without listhesis during a series of univariate analyses, however the regression was not significant. Cervical degenerative spondylolisthesis is 20% common. [28]. Despite having visible motion on flexion-extension radiographs, patients who had imaging, including plain cervical radiographs, magnetic resonance imaging and computed tomography, and flexion-extension myelography, had at least 2 mm of spondylolisthesis at one or two levels, or more, according to the Nurick classification. [29].

Surgical factors in degenerative cervical spondylolisthesis

Generally, spondylolisthesis is represented by the degeneration of a number of levels that affect the pathology with a circumferential compression in this type of patient, but in T2 hyperintensity, there is no significant difference in its prevalence statistics in patients with or without spondylolisthesis. Some patients undergo discectomy because they are a young group focused on a single disc level, so a greater focus on ACDF is likely. This approach will vary depending on the anterior, posterior, or simply combined position. Patients with spondylolisthesis treated via a posterior approach are frequently subjected to a laminectomy with or without fusion and less often to laminoplasty. When receiving posterior surgery, patients with spondylolisthesis undergo fusion in 72.7%, while patients without spondylolisthesis undergo fusion in 43%. This will depend on the experience and preference of the surgeon. According to an AOSPINE survey that looked at cervical pathology via MRI influencing surgical decision-making for cervical degeneration spondylolisthesis, the survey leaned toward a preference for the anterior approach in spondylolisthesis, whereas in degeneration there is other pathophysiology or pathologic changes that may incline toward posterior surgery. [30].

ACDF

The ACDF procedure, can be vital to avoid unnecessary complications. According to various studies in cadavers, they explained that the bifurcation of the common carotid artery, especially at the level of C4 in 78%, and the belly of the inferior omohyoid crossed the field at the level of C5-C6, the facial vein drains into the internal jugular vein predominantly at the level of C3-C4 in 54%, while in the superior sympathetic ganglion it was located mainly at the level of C4, as for the location of the intermediate ganglion it varies, and the vertebral artery entered the transverse foramen at the level of C6, in 90%, followed by C7 in 7% and C4, in 3%; and finally the inferior thoriated artery was found mainly at the level of C6-C7. [31].

Conclusion

This study shows that cervical degeneration, spondylolisthesis, is less frequent in young people and associated with trauma in this population, while the aging population presents due to wear and tear or degeneration of the vertebra. Therefore, we recommend MRI and CT imaging studies; the displacement measurements in flexion-extension to consider surgery should be more than 2 mm to consider the level of instability. Some patients will undergo conservative treatment in grades 1 and 2, while grade 3-4 is considered unstable cervical degenerative spondylolisthesis that will be evaluated by the degree of stenosis and compression of the displaced vertebra, so we recommend anterior cervical discectomy and fusion. [ACDF] by decompression includes patients with kyphosis, so laminoplasty is being evaluated depending on the case. It is possible to use a posterior cervical approach along with cervical spinal fusion and lateral mass fixation, but this might require another surgery, which we want to avoid in this study of spondylolisthesis. Additionally, it might be suggested for patients with posterior cervical approaches, misaligned pedicle screws, vertebral artery disease, or spinal cord injuries.

Limitations and future directions

In our research based mainly on cervical degeneration spondylolisthesis, the database is not so wide to find very relevant studies, which is quite limited. The pathology when treated in a hospital declines to surgery due to instability

of the vertebra and its displacement, so they are subjected to surgery not only to the ACDF, comparing with open, minimally invasive spine surgery is advancing very quickly and will be a reference point for the placement of a cage in the vertebra to reduce and decompress the affected spinal cord and finally perform vertebral fusion for stable dynamics of the vertebra. And it is the reference point to correct anterolithesis or retrolisthesis. after the postoperative period and with conservative treatment and ICU care for more efficient recovery.

Disclosure

There is no conflict of interest

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