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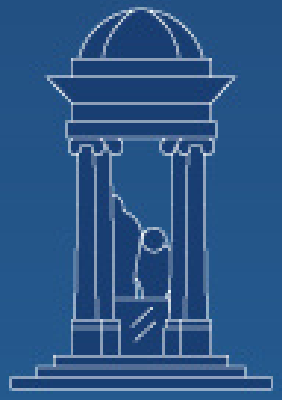
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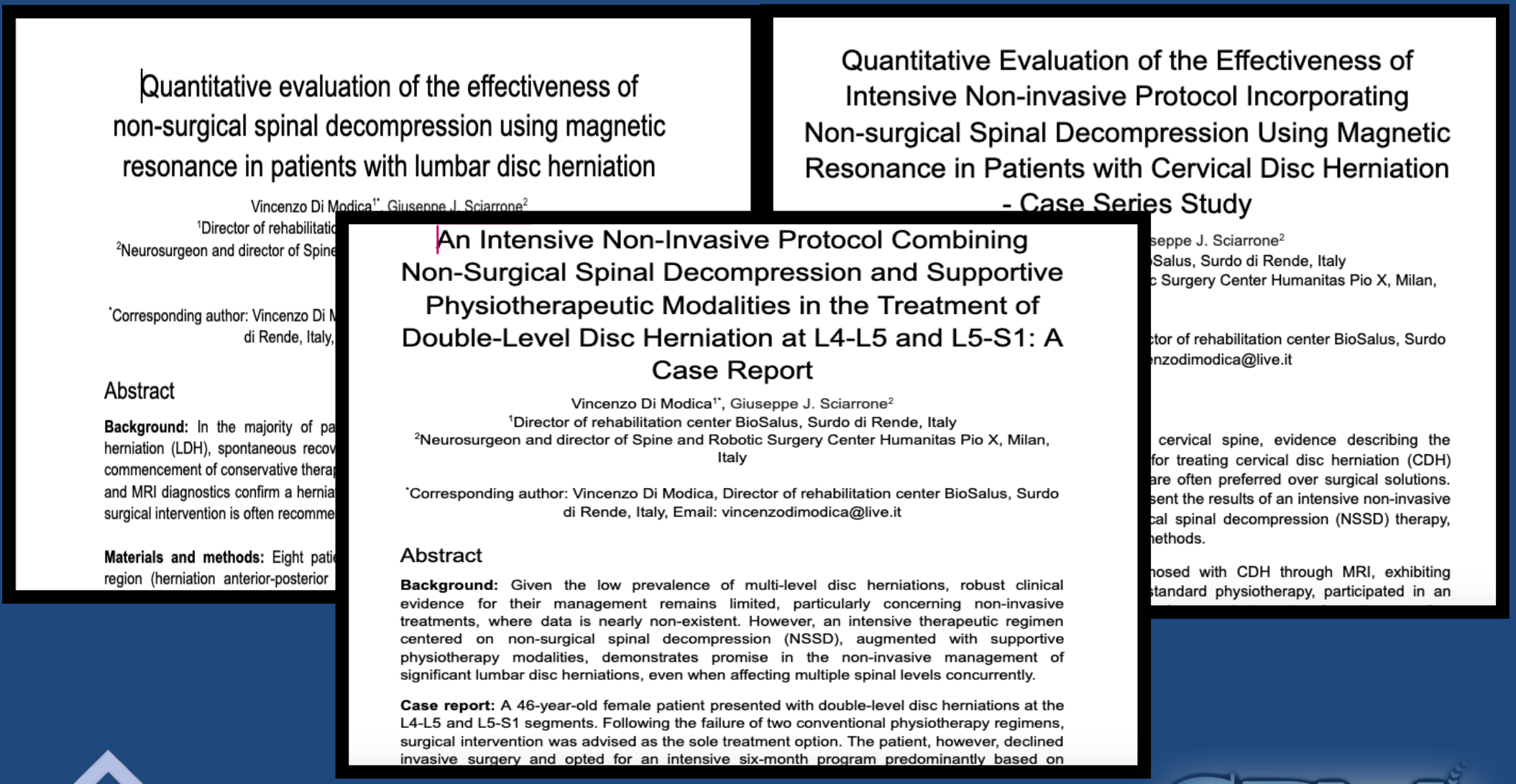
DA UN'IDEA DEL

Dott. Vincenzo Di Modica

IN COLLABORAZIONE CON

Dott. Giuseppe J. Sciarrone
e BTL Italia

BACKGROUND SCIENTIFICO



Quantitative evaluation of the effectiveness of non-surgical spinal decompression using magnetic resonance in patients with lumbar disc herniation

Vincenzo Di Modica[1*], Giuseppe J. Sciarrone[2]

[1]Director of rehabilitatio

[2]Neurosurgeon and director of Spine

*Corresponding author: Vincenzo Di M
di Rende, Italy,

Abstract

Background: In the majority of pa
herniation (LDH), spontaneous recov
commencement of conservative therap
and MRI diagnostics confirm a hernia
surgical intervention is often recomme

Materials and methods: Eight pati
region (herniation anterior-posterior

Quantitative Evaluation of the Effectiveness of Intensive Non-invasive Protocol Incorporating Non-surgical Spinal Decompression Using Magnetic Resonance in Patients with Cervical Disc Herniation - Case Series Study

seppe J. Sciarrone[2]
Salus, Surdo di Rende, Italy
c Surgery Center Humanitas Pio X, Milan,

tor of rehabilitation center BioSalus, Surdo
nzodimodica@live.it

cervical spine, evidence describing the
for treating cervical disc herniation (CDH)
are often preferred over surgical solutions.
sent the results of an intensive non-invasive
cal spinal decompression (NSSD) therapy,
ethods.

nosed with CDH through MRI, exhibiting
standard physiotherapy, participated in an

An Intensive Non-Invasive Protocol Combining Non-Surgical Spinal Decompression and Supportive Physiotherapeutic Modalities in the Treatment of Double-Level Disc Herniation at L4-L5 and L5-S1: A Case Report

Vincenzo Di Modica[1*], Giuseppe J. Sciarrone[2]

[1]Director of rehabilitation center BioSalus, Surdo di Rende, Italy

[2]Neurosurgeon and director of Spine and Robotic Surgery Center Humanitas Pio X, Milan, Italy

*Corresponding author: Vincenzo Di Modica, Director of rehabilitation center BioSalus, Surdo di Rende, Italy, Email: vincenzodimodica@live.it

Abstract

Background: Given the low prevalence of multi-level disc herniations, robust clinical evidence for their management remains limited, particularly concerning non-invasive treatments, where data is nearly non-existent. However, an intensive therapeutic regimen centered on non-surgical spinal decompression (NSSD), augmented with supportive physiotherapy modalities, demonstrates promise in the non-invasive management of significant lumbar disc herniations, even when affecting multiple spinal levels concurrently.

Case report: A 46-year-old female patient presented with double-level disc herniations at the L4-L5 and L5-S1 segments. Following the failure of two conventional physiotherapy regimens, surgical intervention was advised as the sole treatment option. The patient, however, declined invasive surgery and opted for an intensive six-month program predominantly based on

technical complexity associated with MRI scans, this diagnostic tool is typically reserved for patients who do not respond to conventional treatments or exhibit symptoms suggestive of the need for surgery. Consequently, many studies examining the effectiveness of non invasive therapeutic approaches do not include MRI assessments, relying instead on subjective symptom evaluation [11-15].

An increasingly popular non surgical alternative to surgery is spinal decompression therapy. This treatment operates on the principle of delivering targeted decompression force to the affected spinal segment using a sophisticated positioning and motion system integrated into the treatment couch. The mechanism is controlled through a computerised algorithm that applies the accurate decompression load to the specified segment. Non invasive spinal decompression therapy can be administered alone or in conjunction with other physical therapy modalities, providing complementary effects such as tension release, improved circulation and pain reduction [12,16].

The existing clinical evidence focusing on the relatively recently developed NSSD approach promises satisfactory results for herniations at various spine levels in patients of different age groups [13-15]. However, when assessing improvements in herniation, only two studies utilised quantitative MRI measurements, specifically focusing on parameters such as the Herniation Index (HI), disc height and herniation thickness [17,18]. These studies primarily included patients with mild to moderate herniation and did not evaluate indicators such as disc area, canal area, or canal length. The threshold of 6 mm for disc herniation was selected based on existing clinical evidence, as herniations of this size are often considered indicators for successful outcomes through invasive procedures. However, from a non invasive treatment standpoint, such cases pose a significant therapeutic challenge, and studies documenting the efficacy of NSSD in herniations of this magnitude remain limited.

The present study was aimed to quantitatively assess the improvement of lumbar herniation using MRI in patients with herniation exceeding 6 mm after completing an intensive treatment regimen consisting of a combination of non invasive therapeutic methods, including NSSD, HIL, and RPMS.

MATERIALS AND METHODS

A retrospective quasi-experimental study was conducted in Biosalus Private Clinic, Surdo di Rende, Italy, from November 2022 to September 2024. The study adhered to ethical guidelines outlined in the 1975 Declaration of Helsinki, as adopted by the Convention on Human Rights and Biomedicine of the Council of Europe (1997) and endorsed by the General Assembly of the World Medical Association (1997-2000) [19]. The research was approved by the local ethics committee, Comitato Etico Regione Calabria (11125 DEL 01/08/2023), under registration number 251/2024. Eight patients were provided with detailed information about the treatment program's potential risks, and any queries were addressed. Patients confirmed their willingness to participate and agreed to the publication of the results by signing a written consent form.

Inclusion criteria: Individuals experiencing painful and debilitating symptoms attributed to LDH, as confirmed by functional assessments such as the Femoral Nerve Tension Test (FNTT) [20], Straight Leg Raising Test (SLRT) [21], evaluation of the ability to walk on tiptoes and heels, the Muscle Research Council (MRC) scale for muscle strength [22], and pain measurement using the Visual Analog Scale (VAS) [23]. Based on existing evidence, the majority of patients with LDH symptoms experience spontaneous recovery within the first 6-12 weeks of initiating conservative treatment [24]. To reduce the potential influence of spontaneous recovery on study outcomes, a criterion was added to the inclusion requirements: only patients who had not responded to prior conservative treatment were eligible for participation in the study, and the program began at least one month after the completion and three months after the initiation of their previous conventional treatment. Another condition was confirmed disc herniation at the L4-L5 level by MRI scan with an AP length greater than 6 mm and consent to participate in the intensive non invasive program and associated evaluations.

Exclusion criteria: Those with contraindications for NSSD, such as malignant bone tumours, fractures, joint inflammation, spastic paralysis, osteoporosis, meningeal signs, hernia, pregnancy, cardiac and pulmonary insufficiency, haemorrhagic conditions, infectious diseases, claustrophobia, and any condition for which movement is contraindicated were excluded from the study. Similarly, patients who had contraindications for HIL or RPMS were excluded.

Study Procedure

All participants underwent a 3-month treatment protocol involving a combination of NSSD, HIL and RPMS therapy. MRI scans were performed at baseline and immediately following the completion of treatment. Key parameters obtained by analysis of MRI images included the herniation AP length, herniation area, canal AP length, canal area and the HI [8,17]. Patients were further monitored using functional tests to detect symptom recurrence for three months post-treatment. During the first month, treatment sessions were administered five times per week; during the second and third months, the frequency was reduced to three and two times per week, respectively. In total, patients completed an intensive treatment program comprising 40 combined sessions.

NSSD therapy (BTL Spinal Decompression, Model Premium, BTL Industries Ltd.) was performed with the patient in a supine position on a therapeutic couch equipped with movable parts for optimal positioning [Table/Fig-1]. The computerised control unit ensured precise delivery of decompression force, never exceeding 50% of the patient's body weight, specifically targeted to the affected spinal segment. The therapy session lasted 30 minutes, followed by a stabilisation period during which the patient remained still and relaxed [13,14].



[Table/Fig-1]: Patient position during therapy with NSSD in order to reduce the extent of disc herniation at the lumbar level.

Following NSSD therapy, HIL (BTL Industries Ltd.) and RPMS (BTL Industries Ltd.) were administered. The treatment plan for each patient was individualised, taking into consideration their specific condition and symptoms. During the final month of therapy, additional therapeutic exercises were introduced to reinforce the progress made. These included proprioceptive exercises to enhance balance and body awareness, ambulatory step activities to improve gait, Re-education Global Postural (RPG) for correcting posture, diaphragmatic rehabilitation for improving breathing mechanics, and core stability exercises to strengthen the deep muscles of the torso, all aimed at sustaining the treatment outcomes.

To ensure an accurate comparison of the MRI results with existing clinical evidence, multiple measurement methods were employed (MicroDicom DICOM Viewer 2023.3 x86). Transverse T2-weighted MRI images of the L4-L5 region were analysed. The herniation AP length, determined by the maximum AP length of the disc herniation, was selected as the primary indicator of herniation size. Additionally, the herniation area was measured, along with indicators of changes in the area and length of the spinal canal. Canal AP length, in this context, refers to the distance from the lowest point of the disc to the lowest point of the canal. Several other measurements were taken to calculate the HI using the formula [17]:

$$HI=\frac{HL\times HW}{TCL\times TCW}\times 1000$$

Where:

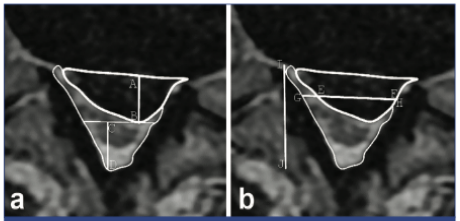
HL=Herniation AP length as described above,

HW=Herniation width determined as the width of the disc at the level of half of the HL distance,

TCL=Total canal length determined as the maximal AP canal length,

TCW=Total canal width determined as the width of the canal at the level of half of the HL distance.

All the quantitative changes in the MRI images and the measurements utilised for calculating the HI are depicted in [Table/Fig-2a,b], respectively. The transverse MRI images were additionally categorised using the Michigan State University (MSU) classification system, which considers both the size and location of the disc herniation [25].



[Table/Fig-2]: a) Visualisation of quantitative indicators of disc herniation from an MRI image. Herniation AP length (AB), herniation area (the upper area bounded by a thick line), canal AP length (CD) and canal area (the bottom area); b) Display of measurements determining HI calculation. Herniation width (EF), total canal width (GH) and total canal length (IJ).

All MRI images included in the study underwent evaluation by an impartial neuroradiologist, who assessed the images as part of routine clinical practice and was unaware of the study's specifics. Patients were monitored for up to three months following the completion of the treatment program through a series of functional tests.

STATISTICAL ANALYSIS

Statistical analysis was conducted using the Matlab environment (MatLab R2010b, Mathworks, Inc., Natick, MA, USA) with a custom script. Given the normal distribution of the data, as determined by the Shapiro-Wilk test, the statistical significance of the observed changes in the measured values derived from the MRI image analysis was assessed using a paired t-test. A p-value of <0.05 was considered statistically significant.

RESULTS

Eight patients with LDH exceeding 6 mm, as confirmed by MRI examination, were enrolled in the study. A summary of the demographic and other characteristics of the study participants has been provided in [Table/Fig-3]. All patients completed the treatment program without reporting any adverse events or discomfort during treatment. Quantitative measures of disc herniation were obtained by analysing MRI images taken before the initiation and after the completion of the treatment program [Table/Fig-4]. According to the MSU classification, all herniations observed before the study fell within the range of grades 2 to 3, with locations predominantly categorised as B or AB. Throughout the treatment program, all patients exhibited improvement, as evidenced by the final MRI classification according to the MSU, which ranged from grades 1 to 2, mostly in locations A or B. This improvement was further substantiated quantitatively by various indicators, with notable significance observed in terms of the HI and herniation AP length. Importantly, changes in all monitored parameters achieved statistical significance during the treatment program, with p-values <0.05. Besides quantitative analysis, MRI images underwent evaluation by an impartial neuroradiologist. The summarised text of the evaluation report is provided in [Table/Fig-5].

Patient no.	Gender	Age	Occupation	Symptoms	Duration of symptoms
1	Male	49	Engineer	Functional impairment in the left leg challenges in maintaining an upright posture	7 months
2	Female	50	Employee	Functional deficit in the right leg, which is accompanied by difficulty walking and a sensation of paresthesia in the L5 root area	4 months
3	Male	49	Sales agent	An inability to walk and drive due to a loss of sensation in the left foot	5 months
4	Female	54	Bank clerk	Functional deficit in the right leg, which is accompanied by difficulty walking and a sensation of paresthesia in the l4-l5 root area.	5 months
5	Male	50	Driver	Pain and lumbar functional limitations	15 months
6	Female	46	Housewife	Pain and lumbar functional limitations	12 months
7	Male	57	Bank clerk	Pain and lumbar functional limitations	4 months
8	Female	33	Housewife	Pain and lumbar functional limitations	4 months

[Table/Fig-3]: Patients' characteristics, regarding demographics, onset and manifestations of symptoms.

To provide a comprehensive understanding of the changes attained during the treatment program, MRI images of patient one are depicted in both [Table/Fig-6,7]. The improvement achieved is evident from both sagittal and transverse plane images. However, for the sake of quantitative evaluation, only the transverse images were processed. The obtained quantitative data are illustrated through box plot graphs in [Table/Fig-8]. These graphs depict the changes resulting from the treatment, showing a decrease in the AP length and area of the herniation, alongside an increase in the canal indicators. Of particular significance is the observed change in the HI parameter, which provides a comprehensive assessment of the achieved improvements.

All patients underwent continuous monitoring using functional assessment methods for up to three months following the completion of the treatment program. In seven patients, herniation symptoms, evaluated through the FNTT, SLRT, and the ability to walk on tiptoes and heels had completely resolved. These patients also reported a final VAS pain score of 0 and achieved an MRC strength grade of 5. One patient (no. 8) exhibited minor residual signs of herniation but experienced significant improvement in symptoms and functional capacity. Despite these remaining signs, his condition showed marked progress compared to the initial presentation.

DISCUSSION

The current study underscores the potential efficacy of an intensive non invasive treatment protocol comprising NSSD therapy supplemented with HIL and RPMS for the management of LDH exceeding 6 mm in patients with chronic manifestations. This investigation diverges from the prevailing trend in existing clinical evidence, not only by employing quantitative MRI evaluation methods but also by focusing on patients who are typically candidates for surgery within standard medical practice. In cases where sciatica

Patient No.	MRI images	MSU*	Herniation AP length (mm)	Herniation area (mm^2)	Canal AP length (mm)	Canal area (mm^2)	HI
1	Before	3AB	9.35	149.7	8.8	121.97	373.50
	After	1A	2.58	48.58	14.87	224.51	98.23
2	Before	3AB	8.39	85.4	9.42	109.74	339.22
	After	2A	3.26	33.61	14.99	162.25	82.93
3	Before	3AB	8.52	114.27	9.07	154.49	370.99
	After	2A	3.45	56.81	12.01	219.41	83.32
4	Before	2B	6.03	57.60	12.25	116.46	228.11
	After	1B	1.99	31.21	16.22	142.78	62.32
5	Before	2B	7.20	92.33	10.44	208.08	182.30
	After	1A	1.49	25.83	16.35	275.37	59.23
6	Before	3AB	7.38	68.84	10.95	135.02	298.86
	After	1B	1.97	27.94	17.29	184.67	66.92
7	Before	3AB	8.66	98.00	9.27	145.74	223.31
	After	2AB	4.23	53.81	13.98	188.67	76.65
8	Before	3A	11.13	186.74	4.87	66.16	455.96
	After	2A	3.97	95.58	12.32	158.32	140.99
Comparison	**Before**	Mean±SD	8.33±1.54	106.61±42.92	9.38±2.16	132.21±40.82	309.03±93.01
	After	Mean±SD	2.87±1.01	46.67±23.13	14.75±1.90	194.50±43.45	83.82±26.41
	Improvement*	Mean±SD (%)	66.02±8.96	56.20±10.21	63.90±38.22	54.30±39.12	72.42±4.56
	p-value (<0.05)		<0.001	<0.001	<0.001	<0.001	<0.001

[Table/Fig-4]: Indicators derived from quantitative analysis of MRI images obtained before and after the treatment program were assessed. A statistical comparison of the changes in these measures was conducted using a paired t-test, with p-values <0.05 deemed statistically significant.
MSU: Michigan state university classification system; AP: Anteroposterior; HI: Herniation index; *The average percentage improvements were calculated by taking the percentage improvement for each individual patient and averaging these values across all participants

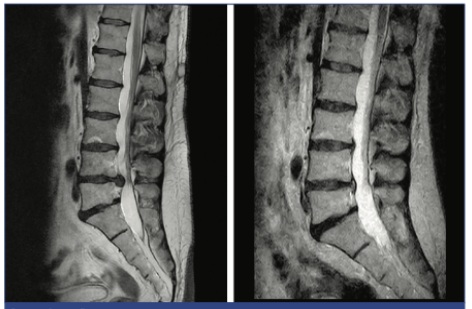
Patient No.	MRI evaluation by a neuroradiologist	
	Before	After
1	At the L4-L5 level, there is a prominent disc herniation protruding into the left median-paramedian region, leading to compression and impingement on the emerging nerve roots.	The herniation seems to have notably reduced in size compared to a previous diagnostic assessment.
2	At the L4-L5 level, there is a disc herniation protruding into the right median-paramedian area, exerting pressure on the ventral surface of the dural sac and resulting in compression and impingement on the emerging nerve roots.	The identified herniation appears smaller compared to the previously noted examination.
3	At the L4-L5 level, there is a posteriorly protruding disc herniation located in the left median/paramedian region. This herniation causes a reduction in the width of the vertebral canal and blocks the ipsilateral intervertebral foramen.	There is a median disc herniation at the L4/L5 level, and the spinal canal has a regular width.
4	At the L4-L5 level, there is a herniated posteriorlateral disc on the right-side, with a fragment protruding and situated superiorly behind the body of L4 at the right anterolateral epidural location. This lesion creates an indentation on the contour of the dural sac.	The previously expelled fragment, positioned superiorly behind the body of L4 at the right anterolateral epidural site, is no longer observable at the L4-L5 level. However, there remains a residual modest elevation of herniation on the postero-lateral right-side, at the level of the disc plane.
5	There is a left median-paramedian herniation with the disc extending into the intervertebral foramen at the L4-L5 level. In the left lateral recess of L5, there is isointense tissue to the disc present in close proximity to the cauda equina nerve roots, at the extramedullary intradural site.	There is a notable decrease in the size of the left-sided median and paramedian herniation at the L4-L5 level. The signal intensity of the cauda equina appears normal.
6	At the L4-L5 level, there is a prominent herniated disc protruding into the left lateral region, causing obliteration of the corresponding foraminal recess and resulting in compression of the L5 nerve root on this side.	At the L4-L5 level, there is disc bulging with involvement of both foraminal regions, particularly notable on the right-side. Additionally, there is a left paramedian-preforaminal herniated disc posteriorly.
7	At the L4-L5 level, there is a conspicuous right lateral-foraminal disc herniation, which is pressing on the dural sac.	At the L4-L5:level, there is a median and right paramedian disc herniation. Spinal canal maintains a regular amplitude, indicating no significant narrowing or compression.
8	At the L4-L5 level, a significant amount of disc tissue appears to be extruded and displaced towards the lower right-side. This displacement reduces the amplitude of the lateral recess and extends into the foraminal space, leading to compression of the corresponding nerve root.	At the L4-L5 level, there is a modest right paramedian and posteromedian disc herniation that indents the ventral surface of the dural sac.

[Table/Fig-5]: Assessment of MRI images obtained prior to the initiation of an intensive non invasive treatment program (pretreatment) and following its completion (post-treatment).

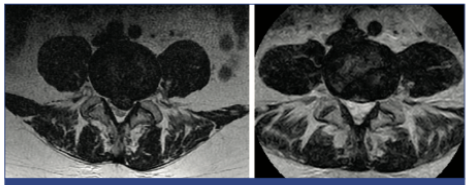
symptoms persist despite undergoing conventional therapy, and these symptoms are attributed to a large-scale disc herniation as diagnosed by MRI, surgery is generally recommended as a final treatment option [8,9].

Demirel A et al., in their study comparing the efficacy of conventional physiotherapy methods alone versus in combination with NSSD, did not observe a statistically significant difference in improvement between the two groups [18]. Notably, the improvement in terms of herniation thickness averaged 1.7 mm, significantly less than the 5.46 mm reduction achieved in the present study. This variance may be attributed to several factors. Firstly, Demirel A et al.'s study predominantly included patients with small to moderate disc herniation, typically not exceeding 6 mm in length. Consequently, comparable improvements may not be anticipated in comparison to patients with large-scale herniation reaching nearly 8 mm in AP length [18].

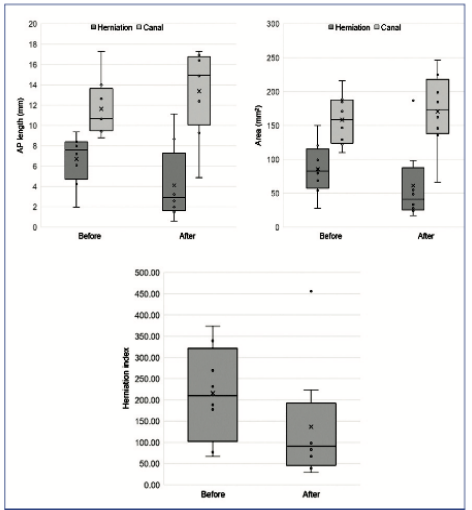
Therapeutically, the main disparity between the results of the two studies lies in the divergent intensity of their treatment protocols. While the current study employed an intensive 3-month treatment



[Table/Fig-6]: Example illustrating the comparison of a sagittal T2-weighted MRI image obtained during the initial visit (left) with that acquired after the completion of the treatment program (right).



[Table/Fig-7]: An illustration demonstrating the comparison between a transverse T2-weighted MRI image obtained during the initial visit (on the left) and one acquired after the completion of the treatment program (on the right).



[Table/Fig-8]: Box plot graphs depicting changes based on quantitative indicators from MRI images captured before the initiation of the treatment program (before) and upon its conclusion (after) are presented. Data set's distribution is visualised by showing the minimum, first quartile, median, third quartile, and maximum values. The graphs illustrate a comparison of herniation and canal AP length (upper left), herniation and canal area (upper right), and HI (bottom left).

regimen comprising 40 combined NSSD, RPMS, and HIL sessions, Demirel A et al., opted for a shorter program consisting of 15 sessions of conventional physiotherapy, 10 NSSD sessions, and five sessions of stabilisation exercises [18]. Furthermore, it is noteworthy that in the present study, final MRI images were acquired immediately after the completion of the treatment program, whereas Demirel A et al., evaluated images taken after a 3-month follow-up period [18].

Similarly, when comparing the present study with the research conducted by Choi E et al., which examined changes in the HI following ten sessions of NSSD over an eight-week period, notable differences arise [17]. Specifically, the average reduction of 27% observed by Choi E et al., is substantially lower than the improvement demonstrated in the current study, which reached 72%. This variance can be attributed to several factors, primarily the disparity in treatment protocol intensity and the evaluation of progress solely after a 3-month follow-up period, which may elucidate this difference [17].

The findings of the present study hold promise for individuals grappling with symptoms stemming from large-scale LDH, particularly those who have experienced unsuccessful outcomes with conventional treatment methods and are hesitant to undergo invasive surgical procedures for various reasons. Through an intensive treatment program incorporating NSSD, HIL and RPMS therapy, patients achieved significant improvement to the extent that surgical intervention was no longer deemed necessary. It is important to note that due to the rigorous and time-intensive nature of the protocol, this non invasive approach may not be suitable for all individuals. However, it holds potential as an alternative for those unwilling or unable to pursue invasive interventions in the future.

An intriguing aspect of the present research is that most participants (7 out of 8) exhibited herniation in segments AB or B according to the MSU classification, regions typically associated with poor responsiveness to medical therapy [25]. Nonetheless, the application of an intensive treatment protocol proved effective for all patients in the present study.

In the current study, anatomical changes were evaluated immediately upon the completion of the treatment program, while functional tests tracking the manifestation of LDH symptoms were conducted three months after the program concluded. However, functional outcomes do not necessarily reflect underlying structural changes. Although symptom relief and functional improvements are crucial from the patient's perspective, particularly in terms of disability, the research emphasis suggests the need for further imaging. Future studies should aim to include follow-up MRI scans, ideally six months post-treatment, to provide a more comprehensive understanding of structural recovery.

In the future, it would also be advantageous to explore the impact of various demographic and clinical factors, including age, BMI, duration of symptoms, level of herniation, etc., on the efficacy of this intensive non invasive protocol. Concurrently, assessing its time and financial requirements, as well as recovery duration, and juxtaposing them with those of invasive procedures could provide valuable insights. Such investigations could yield a decision-making framework for patients who are uncertain about which treatment strategy to pursue.

Limitation(s)

The primary limitations of the present study include the relatively small sample size, the lack of a control group and the absence of adequate follow-up with repeat MRI imaging for further evaluation. Additionally, it is important to acknowledge that the research was conducted at a single centre, which limits the generalisability of the findings to broader populations. Due to the financial constraints associated with MRI examinations and the demanding nature of the intensive treatment protocol, only the minimum requisite number of patients was included in the present study to detect statistical significance with reasonable power. The impact of spontaneous recovery, which typically manifests in the initial weeks following symptom onset and the initiation of conventional treatment, was partially addressed by the inclusion criteria specifying only patients with chronic symptoms persisting for at least three months after commencing and one month after concluding conventional treatment. However, it is advisable to incorporate a control group of patients into the research and substantially enlarge the patient cohort. In addition to enhancing the credibility and statistical robustness of the study, a larger sample size would likely facilitate the inclusion of patients from other age groups. The current study predominantly focuses on a narrow age range of 46-57 years. To

corroborate the efficacy of the protocol employed, further research on a larger scale with the inclusion of a control group is essential. Ideally, studies of this nature should incorporate long-term follow-up assessments to monitor the progression of the condition beyond the immediate post-treatment phase.

CONCLUSION(S)

The current study outlined the potential of an intensive non invasive protocol comprising NSSD, HIL and RPMS in alleviating symptoms of large-scale LDH in patients with chronic manifestations unresponsive to conventional treatments. The substantial improvement observed, as assessed through quantitative analysis of MRI images, enabled patients to forego the necessity of surgery, which had been recommended for half of them. These findings offer a potential solution not only for patients who, for various reasons, are hesitant or unable to pursue surgical intervention and seek non invasive alternatives but also for physiotherapists who advocate non invasive approaches in managing LDH symptoms.

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PARTICULARS OF CONTRIBUTORS:
1. Director, Rehabilitation Centre, BioSalus, Surdo di Rende, Italy.
2. Neurosurgeon and Director, Spine and Robotic Surgery Centre, Humanitas Pio X, Milan, Italy.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Vincenzo Di Modica,
Director, Rehabilitation Center, BioSalus, Surdo di Rende, Italy.
E-mail: vincenzodimodica@live.it

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An intensive non-invasive protocol combining non-surgical spinal decompression and supportive physiotherapeutic modalities in the treatment of double-level disc herniation at L4-L5 and L5-S1: A case report

Vincenzo Di Modica [a,*], Giuseppe J. Sciarrone [b]

[a] Director of Rehabilitation Center BioSalus, Via A. Manzoni, 129, 87036 Surdo di Rende, Italy
[b] Neurosurgeon and Director of Spine and Robotic Surgery Center Humanitas Pio X, Via Francesco Nava, 31, 20159 Milan, Italy

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ABSTRACT

Background: Given the low prevalence of multi-level disc herniations, robust clinical evidence for their management remains limited, particularly concerning non-invasive treatments, where data is nearly non-existent. However, an intensive therapeutic regimen centered on non-surgical spinal decompression (NSSD)[1], augmented with supportive physiotherapy modalities, demonstrates promise in the non-invasive management of significant lumbar disc herniations, even when affecting multiple spinal levels concurrently.

Case report: A 46-year-old female patient presented with double-level disc herniations at the L4-L5 and L5-S1 segments. Following the failure of two conventional physiotherapy regimens, surgical intervention was advised as the sole treatment option. The patient, however, declined invasive surgery and opted for an intensive six-month program predominantly based on NSSD therapy. Magnetic resonance imaging scans taken after the initial onset of symptoms, prior to and two months after initiating the program, and one month following its completion, revealed significant improvements across all monitored parameters, including canal anteroposterior (AP)[1] length and area, disc AP length and area, and herniation index. These structural changes indicated an almost complete restoration of the canal surface and substantial reduction of herniation at both affected levels.

Conclusions: Even in patients with significant herniations at two different levels, substantial improvement can be achieved through a non-invasive approach. These findings underscore the effectiveness of an intensive treatment program utilizing NSSD therapy and offer a viable alternative for patients who are unable or unwilling to undergo surgical intervention.

* Corresponding author.
E-mail address: vincenzodimodica@live.it (V. Di Modica).

[1] NSSD: Non-Surgical Spinal Decompression; AP: Anteroposterior; LDH: Lumbar Disc Herniation; FNTT: Femoral Nerve Tension Test; SLRT: Straight Leg Raising Test; MRC: Muscle Research Council; HI: Herniation Index; HL: Herniation Length; HW: Herniation Width; TCL: Total Canal Length; TCW: Total Canal Width.

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Introduction

LDH[1] is one of the most prevalent causes of low back pain, a leading global disability that affects up to 80 % of individuals at some point in their lives [1,2]. The intervertebral disc, situated between vertebral bodies, consists of the inner gel-like nucleus pulposus and the outer ring-shaped annulus fibrosus, functioning as a shock-absorbing cushion for the spine [2,3]. Degenerative processes, including loss of hydration and weakening of the nucleus pulposus, along with trauma or less common connective tissue and congenital disorders, can cause protrusion of part or the entire nucleus pulposus through the annulus fibrosus, leading to disc herniation. This condition predominantly affects the L4-L5 and L5-S1 segments [2,3].

While most LDHs are asymptomatic and up to 90 % of symptomatic herniations resolve spontaneously within six weeks of symptom onset, typical symptoms include low back pain, radicular pain, limited mobility, increased pain during coughing, sneezing, and sitting, along with sensory abnormalities and weakness [2,3].

The primary management of LDH involves non-surgical conservative methods such as rest, non-steroidal anti-inflammatory drugs, and physical therapy. Other treatments include oral steroids, benzodiazepines, selective nerve root blocks, and epidural injections. Surgical intervention is considered a last resort for cases where non-invasive treatments fail or severe neurological symptoms manifest [4].

With advancements in spine endoscopy, traditional surgical approaches like open discectomy and microdiscectomy have been supplemented by minimally invasive procedures, offering less surgical trauma and faster recovery [5]. In recent years, percutaneous endoscopic transforaminal discectomy has become the most widely used percutaneous endoscopic procedure for LDH treatment [6]. However, anatomical challenges in the L5-S1 region complicate this method, often leading to the preference for interlaminar endoscopic discectomy despite the proven advantages of the transforaminal approach [6,7].

In addition to traditional physiotherapeutic modalities such as the application of heat, cold, stimulating energy, and structured exercise, non-invasive physical therapy has advanced to incorporate new methodologies that enhance recovery through controlled manipulation techniques [4]. Among these, NSSD has gained traction for the treatment of lumbar and cervical disc herniation. During NSSD, the patient reclines on a specialized table that facilitates the alignment of spinal segments, allowing decompression forces to be precisely targeted to the herniation site. For LDH, the patient is secured with a lumbar belt through which decompression force is meticulously controlled by a computer system. Numerous studies have demonstrated the efficacy of NSSD in alleviating LDH symptoms; however, its impact on structural changes in cases of multi-level LDH remains unreported [8–12].

While specific prevalence data are lacking, existing evidence suggests that multi-level disc herniations are relatively uncommon [13,14]. Such multi-level involvement may result from acute trauma, such as a car accident, or from degenerative diseases affecting multiple spinal segments. Treatment options for multi-level LDH mirror those for single-level LDH, though severe pain and sensory deficits often necessitate more invasive surgical interventions [15]. Although evidence supporting the effectiveness of surgical approaches for multi-level LDH includes case studies, case series, and retrospective analyses, research on non-invasive treatments is notably sparse [14,16,17]. This study presents a case of a patient with double-level LDH at L4-L5 and L5-S1, who opted for an intensive non-invasive treatment regimen centered on NSSD, despite significant functional impairments and previous failures of conventional physiotherapy.

Case report

A forty-five-year-old female patient, with a normal body mass index and no regular engagement in sports activities, presented with significant lower back pain and functional limitations. She initially received a conventional treatment regimen comprising ten sessions of physio-kinesiotherapy, diathermy, massage, and pharmacotherapy, which yielded only minimal improvement. MRI conducted in October 2022 identified double-level disc herniation at the L4-L5 and L5-S1 segments. Specifically, the L4-L5 herniation was located in the left paramedian region, sufficiently protruding to indent the ventral surface of the dural sac and make slight contact with the L5 nerve root. At the L5-S1 level, a substantial herniated disc in the left lateral position was observed, impinging on the ventral surface of the dural sac, partially obstructing the adjacent foraminal recess, and compressing the S1 nerve root on the same side.

Upon exacerbation of symptoms, the patient sought further medical intervention in February 2023. She was subsequently prescribed a rehabilitation program encompassing ten sessions of dry needling, traditional magnetotherapy, and Tecar therapy. This treatment failed to produce significant improvement, and the patient was advised to seek neurosurgical consultation. By the end of March 2023, surgical intervention was recommended as the definitive solution. However, the patient declined surgical intervention and instead pursued alternative non-surgical options at the private clinic.

In April 2023, a functional examination including assessments such as the FNTT[1], SLRT[1], evaluation of the ability to walk on tiptoes and heels and MRC[1] scale for muscle strength, confirmed substantial herniation, prompting a recommendation for a new MRI scan following neurosurgical consultation. The subsequent MRI confirmed the presence of herniated discs at the L4-L5 and L5-S1 levels, with protrusions causing compression of the adjacent foraminal recess and impingement on the L5 and S1 nerve roots. Due to the extent of the double-level herniation, an intensive non-invasive treatment regimen was promptly initiated. The treatment protocol began with five weekly sessions of combined NSSD and conventional physiotherapy over one month. In subsequent months, the treatment frequency and session content were adjusted according to the patient's clinical response. The patient underwent a total of 92 treatment sessions incorporating various therapeutic modalities. To provide a clearer overview of the diagnostic evaluations and therapeutic interventions, a detailed timeline is presented in Table 1.

During NSSD therapy (BTL Industries, Ltd.), the patient was positioned supine with legs extended and angled downward, enabling decompression forces to target the affected spinal segments (Fig. 1). The decompression force was precisely controlled and did not

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Table 1
Timeline illustrating the course of diagnostic and therapeutic interventions before the initiation, during, and after the completion of the intensive rehabilitation protocol. All diagnostic and therapeutic procedures conducted prior to April 2023 were not designed or supervised by the authors of this study.

Date	Diagnostics / events	Therapy	Notes
Sep 2022	Onset of symptoms	10sessions: physio-kinesiotherapy, diathermy,massage, pharmacotherapy	Minimal improvement
Oct 2022	MRI scan		
Feb 2023		10 sessions: dry needling, magnetotherapy, Tecar therapy	No improvement
Mar 2023	Neurosurgical consultation		Surgical intervention recommended
Apr 2023	Clinic change: functional exam (FNTT, SLRT, gait, MRC), MRI, neurosurgical consultation	Start of intensive therapy program	Study protocol initiated by authors
May 2023		20 sessions: NSSD + CP	
Jun 2023		12 sessions: NSSD + CP	
		8 sessions: CP	
Jul 2023	MRI scan	12 sessions: NSSD + CP	
		8 sessions: CP	
Aug 2023		12 sessions: NSSD + CP	
Sep 2023		8 sessions: NSSD + CP	
		4 sessions: CP	
Oct 2023		8 sessions: NSSD + CP + targeted exercise	
Dec 2023	MRI scan; functional exam (FNTT, SLRT, gait, MRC)		
Jun 2024	Functional exam (FNTT, SLRT, gait, MRC)		

NSSD: Non-surgical Spinal Decompression; CP: Conventional physiotherapy; FNTT: Femoral Nerve Tension Test; SLRT: Straight Leg Raising Test; MRC: Muscle Research Council.

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Fig. 1. Patient positioning: patient position during NSSD treatment.

exceed 50 % of the patient's body weight. Each active therapy session lasted 30 min, followed by a stabilization phase in a stationary position. Conventional physiotherapy involved various modalities (BTL Industries Ltd.) delivering different types of stimulation energies, aimed at symptom alleviation, acceleration of tissue regeneration, and facilitation of structural changes. The final month included therapeutic exercises designed to stabilize and maintain treatment outcomes.

Follow-up MRI scans conducted two months into the treatment and one month post-treatment completion revealed notable structural changes, most prominently in the sagittal plane, and quantitatively assessed improvements from axial images. Despite the visible positive changes, the MRI data were further processed to provide a quantitative evaluation of structural changes, offering a comprehensive view of the patient's condition progression (MicroDicom DICOM Viewer 2023.3 × 86). The HI[1] was calculated using the equation published by Choi et al. [18]:

$$HI = \frac{HL \times HW}{TCL \times TCW} \times 1000$$

where:HL = Herniation Length determined by the maximum anteroposterior length (AP) of the disc herniation,HW = Herniation Width, determined as the width of the disc at the level of half of the HL distance,TCL = Total Canal Length determined as the maximal AP canal length,TCW = Total Canal Width determined as the width of the canal at the level of half of the HL distance.

In addition to these indicators, the parameters herniation area, canal area, and canal length were also assessed. In this context, canal length refers to the distance from the lowest point of the disc to the lowest point of the canal [19]. To provide a clearer understanding, the measurement methodology is visually illustrated using an example MRI image in Figs. 2a and 2b. The actual MRI scans obtained before, during, and after the completion of the treatment program are presented in Figs. 3–5.

Values obtained from MRI image processing since the initial symptom manifestation in October 2022 demonstrate structural

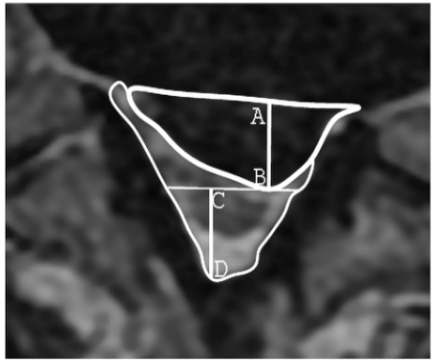


Fig. 2a. MRI measurements: demonstration of the assessment of objective indicators of herniation severity based on MRI images. This example illustrates the parameters: herniation length (AB), herniation area (upper region bounded by a thick line), canal length (CD), and canal area (lower region).

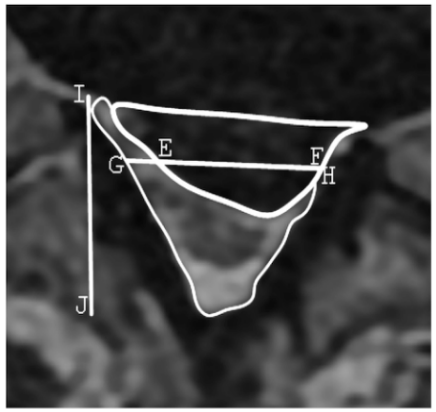


Fig. 2b. HI measurements: illustration of the methodology for measuring parameters used in calculating the herniation index, including herniation width (EF), total canal width (GH), and total canal length (IJ).

changes throughout the entire monitored period (Table 2). The MRI taken before the commencement of the treatment program confirmed significant deterioration in the patient's condition between October 2022 and April 2023, particularly at the L4-L5 vertebral level. Two months after initiating treatment, a slight improvement was observed, progressing to near-complete recovery at both spinal segments. In terms of herniation AP length, improvements exceeded 5 mm and 4 mm in the L4-L5 and L5-S1 segments, respectively, representing over 73 % improvement at both levels. The change in herniation index slightly favored the L4-S1 segment, corresponding to a 74 % improvement versus 65 % at L4-L5.

The progression of the measured parameters reflecting ongoing structural changes is depicted in a series of graphs in Fig. 6. These curves illustrate that, from the onset of the treatment program, improvements at both herniation levels followed a similar trend across all evaluated parameters. While parameters such as herniation AP length, herniation area, and herniation index decreased, the non-invasive intensive treatment led to an increase in parameters related to the area and AP length of the canal.

Structural changes in the intervertebral disc region were also manifested by the disappearance of symptoms in the monitored series of functional tests (FNTT, SLRT, evaluation of the ability to walk on tiptoes and heels, and MRC). The absence of deficits arising from LDH persisted throughout the 6-month follow-up.

Discussion

This case highlights the potential of NSSD therapy, supported by adjunct modalities, in treating double-level LDHs typically predisposed for surgical intervention. The treatment of multiple LDHs using non-invasive methods lacks sufficient clinical evidence, and while these approaches are applied in practice, the extent of herniations and quantitative monitoring of structural changes via MRI image processing make this report relatively unique.

The effectiveness of NSSD, a key therapy in the present treatment program, has been substantiated by multiple studies demonstrating symptom reduction in LDH [8–12]. Although there is insufficient evidence tracking objective changes through imaging methods, a positive effect on the structural changes of the intervertebral disc and spinal canal can be postulated. This assumption is supported by the mechanism of action of NSSD therapy, which involves directing the decompression force precisely to the damaged segment, resulting in the distraction and mobilization of the intervertebral joint and unloading of the disc. This approach facilitates the reduction of the herniation level and the subsequent increase in the canal area. The release of the spinal canal reduces the risk of compression of the nerve roots, alleviating sciatic and other associated symptoms.

The effect of NSSD therapy in the treatment of double-level LDHs has not been previously described, though it is plausible that a well-designed protocol could facilitate improvements at multiple levels. The protocol employed in this case involved significantly more sessions compared to other NSSD studies on LDH patients. This increased frequency is likely due to the necessity of addressing two segments afflicted by substantial disc herniations measuring 7.38 mm and 5.8 mm, respectively. The goal of the treatment extended beyond symptom alleviation to the complete resolution of their underlying cause by modifying the structure of the intervertebral area.

Due to the case study nature of this research, the findings cannot be generalized to the broader population. Treatment responses can vary: some patients may not respond adequately, while others may experience spontaneous resorption of herniations. Hornung et al. found that in cases of multilevel herniations, spontaneous recovery occurs as frequently as in single-level cases [20]. However, in the present case, no significant improvement was observed during the first six months of treatment, unlike the positive changes seen early in Hornung's cohort. Therefore, spontaneous recovery was unlikely, and intensive treatment was deemed necessary.

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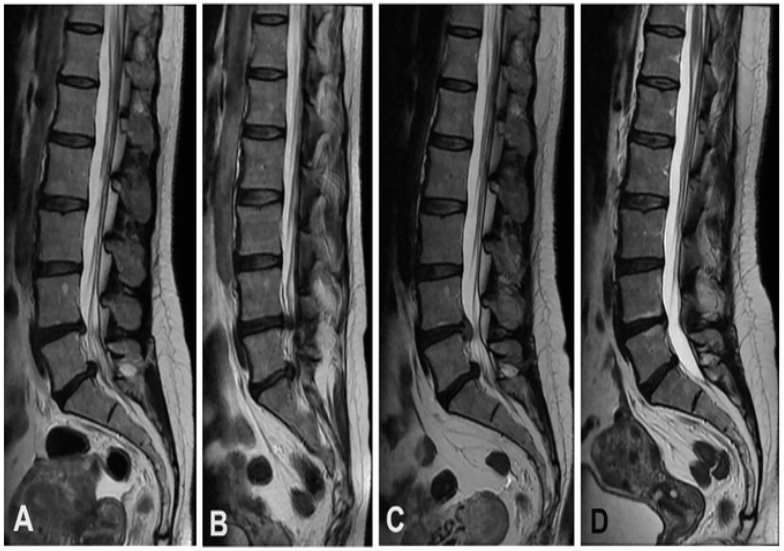


Fig. 3. MRI images in the sagittal plane: sagittal T2-weighted MRI images taken after the onset of the first symptoms in October 2022 (A), after initial visit in April 2023 (B), 2 months from the start of the treatment program in July 2023 (C) and 1 month after its completion in December 2023 (D).

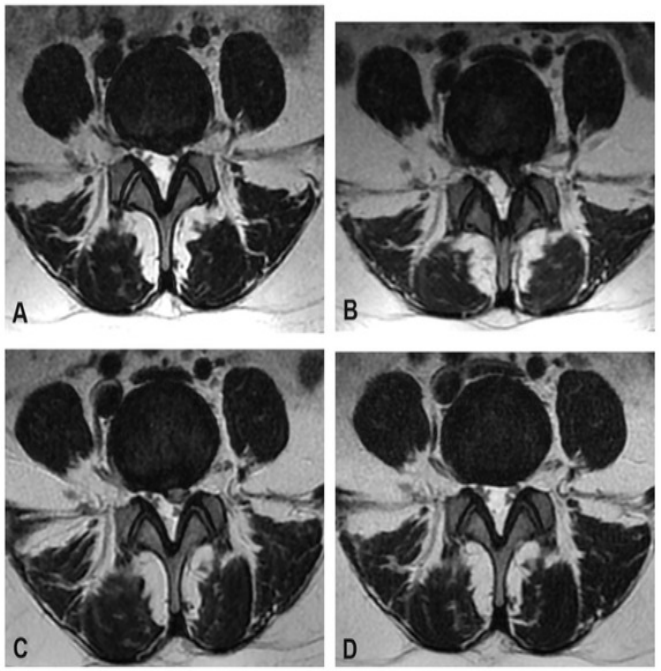


Fig. 4. MRI images at the L4-L5 level in the axial plane: axial T2-weighted MRI images at the L4-L5 level taken after the onset of the first symptoms in October 2022 (A), after initial visit in April 2023 (B), 2 months from the start of the treatment program in July 2023 (C) and 1 month after its completion in December 2023 (D).

Given the extensive number of sessions and the resultant time and financial demands of the treatment program, the advantage of non-invasive treatment over surgery may be questioned. It would be valuable to compare both approaches in terms of the costs associated with treatment and subsequent recovery. However, this comparison falls outside the scope of the current report and should be addressed by future research. This report aims to highlight the potential of a non-invasive approach for patients who decline surgical intervention as their sole treatment option. Patients who are unable or unwilling to undergo surgery and the associated hospitalization should have access to an alternative non-invasive approach.

The image processing methods utilized in this study, which allow for the quantitative monitoring of structural changes, are not routinely employed in clinical diagnostics. This is due to the fact that the accuracy of these relatively time-consuming measurements partially depends on the evaluator's skill and experience. Additionally, MRI examinations are not typically included in the standard diagnostic workup for patients presenting with LDH symptoms. However, it is believed that integrating these methods into research could enhance their adoption, refinement, and subsequent validation. Future application of similar techniques is recommended, particularly in the context of developing decision-making tools that tailor treatment programs based on MRI findings. Current research underscores that symptom severity alone is an insufficient guide for determining treatment, as it does not always correlate with underlying structural changes [21].

Given the presumed low incidence of multi-level disc herniations and the significant time commitment required for an intensive non-invasive treatment program, conducting large-scale clinical research in this area presents a considerable challenge. Furthermore, many patients presenting with LDH symptoms at physiotherapy clinics may not undergo MRI as part of their routine evaluation, potentially leaving multi-segment herniations undiagnosed. Nevertheless, it would be valuable to statistically compare the outcomes of patients undergoing intensive NSSD therapy with those receiving standard conservative treatments. Assessing correlations between therapy outcomes and demographic and clinical factors - such as time since symptom onset, herniation size and location, body mass index, and patient age - could lead to the development of a decision-making tool that better informs whether non-invasive therapy or surgical intervention is the more appropriate course of action.

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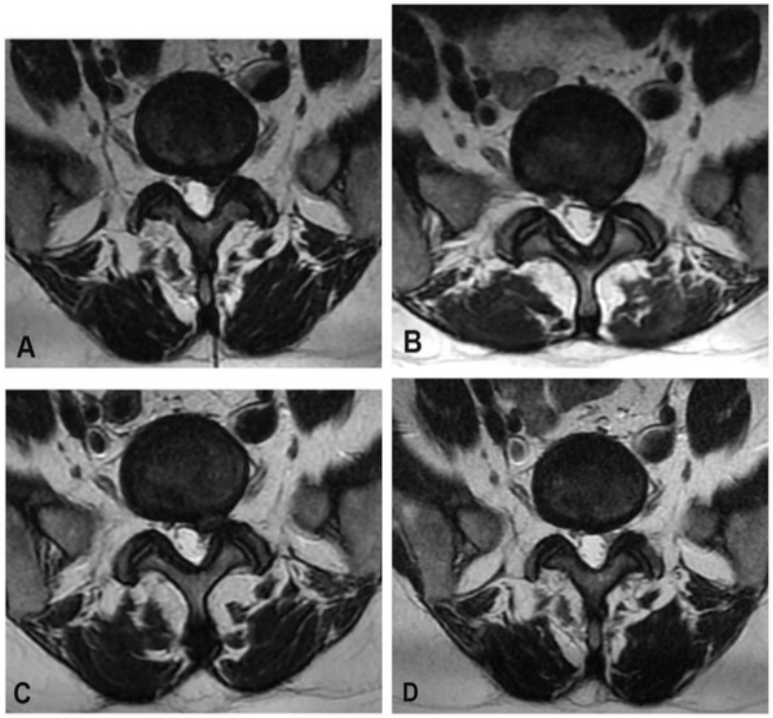


Fig. 5. MRI images at the L5-S1 level in the axial plane: axial T2-weighted MRI images at the L5-S1 level taken after the onset of the first symptoms in October 2022 (A), after initial visit in April 2023 (B), 2 months from the start of the treatment program in July 2023 (C) and 1 month after its completion in December 2023 (D).

Table 2
Values of parameters obtained by analysis of MRI images taken after the onset of the first symptoms (October 2022), after initial visit (April 2023), 2 months from the start of the treatment program (July 2023) and 1 month after its completion (December 2023).

Parameter		October 2022	April 2023	July 2023	December 2023
Herniation AP length (mm)	L4-L5	4.54	7.40	5.4	2.00
	L5-S1	5.68	5.80	5.26	1.56
Herniation area (mm^2)	L4-L5	47.03	94.72	55.66	28.00
	L5-S1	50.33	55.09	49.23	23.66
Canal AP* length (mm)	L4-L5	14.53	10.20	12.99	17.32
	L5-S1	7.79	8.25	8.54	12.58
Canal area (mm^2)	L4-L5	160.09	141.12	148.36	185.20
	L5-S1	154.97	144.81	155.3	181.06
HI	L4-L5	143.06	299.67	159.96	67.94
	L5-S1	97.54	163.12	103.47	57.64

AP: Anteroposterior.

Conclusions

MRI analysis of structural changes in the intervertebral disc and spinal canal revealed that significant improvements can be achieved in patients with substantial herniations at multiple levels through a non-invasive approach. These findings underscore the potential of an intensive treatment regimen centered on NSSD therapy, presenting a viable alternative for patients who are either unwilling or unable to undergo surgical intervention. Further large-scale research in the treatment of patients with multi-level LDH, combined with the development of objective evaluation methods, could pave the way for establishing a decision-making tool. Such a tool would guide patients in choosing between invasive surgical procedures and non-invasive therapeutic options.

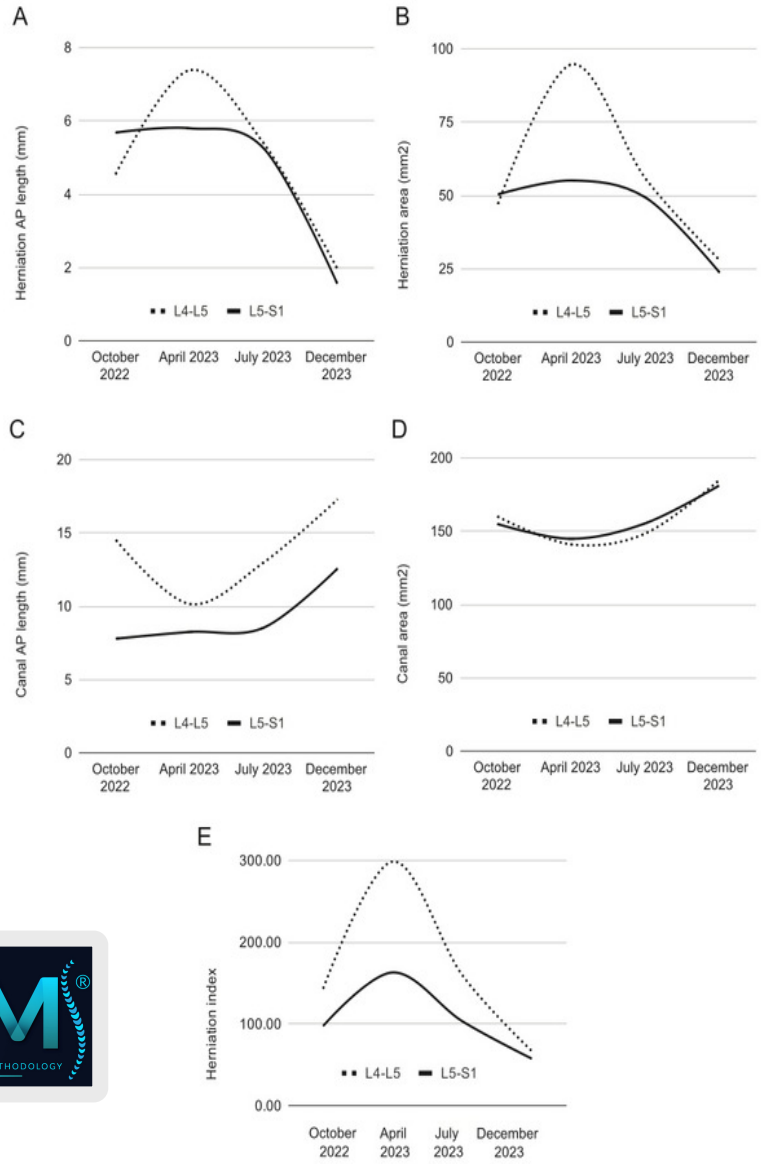


Fig. 6. Graphs of structural changes: Visualization of the course of structural changes using monitored parameters obtained from the analysis of MRI images taken after the onset of the first symptoms in October 2022, after initial visit in April 2023, 2 months from the start of the treatment program in July 2023 and 1 month after its completion in December 2023.

CRediT authorship contribution statement

Vincenzo Di Modica: Writing – original draft, Methodology, Investigation, Conceptualization. **Giuseppe J. Sciarrone:** Software, Methodology, Investigation.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Vincenzo Di Modica reports a relationship with BTL Industries Ltd. that includes: speaking and lecture fees. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Case Reports & Case Series

Effect of an intensive non-invasive program including spinal decompression on MRI-assessed structural changes in cervical disc herniation

Vincenzo Di Modica [a,*], Giuseppe J. Sciarrone [b]

[a] Director of Rehabilitation Center BioSalus, Via A. Manzoni, 129, 87036 Surdo di Rende, Italy
[b] Neurosurgeon and Director of Spine and Robotic Surgery Center Humanitas Pio X, Via Francesco Nava, 31, 20159 Milan, Italy

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ABSTRACT

Background: Despite the critical role of the cervical spine, evidence describing the effectiveness of specific non-invasive protocols for treating cervical disc herniation (CDH) remains limited, even though these approaches are often preferred over surgical solutions. The aim of the present case series study is to present the results of an intensive non-invasive treatment program primarily based on non-surgical spinal decompression (NSSD) therapy, evaluated using objective MRI image processing methods.
Materials and methods: Three subjects diagnosed with CDH through MRI, exhibiting radiculopathy symptoms, and unresponsive to standard physiotherapy, participated in an extensive non-invasive treatment protocol lasting for a period ranging from three to five months. Progress was monitored by quantitative evaluation of structural changes observed on MRI scans taken before and after treatment.
Results: Quantitative indicators confirmed an improvement in the extent of CDH in all patients who underwent the intensive treatment program, ranging from approximately 32% to 55%.
Conclusions: This case series suggests that an intensive, non-invasive protocol incorporating NSSD therapy may promote symptom relief in CDH, with MRI observations indicating possible structural changes. However, due to inherent study limitations, generalizable conclusions or assessments of NSSD's overall efficacy for CDH cannot be established. Larger-scale investigations, with expanded patient cohorts and a control group, are needed to validate these preliminary findings and determine the therapeutic impact of NSSD on CDH with greater accuracy.

1. Background

Among the five spinal regions, the cervical spine is of particular importance due to its proximity to the brain and critical neurovascular structures, including the spinal cord and vertebral arteries supplying the posterior brain [1]. Neck pain affects 10–30 % of adults globally, contributing significantly to disability and socioeconomic burden. It can be classified by duration: acute cases often result from trauma, while subacute and chronic cases have mechanical or neuropathic causes, including stenosis, nerve compression, and disc herniation, which may lead to cervical radiculopathy and myelopathy [2,3]. Symptomatic cervical disc herniation (CDH), most common at the C6-7 level, compresses nerve roots (typically C7), leading to symptoms like triceps weakness and finger paresthesia [4]. CDH is more frequent in women (about 60 % of cases) and peaks in the fifth decade of life [5]. Treatment begins conservatively, including rest, pharmacotherapy (NSAIDs, corticosteroids, muscle relaxants), and physical therapy, progressing to surgery if symptoms persist or worsen after 6–12 weeks, with approximately 26 % of cervical radiculopathy cases requiring surgery [6–8].

Despite the critical importance of the cervical spine, clinical research on CDH trails behind lumbar disc herniation (LDH) due to its significantly lower prevalence [4,9]. High-quality studies on non-invasive treatment effectiveness are limited, even though these treatments are generally preferred over surgical options [10]. While systematic reviews highlight the lack of rigorous studies on therapeutic exercises for neck pain and associated conditions, there is evidence suggesting that strengthening exercises benefit chronic neck pain and related issues, while stretching exercises show limited effect [11,12]. Notably, while surgery provides short-term advantages for cervical radiculopathy over physiotherapy, long-term outcomes appear similar [13]. In addition to conservative methods for treating disc herniation symptoms, a new technological approach called non-surgical spinal decompression (NSSD) is gaining popularity.

NSSD involves mechanical decompression of the affected spinal

* Corresponding author.
E-mail address: vincenzodimodica@live.it (V. Di Modica).

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Table 1
A detailed protocol schedule of treatment procedures for individual patients.

	Patient 1	Patient 2	Patient 3
1st month	NSSD: 3 times/ week CP: 3 times/ week	NSSD: 5 times/ week CP: 5 times/ week	NSSD: 3 times/ week CP: 5 times/ week
2nd month	NSSD: 3 times/ week CP: 2 times/ week	NSSD: 3 times/ week CP: 3 times/ week	NSSD: 3 times/ week CP: 3 times/ week
3rd month	TE: 2 times/ week	NSSD: 2 times/ week CP: 2 times/ week TE: 2 times/ week	NSSD: 3 times/ week CP: 2 times/ week
4th month	–	–	NSSD: 2 times/ week CP: 2 times/ week
5th month	–	–	NSSD: 2 times/ week TE: 2 times/ week

NSSD: Non-surgical spinal decompression, CP: Conventional physiotherapy, TE: Therapeutic exercises.

segment using a positioning system and controlled decompression forces. It may produce structural changes—such as reduced disc herniation volume and increased intervertebral space—detectable via MRI. Additionally, by stretching surrounding soft tissues, NSSD may improve spinal mobility and function [14]. During cervical therapy, the patient's head is stabilized using an integrated cervical slider, enabling precise positioning and controlled decompression of the affected spinal segment [15].

Unfortunately, the available clinical evidence on NSSD is relatively weak and focuses primarily on treating subjective symptoms such as pain and disability [13,16–18]. There is a lack of studies investigating the direct effect of this non-invasive method on the extent of herniation. Ma et al. reported pain and disability reductions of 21 % and 14 %, respectively, using the visual analog scale (VAS) and the neck disability index (NDI) in a sample of 10 patients [16]. Similarly, Arumugam et al., in a study with a control group, observed comparative improvements of 24 % in pain and 19 % in disability between groups [18]. Kim et al. also evaluated pain and quality of life, but combined patients with cervical and lumbar disc herniations, limiting the specificity of findings to CDH [17]. Their study concluded that NSSD combined with traditional Korean medicine was more effective than Korean medicine alone. Henry focused on pain levels in patients with CDH and LDH, noting an average VAS reduction of 4.2 points [13]. In the studies reviewed, patients typically underwent between 9 and 20 sessions of NSSD, which is fewer than the session count for any patient in the current case series. Progress in these studies was primarily tracked through subjective symptom assessments, and none concentrated on quantifying structural changes or evaluating these changes in objective detail.

This case series presents outcomes of patients with cervical radiculopathy treated through an intensive, non-invasive program centered on NSSD, supplemented by conventional physiotherapy. Outcomes include both symptom assessment and quantitative evaluation of herniation via MRI-based image analysis.

2. Methods

Three patients with left cervicobrachialgia, unresponsive to pharmacotherapy and conventional physiotherapy, underwent an intensive treatment program combining NSSD and supportive physio modalities. Before initiating the treatment program, all patients underwent a functional examination to assess radiculopathy, indicating potential nerve irritation in the cervical spinal segment. Patients with persistent symptoms after completing conventional physiotherapy, and whose radiculopathy diagnosis was confirmed via MRI, were invited to participate in an intensive non-invasive treatment program centered on NSSD therapy. Eligibility required that participants opted for a non-surgical approach and presented no contraindication including any condition for which movement is contraindicated, malignant bone tumors, fractures, joint inflammation, spastic paralysis, osteoporosis, or meningeal signs. Additional exclusion criteria included pregnancy, hernia, cardiac or pulmonary insufficiency, hemorrhagic disorders, infectious diseases, and claustrophobia.

MRI confirmed herniated discs at the C5-C6 or C6-C7 levels in all patients who agreed to an intensive treatment protocol and the possible publication of its results by signing an informed consent. The protocol was approved by the local ethics committee Comitato Etico Regione Calabria (11125 DEL 01/08/2023) under registration number 251/2024.

The treatment program was individualized based on the patient's current condition and progress, with a duration ranging from three to

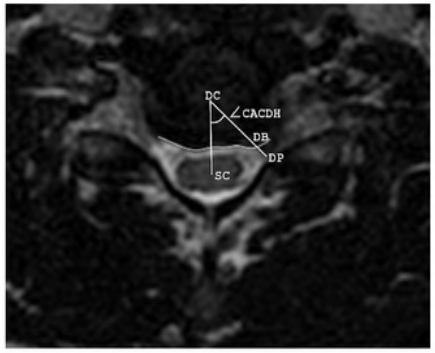
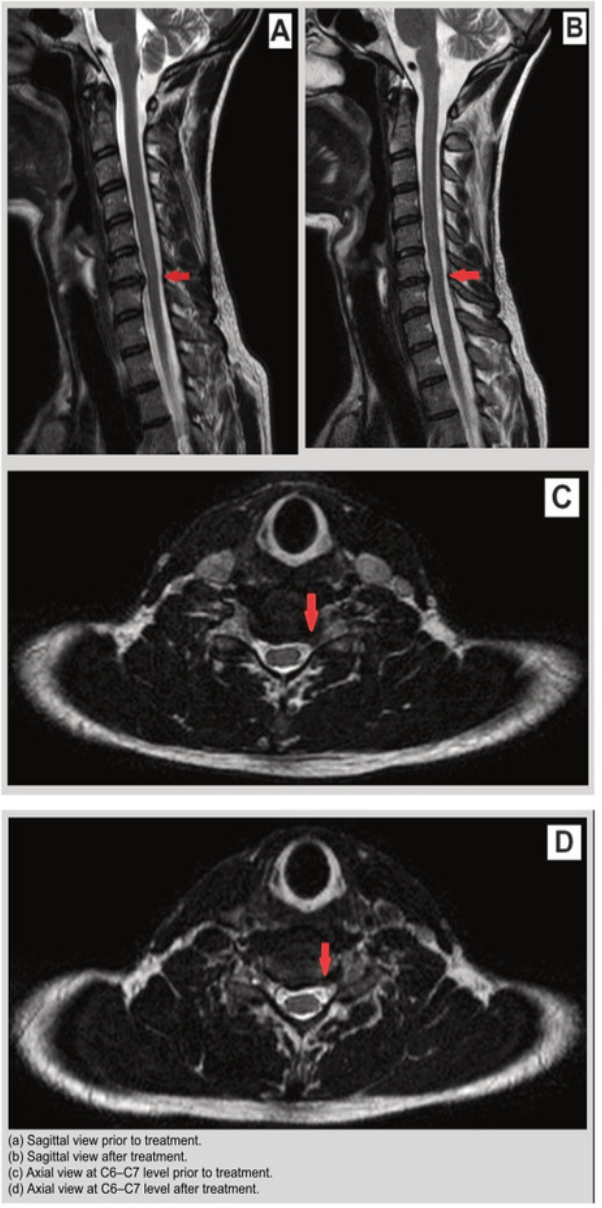


Fig. 2. Visualization of the measurement methodology used to evaluate the degree of herniation: Point DC represents the center of the cervical disc, SC the center of the cervical cord, DP the peak of the herniated disc, and DB the border of the cervical disc. The angle CACDH corresponds to the central angle of cervical disc herniation.



Fig. 1. Patient positioning during the NSSD session.



(a) Sagittal view prior to treatment.
(b) Sagittal view after treatment.
(c) Axial view at C6–C7 level prior to treatment.
(d) Axial view at C6–C7 level after treatment.

Fig. 3. T2-weighted MRI images of patient 1. Red arrows indicate the area of disc herniation. (a) Sagittal view prior to treatment. (b) Sagittal view after treatment. (c) Axial view at C6–C7 level prior to treatment. (d) Axial view at C6–C7 level after treatment.

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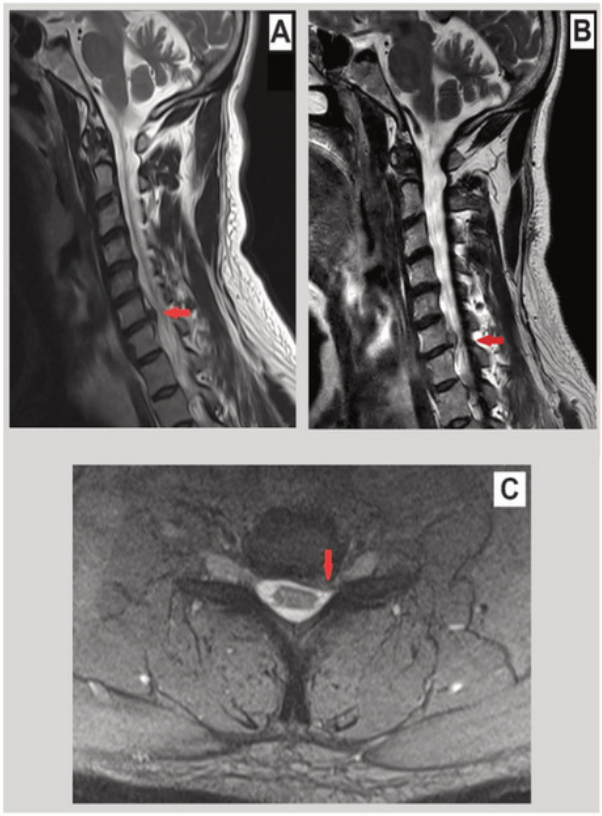


Fig. 4. T2-weighted MRI images of patient 2. Red arrows indicate the area of disc herniation. (a) Sagittal view prior to treatment. (b) Sagittal view after treatment. (c) Axial view at C6–C7 level prior to treatment. (d) Axial view at C6–C7 level after treatment.

five months. In addition to NSSD sessions, it included conventional physiotherapy (CP) and therapeutic exercises (TE). The treatment frequencies for individual patients throughout the entire course are summarized in Table 1.

NSSD therapy was administered in a supine position on a spinal decompression couch equipped with a built-in cervical adapter (BTL Industries, Ltd.), allowing precise delivery of decompression force to the herniated segment with minimal discomfort and pain (Fig. 1). Prior to applying the decompression force, the treated area was heated using a built-in heating system integrated into the bed, facilitating muscle relaxation. The patient's head was then secured in the cervical adapter, and the couch's adjustable components were positioned to ensure both patient comfort and the appropriate angle to effectively target the affected cervical spine segment.

Decompression force and speed were set according to the patient's body constitution, extent of herniation and pain level, not exceeding 20 % of the patient's body weight. Another fundamental element of the protocol was the precise positioning of the cervical slide's angle of inclination, which was adjusted within a 0–30° range to target specific cervical segments. For instance, to treat the C6–C7 level, the slide was set at a 20° tilt, enhancing the selectivity and effectiveness of the decompression force. Prior to the therapy, a tolerance test was conducted to assess tolerability of the settings using a specified pulling force and velocity, with a sequence of three pulls, each followed by a 3-second pause. For the therapy itself, a manufacturer-defined protocol comprising three distinct phases was employed:

1. **Warm-up phase**: This sequence provided gradual and incremental application of traction forces, facilitating patient adaptation to the treatment.
2. **Therapeutic phase**: During this sequence, traction forces varied in a controlled manner, inducing alternating tissue tension and relaxation to achieve therapeutic effects.
3. **Cool-down phase**: This final sequence gradually reduced traction forces, supporting the patient's adaptation and promoting a controlled return to baseline.

Post-therapy, patients remained in a supine position for at least half the therapy duration to stabilize the treatment effects. The entire NSSD session did not exceed 30 min. Conventional physiotherapy involved the application of various energy modalities (BTL Industries, Ltd.), which provided a synergistic effect, resulting in muscle relaxation, enhanced



(a) Sagittal view prior to treatment.
(b) Sagittal view after treatment.
(c) Axial view at C6–C7 level prior to treatment.
(d) Axial view at C6–C7 level after treatment.

Fig. 4. (*continued*).

tissue blood flow, pain reduction, and accelerated regeneration of the treated area. Therapeutic exercises were incorporated during the final month of the treatment program to maintain and stabilize the achieved outcomes. Patients were monitored for a duration of 3 months following the conclusion of the treatment program to assess the potential persistence or recurrence of radiculopathy symptoms. Symptom monitoring included assessments through various validated methods: pain was measured using the Visual Analog Scale (VAS), muscle strength was evaluated via the Medical Research Council (MRC) scale, and the presence of cervicobrachialgia was identified using functional tests, such as Mingazzini's sign [19–21].

The MRI T2-weighted images in a transverse plane were subjected to advanced image processing (MicroDicom DICOM Viewer 2023.3 x86) to quantify the extent and location of the herniation using multiple indicators:

- **Modified disc herniation index (mDHI):** The Disc Herniation Index (DHI), initially introduced by Fagerlund et al. to assess the degree of lumbar disc herniation, was modified to enhance its suitability for cervical measurements [22]. The mDHI was defined by Liu et al. as follows [23]:

$$mDHI = \frac{(DCDP - IDC)}{DCSC}$$

Where:

- DCDP stands for the distance between the center of the cervical disc (DC) and the peak of the herniated disc (DP). This measurement indicates the relative position of the herniation in relation to the spinal cord and cervical disc, accounting for the irregular shape of the herniation.
- DCSC represents the distance between the DC and the center of the cervical cord (SC).
- IDC refers to the internal diameter of the disc, defined as the length from the DC to the intersection of the DCDP line and the border of the cervical disc (DB). This parameter serves as the benchmark for calculating the degree of herniation.
- **Axial length of CDH:** This parameter is defined as the difference between the DCDP and IDC distances. It reflects the size of the protruded part of the disc on the cross-sectional plane and indicates the absolute degree of CDH.
- **Central angle of cervical disc herniation (CACDH):** This parameter is intended for the quantitative evaluation of the CDH position and is defined by the angle between the DCSC and DCDP lines.

For improved clarity, the specific points used for measuring and evaluating the aforementioned quantitative parameters are illustrated in Fig. 2.

3. Results

Three subjects diagnosed with cervical disc herniation through MRI, and unresponsive to standard physiotherapy, participated in an extensive non-invasive treatment protocol spanning from October 2023 to April 2024. Each patient exhibited symptoms of left cervicobrachialgia for a duration of one to two months prior to commencing the intensive treatment regimen. MRI images depicting impaired cervical segments in individual patients are presented in Fig. 3a-d, Fig. 4a-d, and Fig. 5a-d. Table 2 displays patient demographics and symptom presence during the monitored period.

While the improvement from the descriptive assessment of the most MRI images is evident, it does not permit a quantitative comparison of the changes achieved. Consequently, the images underwent further analysis using advanced image processing techniques detailed earlier. The measured values and the percentage changes of key indicators for each patient are presented in Table 3.

Quantitative indicators confirmed an improvement in the extent of cervical disc herniation (CDH) in all patients who underwent the intensive treatment program. Despite following the most rigorous treatment plan, patient 3 showed the least progress, with an improvement of approximately 32 % in terms of mDHI and axial length of the CDH. The improvement was substantiated by the resolution of radiculopathy symptoms in all patients, which persisted for up to 3 months following the conclusion of the treatment program.

4. Discussion

While most clinical evidence on NSSD focuses on subjective

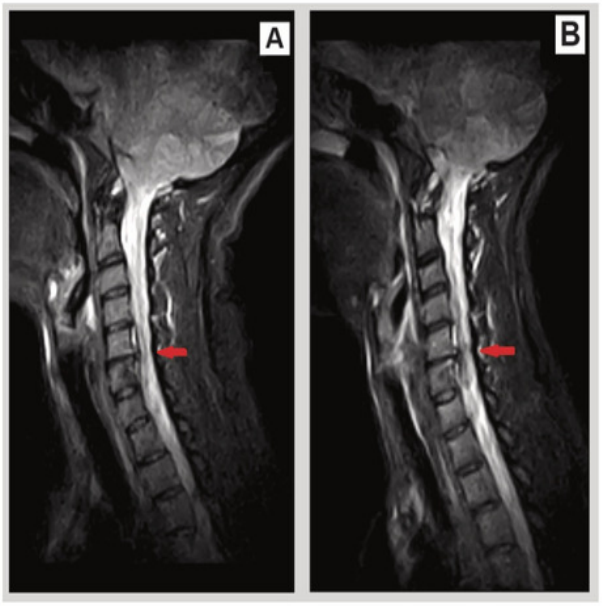


Fig. 5. T2-weighted MRI images of patient 3. Red arrows indicate the area of disc herniation. (a) Sagittal view prior to treatment. (b) Sagittal view after treatment. (c) Axial view at C5–C6 level prior to treatment. (d) Axial view at C5–C6 level after treatment.

Table 2
Primary patient attributes and the assessment of symptoms performed before and 3 months after the treatment program.

	Patient 1	Patient 2	Patient 3
Age	36	57	41
Gender	male	male	female
Herniation level	C6-C7	C6-C7	C5-C6
Occupation	office worker	sales agent	lawyer
Symptoms Before	positive Mingazzini's sign left cervicobrachialgia VAS: 6 MRC: 4	positive Mingazzini's sign left cervicobrachialgia VAS: 7 MRC: 3	positive Mingazzini's sign left cervicobrachialgia VAS: 7 MRC: 3
Symptoms After	negative Mingazzini's sign VAS: 0 MRC: 5	negative Mingazzini's sign VAS: 0 MRC: 5	negative Mingazzini's sign VAS: 0 MRC: 5

VAS: visual analog scale; MRC: the medical research council scale for muscle strength.

Table 3
Quantitative analysis results of MRI images taken before the commencement and after the completion of the treatment program.

		Patient 1	Patient 2	Patient 3
mDHI	Before	0.38	0.47	0.34
	After	0.19	0.21	0.23
	Improvement	**50.85 %**	**54.64 %**	**31.90 %**
DCDP (mm)	Before	15.14	19.3	15.81
	After	12.61	15.36	14.18
DCSC (mm)	Before	12.74	15.44	14.92
	After	12.72	15.51	14.94
Internal diameter of the disc (mm)	Before	10.27	12.08	10.78
	After	10.22	12.07	10.75
Axial length of CDH (mm)	Before	4.87	7.22	5.03
	After	2.39	3.29	3.43
	Improvement	**50.92 %**	**54.43 %**	**31.81 %**
CACDH (°)	Before	53.17	47.03	52.6
	After	48.9	42.34	45.84
	Improvement	**8.03 %**	**9.97 %**	**12.85 %**

mDHI: modified disc herniation index; DCDP: distance between the center of the cervical disc (DC) and the peak of the herniated disc (DP); CDH: cervical disc herniation; CACDH: Central angle of cervical disc herniation.

symptoms of CDH, this case series explores its potential to address structural changes, evaluated objectively via MRI. Three patients who completed an intensive non-invasive NSSD-based treatment showed significant improvement.This was evidenced by a 32–55 % reduction in axial herniation length and a decrease in the modified disc herniation index for the cervical spine. The CACDH angle also changed, though it reflects lesion location rather than therapeutic progress.

Treatment outcomes varied among patients, with the most intensive program yielding the least quantitative improvement—yet subjective symptom relief was comparable. Factors such as herniation level (C5-C6 vs. C6-C7), baseline severity, herniation extent, symptom onset, and individual anatomy may influence structural changes seen on MRI. Given the limited clinical evidence for cervical NSSD, further research is needed to clarify the link between subjective outcomes and objective imaging findings.

Study conclusions align with prior research demonstrating NSSD's benefits in CDH symptom relief. Henry's research highlighted the positive impact of NSSD on pain relief in patients with radiculopathy and chronic spinal pain unresponsive to conventional therapeutic programs [13]. In addition to pain relief, two other studies have demonstrated improvements in disability, and Kim et al. reported enhancements in satisfaction and quality of life [16–18]. Although previous evidence pertains to patients diagnosed with CDH, the results have been based solely on subjective outcome measures. Supporting this, a case study of a patient with multi-segmental CDH provided results validated by MRI images and functional diagnostics, demonstrating the efficacy of NSSD therapy combined with electroacupuncture on the C3-C7 segments of CDH [14]. Limited evidence on NSSD's structural effects in CDH stems from its lower prevalence relative to LDH and the lack of standardized MRI evaluation methods. Treating the cervical area requires a special cervical adapter, which is not standard on all NSSD devices, limiting their use primarily to LDH patients.

Given the small sample size, this study does not aim to generalize NSSD's effectiveness for CDH. It highlights the potential of a non-invasive protocol to reduce CDH based on MRI findings. Existing evidence on NSSD's impact in the cervical region has largely focused on short-term outcomes, leaving its long-term effects on the treated tissues insufficiently established. Although NSSD is widely considered a safe intervention with minimal adverse effects, its long-term safety and sustained efficacy in the treatment of CDH remain subjects for further investigation.

Future research involving larger sample sizes and inclusion of control groups receiving either no treatment or conventional therapy will be essential to confirm these findings. Moreover, a follow-up period of at least six months would be necessary to assess the long-term impact of this non-invasive approach. Supplementing objective MRI image processing methods with standard assessments, including subjective pain, disability, quality of life evaluations, and functional tests, would be beneficial. Moreover, expansion and modification of existing MRI image evaluation methods are under consideration. Due to the three-dimensional structure of CDH, current measurements may be inaccurate in certain cases, and localized herniations may cause deviations. This evaluation method is relatively new, with no existing clinical alternatives.

Analyzing how outcomes relate to herniation characteristics, demographics, and risk factors like age, BMI, and symptom duration could improve patient selection. Comparing treatment costs, recovery time, and impact on daily function between surgery and NSSD could inform a clinical decision-making tool. This would help tailor care to individual patient needs.

Despite its limitations, this is the first study to quantitatively assess NSSD-induced structural changes in CDH. It highlights the potential of an intensive treatment program, incorporating non-invasive physiotherapeutic modalities, to alleviate symptoms and reduce the extent of cervical disc herniation as evidenced by MRI findings. While these preliminary observations are encouraging, they should be interpreted with caution and validated through larger, controlled studies. Nonetheless, the findings may support the inclusion of NSSD within the broader scope of physiotherapeutic interventions for patients with cervical disc herniation who prefer non-invasive management options.

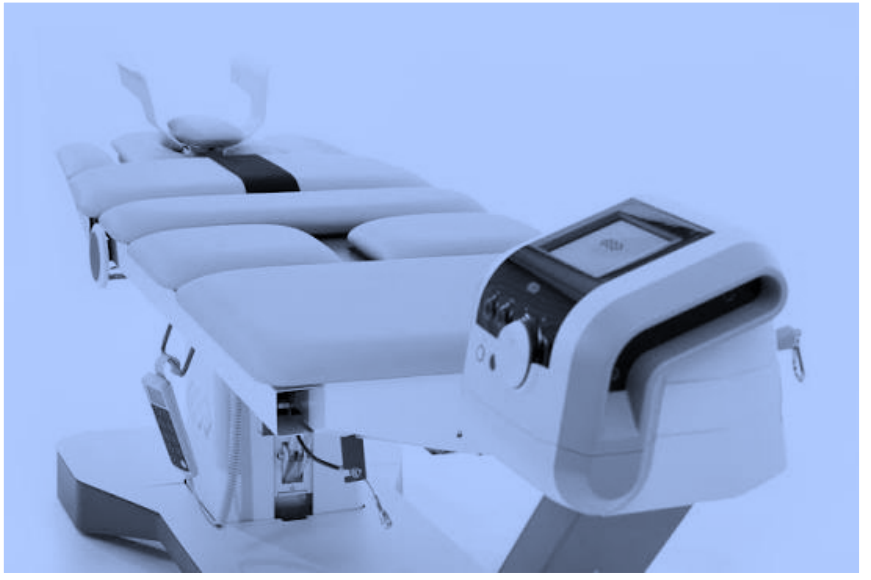
5. Conclusions

Clinical research on non-invasive treatment of CDH has predominantly focused on symptom suppression, with insufficient evidence regarding its direct effect on structural disc changes. The current case series study explores the potential of an intensive non-invasive protocol primarily based on NSSD therapy, highlighting the reduction in herniation extent as evaluated through MRI imaging. The positive results demonstrate this non-invasive method's potential in patients unresponsive to conventional physiotherapy, allowing symptoms alleviation without surgical intervention. Large-scale follow-up research is

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Combined Double-Coil and Handheld rPMS in Low Back Pain: An Observational Case Series Based on Routine Clinical Practice

Vincenzo Di Modica [1,*], Giuseppe J. Sciarrone [2] and Miloš Barna [3]

[1] Director, Rehabilitation Center, BioSalus, Surdo di Rende, Italy; vincenzodimodica@live.it
[2] Neurosurgeon and Director, Spine and Robotic Surgery Centre, Humanitas Pio X, Milan, Italy; sciarron@gmail.com
[3] Head of the rehabilitation medicine clinic Barna Medical, Barna Medical, Prague, Czechia; milosbarna@barnamedical.cz
* Correspondence:vincenzodimodica@live.it

Abstract

Despite the high prevalence of low back pain (LBP), evidence supporting the clinical effects of repetitive peripheral magnetic stimulation (rPMS) remains limited. A combined double-coil and handheld rPMS approach may enhance the therapeutic potential of this technology. This observational case series analyzed prospectively collected routine clinical data from 37 patients treated with a combined protocol of static double-coil lumbar rPMS and dynamic handheld lower-limb rPMS. Pain intensity, disability, and quality of life were assessed at baseline, post-treatment, and 1-month follow-up. Statistical analyses were complemented by evaluation of clinical relevance using established minimal clinically important difference (MCID) thresholds. Significant improvements were observed across all outcomes. Pain decreased by 62.5% post-treatment and by 87.5% at follow-up, while disability was reduced by 86.8% and 92.1%, respectively. Quality of life scores approximately doubled. High MCID responder rates and consistent within-group changes were observed; however, given the single-arm design without a control group, these findings should be interpreted as exploratory and hypothesis-generating rather than confirmatory evidence of treatment effectiveness. This combined rPMS approach was feasible and well tolerated in routine clinical practice and was associated with clinically meaningful within-group improvements in pain, function, and quality of life. Further controlled studies are warranted.

Keywords: Low Back Pain; Electromagnetic Fields; Lumbosacral Region; Buttocks

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1. Introduction

Low back pain (LBP) is one of the most common musculoskeletal conditions worldwide, affecting up to 85% of the population during their lifetime. It is also a leading cause of work-related disability and reduced quality of life [1]. Due to these factors, the management of LBP has significant socioeconomic implications and, for example, in the United States it accounts for the third highest national health expenditure [2]. In most cases, LBP is non-specific and multifactorial, with contributing factors including lumbar disc degeneration, soft tissue strain, impaired movement patterns, and postural dysfunction [3, 4].

Even in cases of persistent or recurrent pain, LBP is not necessarily accompanied by abnormal MRI findings [5]. Symptoms often have a negative impact on daily activities, particularly among individuals in older working-age groups. The burden of disability caused by LBP is greatest among people aged 45-49 years, reflecting its substantial effect on quality of life and productivity during the most active period of life [2]. Moreover, the resulting disability can significantly influence mental health, leading to elevated levels of anxiety and depression, as well as reduced overall well-being [6].

Current treatment strategies for LBP vary widely, ranging from pharmacological management and physiotherapy to more invasive approaches depending on the examination findings. In Europe, physiotherapy remains the predominant treatment method (88%), followed by pharmacological therapy (53%) and surgical interventions (26%) [4].

In addition to conventional treatment methods for LBP, repetitive peripheral magnetic stimulation (rPMS) is becoming increasingly popular. So far, its clinical use has been mainly documented in the treatment of spasticity and motor function in neurological patients after stroke or in those with other neurological disorders such as cerebral palsy or multiple sclerosis [7,8]. In these populations, rPMS primarily targets impaired central motor pathways and neuroplastic mechanisms. More recently, this technique has gained attention in the management of musculoskeletal conditions for pain reduction, improvement of muscle strength, and enhancement of functional performance in daily activities [9]. In the treatment of LBP, however, the evidence for rPMS remains relatively limited, although several studies have demonstrated its effects on pain, disability, postural control, and psychological well-being in patients with LBP [3,10,11]. Importantly, LBP represents a predominantly multifactorial musculoskeletal condition rather than a primary central neurological disorder, and therefore the mechanisms described in neurological populations cannot be directly extrapolated. The proposed mechanism of action in musculoskeletal populations involves neuromuscular activation of superficial muscles, enhancement of local blood flow and proprioceptive input, as well as potential modulation of cortical motor areas involved in postural control and pain perception, although the relative contribution of peripheral and central mechanisms in LBP remains incompletely understood [3,8,11].

Although rPMS is a well-established therapeutic modality, the underlying technology has seen limited innovation [12]. In physiotherapy practice, two types of rPMS applicators are commonly used - the single-coil applicator and the figure-8 applicator, which consists of two coils placed side by side without the possibility of mutual tilting to anatomically conform to the treated area [12,13]. Both applicator types are typically used in a static position, without the option for dynamic adjustment during therapy. While dynamic coil positioning has been explored in experimental transcranial magnetic stimulation (TMS) systems using robotic or electronically controlled arrays [14,15], such approaches have not yet become part of standard therapeutic procedures in physiotherapy Likewise, the clinical effects of a double-coil applicator that allows for mutual tilting of the coils - enabling better anatomical conformity - have only recently begun to be explored in physiotherapy settings. To date, only a limited number of pilot clinical studies have evaluated the effects of double-coil rPMS, reporting positive outcomes in disorders of upper and lower extremity joints, including knee osteoarthritis [16,17]. However, no clinical studies have yet investigated the application of a combined static, tiltable double-coil applicator together with a dynamic handheld applicator in patients with low back pain.

Broader-field stimulation at lower intensity may be preferable for LBP, as rPMS acts through distributed neuromuscular and cortical pathways rather than focal excitation alone [3, 18]. A recent study comparing single- and double-coil rPMS configurations demonstrated that while single coils produce higher stimulation intensity and are more strongly perceived in the lower back region, double-coil applicators cover nearly twice

the area and offer improved patient comfort [19]. Although double coils deliver lower peak intensity, their broader spatial coverage – especially when combined with hand-held dynamic stimulation – may theoretically facilitate more extensive activation of myofascial structures across the lumbopelvic and posterior thigh regions. This expanded stimulation area may enhance neuromuscular modulation and therapeutic outcomes, particularly for indications such as muscle relaxation and postural reconditioning in LBP [20,21]. However, the clinical implications of such combined stimulation remain insufficiently explored.

Moreover, LBP is not always isolated to the lumbar region. Up to 68% of musculoskeletal patients experience pain affecting multiple regions, most commonly involving both the lumbar and gluteal or lower-limb areas [22,23]. In some cases, dysfunction of the gluteal muscles may also contribute to LBP, primarily due to muscle weakness, altered activation patterns, and increased fatigability [23–25]. Impaired load transfer from the gluteal region to the lumbar spine may represent a contributing factor or even a source of LBP [26]. A combined therapeutic approach that stimulates not only the lumbar area but also dynamically targets the gluteal and posterior thigh muscles may therefore better address the myofascial and neuromuscular components of LBP.

Given the limited evidence on combined rPMS protocols targeting both lumbar and lower-limb regions, and the absence of clinical data on tiltable double-coil applicators in musculoskeletal populations, exploratory observational data from routine clinical practice may provide initial insight into the feasibility and potential clinical impact of such an approach.

The aim of observational case series based on prospectively collected routine clinical data was to evaluate the feasibility and preliminary clinical effects of a novel rPMS protocol, rather than to isolate the effects of its individual component.

This approach combines static double-coil lumbar stimulation with dynamic handheld gluteal and posterior thigh stimulation in patients with LBP. This specific combined approach has not been previously described in the literature in patients with LBP Its clinical potential will be interpreted in the context of existing evidence on standard, statically applied rPMS.

2. Materials and Methods

2.1. Study Design

This observational case series was based on prospectively collected data obtained during routine clinical practice to evaluate the feasibility and preliminary effects of a novel rPMS protocol in patients with LBP. The intervention was introduced as part of standard rehabilitation care during a period of clinical implementation of a newly available double-coil rPMS device, and no predefined research hypothesis or trial protocol was established at the time of treatment initiation. The study included only an experimental group and was designed to explore clinical outcomes and patient tolerability under real-world rehabilitation conditions.

Data were analyzed from patients who had undergone the combined rPMS protocol, met all inclusion and exclusion criteria, provided informed consent, and had complete outcome records at all three checkpoints. Clinical outcomes (VAS, ODI, PGIC, SF-12) were systematically recorded at predefined time points as part of internal quality monitoring procedures. The 1-month follow-up assessment was conducted through structured telephone or email communication, during which patients submitted scanned copies of the completed questionnaires identical to those used during in-person assessments. Given the observational design without a control group, the analysis was intended to describe within-group changes rather than to establish causal treatment effects.

The study protocol for secondary analysis of anonymized clinical data was reviewed and approved retrospectively by the local ethics committee Comitato Etico Territoriale

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improvement of local trophism and circulation, (3) analgesic neuromodulation of the affected myofascial areas, and (4) progressive activation of the lumbar and lower-limb musculature as symptoms subsided. The anatomical regions stimulated and the sequence of application were standardized, while intensity was individualized according to patient tolerance.

In both static and dynamic applications, output intensity was initially set below the sensory threshold and gradually increased according to clinical improvement to achieve neuromotor activation. While frequency parameters, pulse shape, and amplitude modulation were predefined within the selected program, output intensity was individualized and adjusted throughout the session based on the patient's tolerance and real-time response.

Participants completed a total of nine sessions (three per week over three consecutive weeks). An example of the therapy setup is shown in Figure 1.



Figure 1. Therapy setup of double-coil rPMS combined with dynamic handheld approach.

2.4. Outcome Measures

Clinical outcomes were assessed using a set of validated self-reported instruments commonly employed in LBP research. All measures were collected at three time points: baseline, post-treatment, and 1-month follow-up.

The following instruments were used:

- Visual Analogue Scale (VAS) for pain intensity: A 10-cm horizontal line ranging from "no pain" to "worst imaginable pain." Scores range from 0 to 10, with higher scores indicating greater pain intensity [27].
- Oswestry Disability Index (ODI): A questionnaire assessing functional disability associated with LBP. The ODI includes ten items, each scored from 0 to 5, with a total score expressed as a percentage (0–100%). Higher scores indicate more severe disability, with 0% representing no disability and 100% indicating maximum limitation [28].

- did not provide relevant outcome data or were only published as abstracts, technical notes, or in non-peer-reviewed formats.

The study identification and selection process is presented using a PRISMA flow diagram to enhance transparency and reproducibility of the search strategy. However, the review was not conducted as a formal systematic review or meta-analysis, but rather as a structured narrative search intended to contextualize the present findings within the available clinical evidence.

2.6. Data Analysis

All statistical analyses were performed using GraphPad Prism version 10 for Windows, GraphPad Software, Inc. Normality of data distribution was assessed using the Shapiro–Wilk test. Outcome measures did not meet the assumption of normality and therefore were analyzed using the non-parametric Wilcoxon Signed Rank Test and reported as median and interquartile range (IQR). Treatment-induced changes were expressed as median change (Δ) (IQR) with Hodges-Lehmann 95% confidence intervals (CI), accompanied by rank-biserial effect sizes (r) and MCID responder rates. The rank-biserial coefficient was used as it represents the natural effect size associated with the Wilcoxon Signed Rank Test and is appropriate for paired, non-normally distributed clinical data. Statistical significance was determined at a threshold of $p < 0.05$. Given the single-arm observational design without a control group, statistical analyses were interpreted as descriptive assessments of within-group change rather than evidence of comparative treatment efficacy.

Sample size was determined by the availability of complete clinical records meeting the inclusion and exclusion criteria. As this study represents an observational case series based on routine clinical data, no a priori power calculation was performed. The analysis should therefore be considered exploratory and hypothesis-generating.

3. Results

3.1. Study Population

A total of 43 patients treated with the combined rPMS protocol at a private outpatient rehabilitation clinic were included based on available clinical records. Six patients were excluded from the analysis due to incomplete outcome data or failure to complete the full treatment program, resulting in a final analytical sample of 37 patients (23 women and 14 men) with a mean age of 48.63 ± 13.95 years. All patients who completed the full treatment program tolerated the intervention well, and no adverse events were documented in the clinical records during or after therapy.

3.2. Clinical Outcomes

The baseline values of the assessed parameters, as well as their changes during treatment and at the 1-month follow-up, are presented numerically in Table 1 and graphically illustrated in Figures 2 and 3.

Table 1. Summary of outcome measures obtained across participants during the treatment course.

		Baseline	Post-treatment	1-month FU
VAS	Median (IQR)	8 (1)	3 (3)	1 (1)
	%Δ	n/a	62.5	87.5
ODI	Median (IQR)	76 (3)	22 (10)	6 (11)
	%Δ	n/a	86.84	92.11
SF-12 PCS	Median (IQR)	27.1 (5.57)	39.03 (5.51)	56.58 (3.22)
	%Δ	n/a	56.58	108.78
SF-12 MCS	Median (IQR)	29.52 (10.52)	52.37 (5.76)	60.76 (0)
	%Δ	n/a	60.76	105.83
PGIC	Median (IQR)	n/a	2 (2)	1 (1)

FU: Follow-up; ODI: Oswestry Disability Index; PGIC: Patient Global Impression of Change; SF-12 PCS = Short Form-12 Physical Component Summary; SF-12 MCS = Short Form-12 Mental Component Summary; VAS: Visual Analog Scale.

All parameters showed statistically significant within-group changes between baseline and post-treatment, as well as between baseline and the 1-month follow-up (Wilcoxon Signed Rank Test, $p < 0.001$). Improvements observed post-treatment were maintained at follow-up, with further numerical changes recorded across several outcomes.

Table 2. Summary of within-subject changes, effect sizes, and MCID responder rates. Values represent median change (Δ) with interquartile range (IQR) in parentheses and Hodges-Lehmann 95 % confidence intervals (CI) in brackets. Effect sizes are expressed as rank-biserial correlation (r), with values of approximately 0.1, 0.3, and ≥0.5 interpreted as small, moderate, and large effects, respectively. Values approaching ±1 indicate that most patients changed in the same direction. The MCID (minimal clinically important difference) threshold and the proportion of patients exceeding MCID (% ≥ MCID) are provided to illustrate clinical relevance. Negative Δ values indicate improvement for pain and disability scores (VAS, ODI), while positive Δ values indicate improvement for quality-of-life scores (SF-12 PCS and MCS).

		Median Δ (IQR) [HL 95 % CI]	Effect size	MCID	% ≥ MCID
VAS	Post-Baseline	−5 (−6 ; −3) [−5.5; −4.5]	-1.00	≥ 2 points	94.59%
	FU-Post	−2 (−4 ; −1) [−3.5; −2.0]	-1.00		70.27%
	FU-Baseline	−8 (−9 ; −7) [−8.0; −7.0]	-1.00		97.3%
ODI	Post-Baseline	-49 (−59 ; −17) [−52.5; −40.0]	-1.00	≥ 10 points	94.59%
	FU-Post	−17 (−22; −15) [−22.0; −15.0]	-0.96		89.19%
	FU-Baseline	−70 (−83; −33) [−72.0; −58.0]	-1.00		97.3%
SF-12 PCS	Post-Baseline	12.46 (9.58 ; 18.00) [10.29; 14.64]	1.00	≥ 3.4 points	89.19%
	FU-Post	15.98 (12.80 ; 17.55)	0.99		91.89%

		[13.08; 17.29]			
	FU-Baseline	27.27 (23.96 ; 30.01) [25.62; 28.37]	1.00		100%
SF-12 MCS	Post-Baseline	18.17 (14.24 ; 24.23) [14.24; 21.69]	0.97	≥ 4 points	81.08%
	FU-Post	8.39 (4.18 ; 11.81) [6.42; 10.45]	1.00		75.68%
	FU-Baseline	28.41 (25.22 ; 36.14) [21.80; 31.87]	1.00		100%

FU = follow-up; HL = Hodges–Lehmann; MCS = Short Form-12 Mental Component Summary; ODI = Oswestry Disability Index; PCS = Short Form-12 Physical Component Summary; VAS = Visual Analog Scale.

Analyses of treatment-induced changes, effect sizes, and MCID responder rates are presented in Table 2. Rank-biserial effect sizes approached ±1 across all analyzed intervals, indicating that the vast majority of patients changed in the same direction. MCID responder rates exceeded 90 % for most outcomes, and for the SF-12 scores between baseline and one-month follow-up reached 100 %.

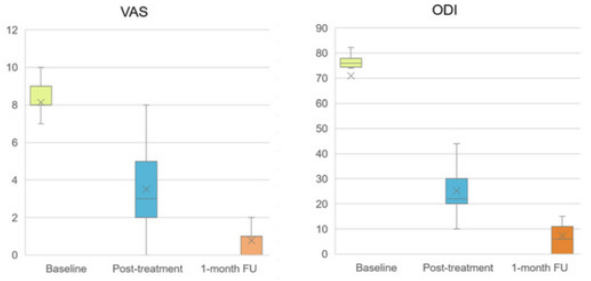


Figure 2. Box plots illustrating the course of: (a) VAS and (b) ODI throughout the treatment period and at the 1-month follow-up. The boxes represent the interquartile range, the horizontal line indicates the median, and whiskers denote the minimum and maximum values.

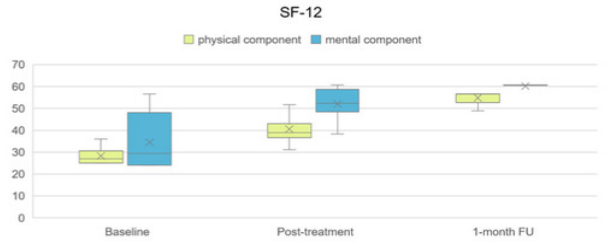


Figure 3. Box plot illustrating the course of SF-12 physical and mental component throughout the treatment period and at the 1-month follow-up. The boxes represent the interquartile range, the horizontal line indicates the median, and whiskers denote the minimum and maximum values.

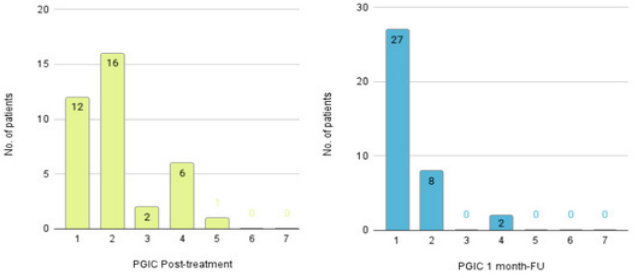


Figure 4. Histogram illustrating Patient Global Impression of Change (PGIC) scores (a) immediately after completion of the final treatment session and (b) at the 1-month follow-up. PGIC scores range from 1 (very much improved) to 7 (very much worse), with lower scores indicating greater perceived improvement.

The PGIC score improved during the follow-up period from "Much improved" (median: 2; IQR: 1.16) to "Very much improved" (median: 1; IQR: 1). Immediately after completion of the treatment, 92% of patients rated their condition as subjectively improved, increasing to 100% at the 1-month follow-up (Figure 4).

3.3. Results of the Literature Review

A total of 49 records were identified. After removing duplicates and screening titles and abstracts, 13 studies were selected for full-text review. Of these, 4 studies met all inclusion criteria and were included for narrative comparison. The screening process is summarized in the PRISMA flow diagram (Figure 5), and the characteristics of the included studies are presented in Table 3 [34].

Table 3. Summary of studies identified in the literature search, including study design, patient population, intervention protocols, and reported outcomes.

Study	Design	Indication	n	Protocol	Outcome	Results
Tammasse et al. 2021	RCT	CLBP	30 (15/15)	5x30min	ISI, NPRS	ISI: 33.6 % vs 7% NPRS: 29.7% vs 20.3%
Kim & Nam 2021	RCT	CLBP	30 (15/15)	20x10min	VAS, KODI, SF-36	VAS: 58.3 % vs 12.5 % KODI: 44.4 % vs 2.7% SF-36: -0.35% vs -1.32%
Jiravichitchai 2024	RCT	CLBP	30 (15/15)	3x15min	VAS, ODI, RMDQ	VAS (post): 52.1 % vs 25.0 % VAS (FU): 45.8 % vs 25.0 % ODI (FU): 43.2 % vs 14.7 % RMDQ (FU): 3.0 pt vs 2.0 pt
Lim et al. 2018	Pilot RCT	Acute LBP	26 (13/13)	10x20min	VAS, ODI, RMDQ	VAS: 57.5 % vs 42.17% ODI: 55.4 % vs 29.25% RMDQ: 65.55% vs 44.09%

CLBP: Chronic Low Back Pain; ISI: Insomnia Severity Index; KODI: Korean Oswestry Disability Index; LBP: Low Back Pain; NPRS: Numeric Pain Rating Scale; ODI: Oswestry Disability Index; RCT: Randomized Controlled Trial; RMDQ: Rolland Morris Disability Questionnaire; VAS: Visual Analog Scale.

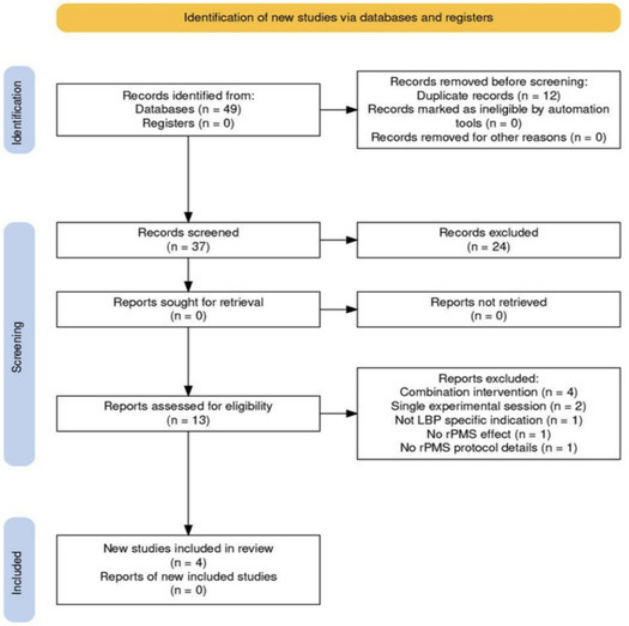


Figure 5. Flow diagram of study identification, screening, eligibility, and inclusion.

4. Discussion

This observational case series based on routine clinical data supports the feasibility of a therapy combining static double-coil and dynamic single-coil rPMS for the treatment of LBP within a real-world rehabilitation setting. The findings suggest potential associations with reductions in pain and disability and improvements in quality of life. Importantly, the aim of the present study was to evaluate the combined rPMS protocol as applied in routine clinical practice, rather than to isolate the effects of its individual components.

The clinical relevance of the observed treatment-induced changes was further supported by the calculated effect sizes and MCID responder rates. Rank-biserial effect sizes approached ±1 across all comparisons, indicating that the vast majority of patients changed in the same direction. In addition, more than 95% of patients exceeded the MCID thresholds across all measures between baseline and the one-month follow-up. However, given the single-arm design without a control group, these findings reflect within-group improvement and cannot establish causal treatment efficacy.

Although direct comparison of treatment efficacy across different studies is methodologically limited, the results were contextualized within the existing clinical evidence to provide a pilot-level interpretation of the novel rPMS approach. The present

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review identified four randomized controlled trials on rPMS for LBP, each with sample sizes ranging from 13 to 15 patients per group [11, 35-37]. Reported protocols varied considerably, with the number of treatment sessions ranging from 3 to 20 and stimulation times between 5 and 30 minutes. Importantly, none of these studies included follow-up beyond one week. For example, Jiravichitchai et al. observed an initial improvement after treatment but reported deterioration of outcomes within seven days. Such heterogeneity, together with the absence of longer-term evaluation, makes it difficult to draw consistent conclusions regarding rPMS protocols in LBP. In addition, many potentially relevant studies had to be excluded from the review due to co-interventions such as exercise or injections, which would have confounded the isolated effects of rPMS. Overall, the current body of evidence is characterized by small scale, methodological diversity, and a historical focus on neurological rather than musculoskeletal applications.

Against this background, the present case series provides preliminary real-world data on a combined stimulation protocol not previously described in musculoskeletal LBP. The inclusion of 37 patients offers feasibility insight within routine practice. In contrast to earlier work, which terminated follow-up within days, we extended observation to one month with maintained improvements in pain, disability, and quality of life. Furthermore, the applied protocol - combining a static dual approach with dynamic manual stimulation and extending treatment to both the lumbar spine and lower limbs - represents a novel approach that addresses both axial and peripheral contributors to pain. While numerical reductions in pain and disability appeared greater than those reported in some prior small RCTs, such cross-study comparisons are inherently limited and must be interpreted cautiously due to differences in study design, baseline severity, treatment parameters, and outcome reporting. The observed progression of improvement at follow-up may reflect continued neuromuscular adaptation; however, alternative explanations such as regression to the mean, natural fluctuation of chronic pain, patient expectation, or contextual therapeutic effects cannot be excluded.

The clinical rationale for including lower limb stimulation is supported by previous work in other treatment modalities. Although Forbes did not confirm additional benefit from combining lumbar and subtalar manipulation, more recent findings by Cai et al. and Krawczyk-Wasielewska et al. showed that treatment protocols involving the lower extremities may provide additional improvements in pain relief and functional capacity [38-39]. These results are consistent with the concept of convergent innervation and overlapping pain pathways and suggest that combined stimulation of the lumbar spine and lower limbs may be relevant in the management of LBP [40].

This study should be interpreted in light of its limitations. The most significant limitation lies in its single-arm observational design, which precludes direct comparison with either sham stimulation or standard static single-coil rPMS. The reliance on self-reported outcomes and partially remote follow-up assessments introduces the possibility of response bias. Because the analysis was based on routine clinical data, the sample size and study structure were determined by practice conditions rather than prospective trial design. No formal blinding or randomization was implemented. Consequently, improvements observed in this study may partly reflect non-specific treatment effects, including placebo responses, regression to the mean, or contextual factors associated with rehabilitation settings.

While the one-month follow-up provided valuable insight into short-term treatment maintenance, future prospective studies with control groups and longer follow-up durations (≥3-6 months) are warranted to determine the durability and comparative effectiveness of the combined rPMS protocol. In addition, the use of complete-case analysis, including only patients who completed the full treatment protocol and had complete outcome data, may have introduced attrition bias and influenced the observed results. The study population was also heterogeneous, including both acute and chronic LBP cases and patients with varying symptom presentations, without stratification

according to clinical subtype, symptom duration, or prior treatment history. Furthermore, due to the composite nature of the intervention, it is not possible to determine the relative contribution of individual treatment components.

In addition to addressing the aforementioned limitations, future research should also focus on evaluating treatment effects in relation to the clinical presentation of LBP. Specifically, it would be valuable to investigate whether the combined protocol demonstrates differential effects in patients presenting with radicular symptoms, or whether comparable benefits are achieved in individuals with chronic versus acute LBP. Given the multifactorial nature of LBP, identifying the precise origin of symptoms is often challenging. Therefore, it would be clinically relevant to explore whether the proposed combined stimulation protocol is universally applicable across different patient subgroups, or whether certain phenotypes may benefit more from conventional, static single-coil stimulation. Such subgroup analyses could help tailor therapeutic strategies and improve individual treatment outcomes. Identifying subgroups that may preferentially benefit from dynamic multi-region stimulation versus conventional static approaches would be clinically relevant.

Despite these limitations, this analysis provides preliminary clinical data on a combined rPMS protocol in musculoskeletal LBP. The findings support the feasibility of this approach and justify further investigation in adequately powered randomized controlled trials.

5. Conclusions

The present observational case series based on routine clinical data evaluated a therapy combining static double-coil and dynamic single-coil rPMS and supports the feasibility of this approach for the treatment of LBP. These findings should be considered preliminary and interpreted in light of the study's observational design and associated methodological and ethical considerations. The observed within-group improvements in pain, disability, and quality of life warrant further investigation under controlled conditions. However, further studies incorporating a control group and extended follow-up periods are essential to verify the potential benefits of simultaneous stimulation of both the lower back and lower limbs in the management of LBP.

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Abbreviations

The following abbreviations are used in this manuscript:

rPMS	Repetitive peripheral magnetic stimulation
LBP	Low back pain
MCID	Minimal clinically important difference
TMS	Transcranial magnetic stimulation
VAS	Visual analog scale
ODI	Oswestry disability index
PGIC	Patient Global Impression of Change
SF-12	Short Form-12 Health Survey
PCS	Physical component summary
MCS	Mental component summary
IQR	Interquartile range
CI	Confidence interval

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Dott. Vincenzo Di Modica

IN COLLABORAZIONE CON

Dott. Giuseppe J. Sciarrone

e BTL Italia

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Two-Month NSSD and Multi-Coil rPMS in Large Lumbar Disc Herniation: MRI Outcomes vs. a Three-Month Protocol

Vincenzo Di Modica[1*], Giuseppe J. Sciarrone[2]

[1] Director of Rehabilitation Center BioSalus, Via A. Manzoni 129, 87036 Surdo di Rende, Italy

[2] Neurosurgeon and Director of Spine and Robotic Surgery Center, Humanitas Pio X, Via Francesco Nava 31, 20159 Milan, Italy

*** Corresponding author:** Vincenzo Di Modica, Director of Rehabilitation Center BioSalus, Via A. Manzoni 129, 87036 Surdo di Rende, Italy. E-mail: vincenzodimodica@live.it

Running title: Two-month spinal decompression and rPMS protocol in lumbar disc herniation

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Two-Month NSSD and Multi-Coil rPMS in Large Lumbar Disc Herniation: MRI Outcomes vs. a Three-Month Protocol

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*** Corresponding author:** Vincenzo Di Modica, Director of Rehabilitation Center BioSalus, Via A. Manzoni 129, 87036 Surdo di Rende, Italy. E-mail: vincenzodimodica@live.it

Running title: Two-month spinal decompression and rPMS protocol in lumbar disc herniation

Abstract

Background: Non-invasive treatment of large lumbar disc herniation (LDH >6 mm) combining non-surgical spinal decompression (NSSD) and single-coil repetitive peripheral magnetic stimulation (rPMS) is effective but demanding (3 months, 40 sessions). Modern double-coil and handheld rPMS configurations may optimize field coverage and shorten treatment duration.

Aim: To evaluate a 2-month (24-session) NSSD and multi-coil rPMS protocol for large LDH and compare structural and clinical outcomes with the earlier 3-month regimen.

Methods: Nine consecutive patients with refractory LDH (>6 mm) received NSSD and multi-coil rPMS three times weekly for two months (Group 1). Pre- and post-treatment T2 MRI parameters (AP length, area, canal dimensions, Herniation Index [HI], MSU grade), VAS pain scores, and clinical tests were assessed within Group 1 and compared with a historical 3-month comparator group (Group 2, n=9).

Results: In Group 1, herniation AP length decreased from 8.35±2.40 to 3.05±1.41 mm, area from 111.34±28.96 to 43.81±17.49 mm², and HI improved by 66.4±16.8% (all $p<0.005$). Canal dimensions increased significantly. All patients improved by ≥1 MSU grade, experienced complete pain resolution, and achieved normalization of neurological tests. Between-group comparisons showed no significant differences in MRI parameter improvements ($p>0.05$). Clinical findings were maintained at three-month follow-up.

Conclusion: A 2-month NSSD and multi-coil rPMS protocol achieves marked MRI regression and complete pain resolution comparable to a 3-month regimen. Prospective randomized trials are warranted to confirm these findings.

Keywords: lumbar disc herniation; non-surgical spinal decompression; repetitive peripheral magnetic stimulation;

magnetic resonance imaging; Herniation Index; conservative management.

Introduction

Low back pain (LBP) is the leading cause of years lived with disability worldwide and the most frequent reason for reduced working capacity in most economies [1]. Its prevalence has continued to rise with population growth and ageing, and further increases are projected over the coming decades [2]. Up to 80% of adults experience at least one episode of LBP during their lifetime [3].

Herniation of an intervertebral disc is among the most clinically relevant causes of LBP, particularly between the third and fifth decades of life. The condition is more common in men and is associated with heavy physical work, weightlifting, smoking, obesity and sedentary occupations [4,5]. Herniation typically develops on a background of age-related degeneration, in which reduced proteoglycan synthesis leads to disc desiccation and loss of disc height; superimposed axial loading and biomechanical stress may then extrude nuclear material, often producing an acute symptomatic episode after physical exertion [4,5]. When radicular symptoms are present, the resulting limitation of walking, standing and everyday activity is substantial [6].

Initial management is conservative and comprises relative rest, analgesia, physiotherapy and, in selected cases, epidural steroid injection. Urgent surgery is indicated for progressive neurological deficit, bladder or bowel dysfunction or saddle anaesthesia, whereas elective discectomy is generally considered when symptoms persist after conservative care has been exhausted [7,8]. Most patients improve without surgery, and spontaneous regression of herniated material is well documented, but it occurs predominantly within the first six to twelve weeks after symptom onset; patients whose symptoms persist beyond this window are substantially less likely to recover spontaneously [9].

Quantitative assessment of herniation size on magnetic resonance imaging (MRI) is the most objective way of grading severity and informs the choice between conservative and operative management [10]. Herniations exceeding 6 mm in anteroposterior (AP) length have been associated with superior postoperative outcomes, and this dimension is often treated in practice as a marker of surgical suitability [10]. No precise size threshold reliably separates patients who will benefit from surgery from those who will not [11], yet large herniations remain a considerable therapeutic challenge for non-invasive care. Most studies of conservative modalities do not repeat MRI and rely instead on subjective symptom scores, which limits what can be concluded about structural recovery [12].

Non-surgical spinal decompression (NSSD) applies computer-regulated distraction to lower intradiscal pressure and relieve neural compression, either as monotherapy or combined with other physical modalities [13,14]. Although clinically effective across various spinal levels [15,16,17], objective imaging data remain limited. Choi et al. reported a 27% reduction in Herniation Index [13] and Demirel et al. observed a 1.7 mm decrease in herniation thickness [14]; however, both studies examined mild-to-moderate herniations and omitted canal and disc area metrics. Our previous work addressed this gap in large herniations (>6 mm) using a 3-month, 40-session protocol of NSSD, HILT, and single-coil rPMS [18]. Nevertheless, the clinical and financial burden of such an extended course limits its practical feasibility.

Repetitive peripheral magnetic stimulation (rPMS) generates eddy currents that depolarize neuromuscular structures without direct skin contact [19,20]. Bypassing skin impedance renders rPMS virtually painless and enables deeper penetration than surface electrotherapy [20,21]. Clinical evidence demonstrates that rPMS reduces pain and improves mobility in low back pain (LBP) [22], enhances symptomatic and electrophysiological outcomes in lumbar radiculopathy [23], and restores spinal motor control during multifidus stimulation [24,25]. Proposed mechanisms include proprioceptive afferent recruitment [26], gate-control segmental inhibition [27], neuropathic pain modulation [28], and enhanced microvascular perfusion via muscle pumping [29].

Spatial distribution depends heavily on coil geometry [30]. Unlike angled joint configurations (e.g., knees at ~90°) where converging fields enhance depth, side-by-side placement on the flat lumbar contour distributes magnetic energy over a significantly broader surface, prioritizing spatial coverage and tolerability over depth [31-33]. Combining double-coil with dynamic handheld rPMS induces widespread activation across the lumbopelvic myofascial complex. Clinically, attenuating hypertonicity and reflex guarding through this broad-field approach preconditions paraspinal tissues, reducing mechanical resistance and optimizing non-surgical spinal decompression (NSSD) distraction [34].

These advancements suggest that combining double-coil, single-coil, and handheld rPMS might reproduce previously observed structural regression within a shorter, 2-month (24-session) course [18]. This study primarily aimed to quantify clinical and MRI changes following a 2-month NSSD and multi-coil rPMS protocol in large lumbar disc herniations (>6 mm). The secondary aim was to compare these outcomes with the historical 3-month cohort [18].

Materials and Methods

Study design and setting

This was a retrospective, uncontrolled, single-centre study of consecutive patients treated at the BioSalus Rehabilitation Centre, Surdo di Rende, Italy. Patients treated with the two-month protocol between March 2025 and June 2026 and having both pre-treatment and post-treatment transverse T2-weighted MRI available were included (Group 1). Eight patients treated at the same centre between November 2022 and September 2024 with a three-month protocol, previously reported in full [18], provided a historical comparator (Group 2). Group allocation was determined by the period of presentation and not by any patient characteristic; no randomisation or concurrent control was possible.

The study was conducted in accordance with the 1975 Declaration of Helsinki as adopted by the Convention on Human Rights and Biomedicine of the Council of Europe (1997) and endorsed by the General Assembly of the World Medical Association [35]. Retrospective ethical approval for the present cohort was granted by the Territorial Ethics Committee of the Calabria Region, which met on 29 December 2025 at the Renato Dulbecco University Hospital (A.O.U.), Catanzaro, and issued an opinion of approval under protocol number 319/2025. All patients gave written informed consent to treatment and to publication of their anonymised results.

Participants

Inclusion and exclusion criteria were identical for both groups and were those applied in the previous investigation [18]. Eligible patients had painful and disabling symptoms attributable to LDH, confirmed on functional assessment by the femoral nerve tension test [36], the straight leg raise test [37], evaluation of the ability to walk on tiptoes and heels, the Medical Research Council (MRC) scale for muscle strength [38] and pain assessment [39]. MRI had to confirm disc herniation with an AP length greater than 6 mm.

Because most patients with symptomatic LDH recover spontaneously within the first 6 to 12 weeks of conservative treatment [9], only patients who had failed prior conservative care were eligible: the programme could begin no earlier than one month after the end, and three months after the start, of the preceding conventional treatment. Patients also had to consent to participate in the intensive non-invasive programme and to the associated assessments.

Patients were excluded if they had any contraindication to NSSD, namely malignant bone tumour, fracture, joint inflammation, spastic paralysis, osteoporosis, meningeal signs, abdominal hernia, pregnancy, cardiac or pulmonary insufficiency, haemorrhagic conditions, infectious disease, claustrophobia, or any condition in which movement was contraindicated. Patients with contraindications to rPMS, including implanted pacemakers, defibrillators, neurostimulators or other electronic or metallic implants, drug delivery pumps and a history of seizures, were also excluded, as were patients with contraindications to HILT in the cohort in which laser therapy was used.

Treatment protocols

Group 1 (two-month protocol). Patients attended three times weekly for two consecutive months, completing 24 combined sessions. Each session began with NSSD (BTL Spinal Decompression, BTL Industries Ltd.), performed with the patient supine on a therapeutic couch with movable segments allowing precise positioning. A computerised control unit delivered the distraction force to the affected motion segment; the force never exceeded 50% of the patient's body weight. The decompression phase lasted 30 minutes and was followed by a stabilisation period during which the patient remained still and relaxed [13,14].

NSSD was followed by rPMS (SIS DUO, BTL Industries Ltd., Prague, Czech Republic), which supports single-coil, double-coil and handheld applicators. Stimulation was applied in two steps. In step 1, the double-coil applicator was positioned on either side of the lumbar spine at an inter-coil angle adapted to the patient's anatomy and to the location of the symptomatic segment, and was used for myofascial release of the lumbar region. In step 2, radiculopathy of the affected lower limb was treated with the handheld applicator, which the therapist moved manually along the symptomatic limb to provide analgesia and muscle relaxation over the whole affected territory, combined with the single-coil applicator positioned over the affected spinal segment to support healing of the herniated tissue. Stimulation intensity was set individually according to patient tolerance and was maintained or increased in small increments at subsequent sessions, always with the patient's agreement. Treatment was individualised to the presenting symptoms and to the side of the radicular deficit. During the final phase of the programme, therapeutic exercise was added to consolidate the gains achieved: proprioceptive work to improve balance and body awareness, ambulatory step activities to improve gait, global postural re-education to correct posture, diaphragmatic rehabilitation to improve breathing mechanics, and core stability exercises to strengthen the deep trunk muscles. HILT was not used in Group 1.

Group 2 (three-month comparator protocol). The comparator cohort followed the protocol described previously [18]. Patients completed 40 combined sessions over three months, delivered five times weekly in the first month, three times weekly in the second and twice weekly in the third. Each session comprised NSSD as described above, followed by HILT, a modality with documented benefit when added to spinal decompression in lumbar disc protrusion [40], and single-coil rPMS (Super Inductive System, BTL Industries Ltd.). The same programme of therapeutic exercise was introduced in the final month. The two protocols therefore differ in three respects: total duration and number of sessions (two months and 24 sessions versus three months and 40 sessions), rPMS configuration (double-coil, single-coil and handheld versus single-coil alone), and the presence of HILT in Group 2 only.

Outcome measures

MRI was performed at baseline and immediately after completion of the programme. Transverse T2-weighted images of the affected level were analysed with a DICOM viewer (MicroDicom DICOM Viewer, version 2023.3 x86). Five quantitative parameters were recorded. Herniation AP length, defined as the maximum anteroposterior extension of the herniated material, was the primary indicator of herniation size. Herniation area was measured by planimetry of the herniated tissue. Canal AP length, defined in this context as the distance from the most posterior point of the disc to the posterior wall of the canal, and canal area described the residual space available for the neural structures. The Herniation Index (HI) was calculated according to the formula proposed by Choi et al. [13]:

$$HI = (HL \times HW) / (TCL \times TCW) \times 1000$$

where HL is the herniation AP length as defined above, HW the herniation width measured at half the HL distance, TCL the maximal AP canal length and TCW the canal width measured at the level of half the HL distance. Transverse images were additionally graded with the MSU classification, which assigns a size grade of 1 to 3 and a location of A, AB, B or C [41].

Clinical outcomes comprised pain [40] and a standard battery of provocation and neurological tests performed at baseline and after treatment: the Delitala, Lasègue (straight leg raise), Wassermann (femoral nerve tension), FABER, FADIR, Mingazzini and Valleix tests, the ability to walk on tiptoes and on heels, and deep tendon reflexes [37,38]. Nerve conduction studies and needle electromyography were available in six of the nine Group 1 patients as part of routine diagnostic work-up. All patients had been assessed by a neurosurgeon before enrolment, and the recorded recommendation was retained as a descriptor of baseline severity.

Statistical analysis

Continuous variables are presented as mean ± standard deviation and as median with interquartile range (IQR). The distribution of the paired within-patient differences was examined with the Shapiro-Wilk test. Within-group changes from baseline were tested with the paired t-test, with the Wilcoxon signed-rank test as the distribution-free confirmation. Because the primary endpoint is a directional reduction, one-sided p values are reported for the within-group tests, with the corresponding two-sided values in parentheses. Effect sizes for within-group changes are reported with 95% confidence intervals, and effect size is expressed as Cohen's d for paired data. Percentage improvement was calculated for each patient individually and then averaged across the group. Between-group comparisons of baseline values, post-treatment values and percentage improvement used the Welch t-test with the Mann-Whitney U test as a distribution-free confirmation. Ordinal MSU grades were compared with the Wilcoxon signed-rank test within groups and the Mann-Whitney U test between groups, and categorical variables with Fisher's exact test. A two-sided p value below 0.05 was considered statistically significant. Analysis was conducted using the Matlab environment (MatLab R2010b, Mathworks, Inc., Natick, MA, USA) with a custom script. Given the exploratory nature of the study and the small sample, no correction for multiple comparisons was applied and no formal sample size calculation was performed; the between-group analysis should be read as hypothesis-generating.

Results

Baseline characteristics

Nine patients were treated with the two-month protocol (Group 1): six women and three men, with a mean age of 43.7 ± 17.2 years (median 37, range 17 to 73). The herniation involved L4-L5 in six patients and L5-S1 in three. All patients had an AP herniation length above 6 mm, all reported unbearable pain at presentation, and all had radicular signs with a motor deficit on tiptoe walking, heel walking, or both. Reported duration of lumbar symptoms before enrolment ranged from 3 to 12 months and was six months or longer in five of the nine patients. Every patient had failed at least one previous course of conservative treatment, including pharmacological therapy and one or more cycles of physiotherapy, transcutaneous electrical nerve stimulation or magnetotherapy. Eight of the nine had been given a conditional surgical indication by a neurosurgeon, discectomy being planned if the motor deficit did not recover within one month. Baseline characteristics are detailed in Table 1.

The retrospective comparator cohort (Group 2) comprised the eight patients described in the original publication [18]: four women and four men, with a mean age of 48.5 ± 7.1 years (range 33 to 57); all eight had L4-L5 herniation. The two groups did not differ significantly in age ($p = 0.46$, Welch t-test) or sex distribution ($p = 0.64$, Fisher's exact test), nor in any of the five baseline MRI parameters ($p \geq 0.45$ for all comparisons; Table 4). Baseline MSU grade was higher in Group 2 (mean 2.75 ± 0.46 versus 2.22 ± 0.44), a difference that reached significance ($p = 0.04$, Mann-Whitney U test) despite the MRI-based measures showing no such difference – addressed in Limitations.

Table 1. Baseline demographic and clinical characteristics of the nine patients treated with the two-month protocol (Group 1).

No.	Sex / Age	Level	Occupation	Duration of symptoms	Neurosurgical recommendation
1	F / 37	L4-L5	Employee	12 months	Surgery if the heel-walking deficit did not recover within one month
2	F / 35	L5-S1	Employee	3 months	Surgery if the heel and tiptoe deficit did not recover within one month
3	F / 17	L4-L5	Student	3 months	Surgery if the heel and tiptoe deficit did not recover within one month
4	M / 36	L5-S1	Nurse	12 months	Electromyography and surgery if the tiptoe deficit did not improve within one month
5	F / 60	L4-L5	Employee	3 months	Electromyography and surgery if the deficit did not improve within one month
6	M / 40	L4-L5	Nurse	12 months	Electromyography and surgery if the deficit did not improve within one month
7	F / 35	L4-L5	Employee	12 months	Medical therapy and physiotherapy
8	F / 60	L5-S1	Teacher	6 months	Electromyography and surgery if the tiptoe deficit did not improve within one month
9	M / 73	L4-L5	Retired	3 months	Surgery if the heel deficit did not improve within one month

MRI outcomes in Group 1

Individual values for all five MRI parameters before and after the two-month programme are shown in Table 2, and the corresponding group statistics in Table 3. Every parameter moved in the expected direction in every patient: herniation AP length and area decreased, while canal AP length and canal area — the space available for the neural structures — increased. The Herniation Index, which combines herniation and canal dimensions in a single measure, fell substantially, consistent with an overall reduction in the severity of nerve root compromise.

Expressed as within-patient percentage change (Table 3), all five parameters improved significantly on both the paired t-test and the Wilcoxon signed-rank test ($p = 0.004$ for every parameter on the latter, the smallest value attainable with $n = 9$), with effect sizes

ranging from 1.75 to 3.59. The Shapiro-Wilk test rejected normality of the paired differences only for herniation AP length ($p = 0.037$), for which the Wilcoxon result should be regarded as primary; for the remaining four parameters the assumption of normality was tenable ($p \geq 0.076$). The two canal parameters were strongly right-skewed because two patients had a severely compromised canal at baseline (canal AP length 2.84 mm and 3.38 mm), so that even a moderate absolute gain represented a very large relative change. The median values in Table 3 describe the typical response more faithfully than the means. Individual responses were consistent in direction: all nine patients improved on all five parameters, six of nine achieved a reduction of at least 50% in herniation AP length and all nine a reduction of at least 30%, while eight of nine achieved a reduction of at least 50% in HI. The distribution of values before and after treatment is shown in Figure 1.

Table 2. Individual MRI-derived parameters before and after the two-month protocol (Group 1, n = 9).

Patient	Time point	MSU	Herniation AP length (mm)	Herniation area (mm²)	Canal AP length (mm)	Canal area (mm²)	HI
1	Before	2B	7.20	95.50	11.40	122.30	350.17
	After	1A	1.90	34.01	19.28	294.12	67.98
2	Before	2A	6.05	75.06	7.83	79.86	424.52
	After	1A	3.44	44.06	10.96	111.65	203.68
3	Before	2A	7.74	118.92	11.05	81.88	334.53
	After	1A	2.63	36.17	16.26	164.24	99.43
4	Before	2B	9.39	116.33	10.88	283.16	257.14
	After	1A	3.51	52.46	18.85	347.82	91.35
5	Before	2B	8.85	161.92	7.30	184.74	280.14
	After	1A	2.79	44.06	13.26	298.56	59.71
6	Before	2B	6.02	97.60	12.79	131.93	281.88
	After	1A	3.16	39.50	15.62	189.00	112.18
7	Before	2B	6.04	73.13	11.72	128.72	248.65
	After	1B	2.46	34.27	15.48	170.22	76.57
8	Before	3B	12.77	134.45	3.38	155.87	389.74
	After	1A	1.28	24.34	14.61	261.81	41.87
9	Before	3AB	11.08	129.14	2.84	21.46	524.62
	After	2A	6.28	85.40	14.83	62.57	350.41

AP: anteroposterior; HI: Herniation Index; MSU: Michigan State University classification; SD: standard deviation.

Table 3. Within-group changes in MRI parameters after the two-month protocol (Group 1, n = 9).

Parameter	Before (mean ± SD)	After (mean ± SD)	Mean change (95% CI)	Improvement, mean ± SD (%)	Improvement, median [IQR] (%)	*d*
Herniation AP length (mm)	8.35 ± 2.40	3.05 ± 1.41	−5.30 (−7.33 to −3.27)	61.5 ± 15.4	62.6 [47.5–68.5]	2.01
Herniation area (mm²)	111.34 ± 28.96	43.81 ± 17.49	−67.53 (−90.97 to −44.09)	59.0 ± 15.2	59.5 [53.1–69.6]	2.21
Canal AP length (mm)	8.80 ± 3.69	15.46 ± 2.57	+6.66 (4.08 to 9.25)	124.4 ± 146.4	69.1 [40.0–81.6]	1.98
Canal area (mm²)	132.21 ± 73.96	211.11 ± 94.94	+78.90 (44.18 to 113.62)	77.8 ± 56.4	61.6 [39.8–100.6]	1.75
Herniation Index	343.49 ± 90.76	122.58 ± 97.26	−220.91 (−268.22 to −173.60)	66.4 ± 16.8	69.2 [60.2–78.7]	3.59

All parameters: $p < 0.001$ by paired t-test and $p = 0.004$ by Wilcoxon signed-rank test. Percentage improvement was computed for each patient and then averaged. AP: anteroposterior; CI: confidence interval; d: Cohen's d for paired data; IQR: interquartile range; SD: standard deviation.

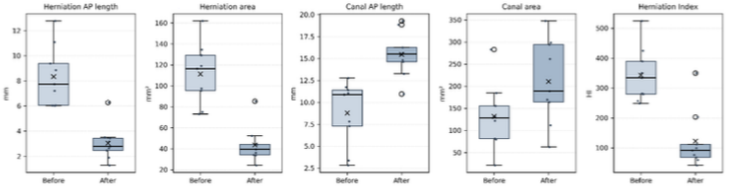


Figure 1. Distribution of MRI parameters before and after the two-month protocol (Group 1, n = 9). Boxes span the interquartile range, the horizontal line is the median and the cross marks the mean; whiskers extend to the most extreme values within 1.5 interquartile ranges and circles denote values beyond that limit. Individual patient values are overlaid as points.

Herniation grade and clinical outcomes in Group 1

Before treatment, herniations were graded MSU 2A in two patients, 2B in five, 3B in one and 3AB in one. After treatment, seven patients were graded 1A, one 1B and one 2A. Every patient improved by at least one grade and one patient improved by two grades, a significant shift overall ($p = 0.004$). The location component moved towards the midline in most patients, so that no patient retained a predominantly lateral (B) location apart from one graded 1B (Table 2).

Clinical improvement paralleled the imaging findings. All nine patients experienced complete resolution of baseline pain upon completion of therapy. At the post-treatment assessment, the Delitala, Lasègue, Wassermann, FABER, FADIR and Valleix tests were negative in all patients, the Mingazzini test remained negative, deep tendon reflexes had returned from hyporeflexia to normal, and the tiptoe and heel walking deficits had resolved in every case. No patient in Group 1 proceeded to surgery. Nerve conduction studies performed before treatment in six patients had shown axonal motor and sensory changes consistent with the clinically affected root, including reductions in compound muscle action potential amplitude of 28% to 98%.

No adverse events, treatment-related discomfort or discontinuations were recorded in Group 1, and no patient required a change of analgesic medication during the programme.

Comparison between the two-month and three-month protocols

Table 4 sets the two-month protocol against the previously reported three-month protocol. The groups were comparable at baseline on all five MRI parameters, so the comparison of improvement is not confounded by differences in initial herniation size or canal compromise, and remained statistically indistinguishable after treatment. None of the five between-group differences in percentage improvement approached significance, whether tested parametrically or non-parametrically (Table 4); the two distributions are shown in Figure 2. Both groups improved by at least one MSU grade in every patient, and the magnitude of grade change did not differ significantly between groups ($p = 0.51$, Mann-Whitney U test); the higher baseline MSU grade in Group 2 noted above is addressed in Limitations.

Table 4. Comparison of the two-month protocol (Group 1) with the retrospective three-month protocol (Group 2).

Parameter	Measure	Group 1 (n = 9)24 sessions / 2 months	Group 2 (n = 8)40 sessions / 3 months	p (t-test)	p (Mann-Whitney)
Herniation AP length (mm)	Baseline	8.35 ± 2.40	8.33 ± 1.54	0.99	0.92
	Post-treatment	3.05 ± 1.41	2.87 ± 1.01	0.76	0.96
	Improvement (%)	61.6 ± 15.4	66.0 ± 9.0	0.47	0.48
Herniation area (mm²)	Baseline	111.34 ± 28.96	106.61 ± 42.92	0.80	0.54
	Post-treatment	43.81 ± 17.49	46.67 ± 23.13	0.78	1.00
	Improvement (%)	59.0 ± 15.2	56.2 ± 10.2	0.66	0.61
Canal AP length (mm)	Baseline	8.80 ± 3.69	9.38 ± 2.16	0.69	0.96
	Post-treatment	15.46 ± 2.57	14.75 ± 1.90	0.53	0.74
	Improvement (%)	124.4 ± 146.4	63.9 ± 38.2	0.26	0.67
Canal area (mm²)	Baseline	132.21 ± 73.96	132.21 ± 40.82	1.00	1.00
	Post-treatment	211.11 ± 94.94	194.50 ± 43.45	0.65	0.61
	Improvement (%)	77.8 ± 56.4	54.3 ± 39.1	0.33	0.32
Herniation Index	Baseline	343.49 ± 90.76	309.03 ± 93.01	0.45	0.54
	Post-treatment	122.58 ± 97.26	83.82 ± 26.41	0.28	0.54
	Improvement (%)	66.4 ± 16.8	72.4 ± 4.6	0.33	0.61

Values are mean ± standard deviation. Percentage improvement was calculated per patient and then averaged. Group 2 is the retrospective comparator treated with non-surgical spinal decompression, high-intensity laser therapy and single-coil rPMS. AP: anteroposterior.

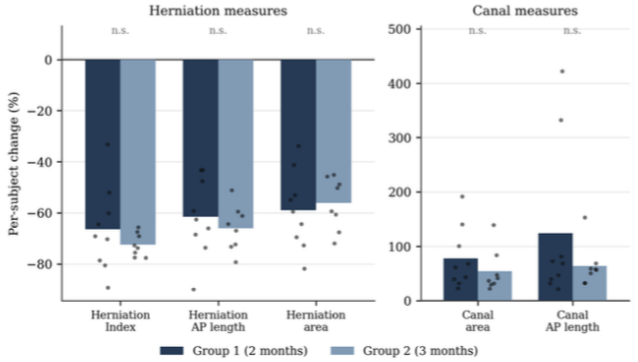


Figure 2. Mean per-subject percentage change by parameter and group, with individual patient values overlaid. No between-group comparison reached significance (n.s.). Herniation and canal measures are shown on separate axes because they change in opposite directions and on different scales.

Patients were monitored for three months after completion of the protocol, as in the comparator cohort, and improvement in pain and functional testing was maintained in all nine. In the comparator cohort, seven of eight patients had complete symptom resolution, and one retained minor residual signs with marked overall improvement [18].

Discussion

This study shows that a two-month, 24-session programme combining non-surgical spinal decompression with double-coil, single-coil and handheld rPMS was followed by substantial regression of large lumbar disc herniations on MRI and by complete resolution of pain and radicular signs in every patient treated. Mean reductions of 61.5% in herniation AP length, 59.0% in herniation area and 66.4% in the Herniation Index were accompanied by increases of 124.4% in canal AP length and 77.8% in canal area, and all patients improved by at least one MSU grade. These changes occurred in a cohort in which eight of nine patients carried a conditional surgical indication and none went on to have surgery.

The clinical relevance of these figures rests on the population in which they were obtained. Herniations exceeding 6 mm in AP length are those most often cited as favouring operative management [10], and the MSU location categories AB and B, which predominated at baseline in both cohorts, are the ones classically associated with poor responsiveness to non-operative care [41]. Furthermore, all patients had already failed conservative treatment and had symptoms lasting beyond the window in which spontaneous regression is most likely [9]. Spontaneous resolution cannot be excluded in an uncontrolled design, but it is an improbable explanation for a coordinated, large-magnitude change across five independent imaging parameters in nine consecutive chronic patients.

Set against the published quantitative evidence for spinal decompression alone, the magnitude of change is considerable. Choi et al. reported a mean 27% reduction in HI after ten NSSD sessions over eight weeks in subacute herniation [13], roughly two fifths of the 66.4% observed here over a comparable calendar period. Demirel et al. found a mean reduction in herniation thickness of 1.7 mm after a shorter physiotherapy programme with or without NSSD and no significant difference between the two arms [14], against a mean reduction of 5.30 mm in the present cohort. Both comparator studies enrolled patients with predominantly mild to moderate herniation, so a smaller absolute change is expected; nevertheless, the contrast supports the view that intensity and composition of the protocol, rather than decompression alone, drive the structural response.

The central question was whether the treatment course could be shortened. Compared with our previous 3-month, 40-session protocol, the 2-month, 24-session regimen yielded statistically indistinguishable baseline-matched outcomes, demonstrating that a 40% reduction in sessions does not compromise structural efficacy. Two features explain this higher per-session potency. First, rather than increasing penetration depth - which relies on converging fields in angled joint models [31,32] - the lumbar double-coil configuration provides broader spatial coverage, greater field homogeneity, and superior patient comfort. This enables more comprehensive neuromuscular activation. Second, the dynamic handheld applicator allows continuous stimulation along the entire radicular tract within a single session. This combined static-lumbar and dynamic-limb approach has shown substantial clinical efficacy [34], mirroring rapid gains seen with double-coil rPMS in other applications [33].

It must be stressed that the design does not permit attribution of the shortened course to the change in rPMS configuration specifically. Group 2 additionally received HILT, a modality with documented benefit when added to spinal decompression in lumbar disc protrusion [40], so the two protocols differ in more than one component and in opposite directions: Group 1 gained a more elaborate rPMS regimen but lost the laser component. That comparable results were obtained despite the absence of HILT and despite 16 fewer sessions is the observation of interest, but the design cannot separate the contribution of each element.

The clinical outcomes are consistent with the wider rPMS literature. Meta-analysis of randomised trials shows reduction of pain intensity and improvement of functional mobility in LBP [22], and in lumbar radiculopathy specifically, rPMS improved both pain and electromyographic parameters, with the greatest benefit when combined with a structured rehabilitation programme [23]. This is directly relevant to the present protocol, in which rPMS was never delivered in isolation but always after decompression and, in the final phase, alongside therapeutic exercise. Proposed mechanisms include recruitment of proprioceptive afferents with modulation of cortical and spinal excitability [24,26], segmental inhibition of nociceptive transmission [27], modulation of neuropathic pain components [28] and improved local perfusion through repeated muscle contraction [29,42]. In a herniated segment, reduced paraspinal hypertonus and improved local circulation may plausibly support the resorptive process, although no mechanistic data were collected in this study to test that hypothesis.

Limitations

The principal limitations are the small sample, the absence of a concurrent control or sham group and the retrospective, non-contemporaneous nature of the comparator. Group 2 was treated at the same centre by the same team but in an earlier period, so secular changes in practice, patient selection and measurement cannot be excluded, and the between-group analysis should be regarded as hypothesis-generating rather than as a test of superiority or equivalence. With nine and eight patients in the two groups respectively, the study had power to detect only large between-group differences; the absence of a significant difference is therefore not evidence of equivalence, and moderate differences in favour of either protocol would have gone undetected. The two groups were not perfectly matched: L5-S1 were more frequent in Group 1, all eight Group 2 patients had L4-L5 herniation only, and baseline MSU grade was significantly higher in Group 2 (mean 2.75 versus 2.22, p = 0.04) despite the five continuous MRI parameters showing no significant baseline difference. This discrepancy between a categorical severity score and continuous morphometric measures is difficult to resolve with the available data and means the two cohorts were not fully equivalent in baseline severity, which should temper the equivalence-suggestive framing of the percentage-improvement comparison. Follow-up MRI was obtained immediately after treatment, so the durability of the structural changes is unknown; imaging at six and twelve months would be needed to establish whether the regression persists. Clinical assessments were not blinded, and no validated disability or quality-of-life instrument, such as the Oswestry Disability Index, was recorded, which limits comparability with the wider LBP literature. Finally, the study was conducted at a single centre with a single treating team, which limits generalisability.

Future work should compare the two protocols prospectively within the same time frame and in the same population, ideally with randomisation, blinded image analysis and a control arm, so that the effect of the shortened course can be separated from patient selection and from the parallel change in rPMS configuration and the removal of HILT. A factorial design would additionally allow the specific contribution of the double-coil and handheld applicators to be quantified. Longer follow-up, standardised disability outcomes and a health-economic comparison against discectomy would help to define where such a protocol belongs in the care pathway for patients with large lumbar disc herniation.

Conclusion

In patients with large, refractory lumbar disc herniations (>6 mm) facing surgery, a 2-month protocol combining NSSD with multi-configuration rPMS achieved complete pain resolution, marked MRI regression, and successfully averted surgery in all cases. Crucially, leveraging double-coil and dynamic handheld rPMS yielded structural and clinical outcomes equivalent to an earlier 3-month protocol, effectively reducing treatment burden by 40%. These findings suggest that advanced rPMS field geometry may accelerate non-invasive spinal recovery, though prospective randomized trials are needed to confirm these results.

Declarations

Ethics approval and consent to participate: Retrospective approval for this study was granted by the Territorial Ethics Committee of the Calabria Region, meeting on 29 December 2025 at the Renato Dulbecco University Hospital (A.O.U.), Catanzaro, under protocol number 319/2025; the Committee examined the submitted documentation and issued an opinion of approval. The study was conducted in accordance with the Declaration of Helsinki and the Convention on Human Rights and Biomedicine [53]. All patients provided written informed consent to treatment and to the publication of their anonymised data and images.

Conflicts of interest: Vincenzo Di Modica has a financial relationship with BTL Industries Ltd., the manufacturer of the SIS DUO system used in this study, in the form of speaking and lecture fees. Giuseppe J. Sciarrone declares no competing interests. The article processing charge for this manuscript is to be paid by BTL Industries Ltd. BTL Industries Ltd. had no role in the study design, data collection, analysis, interpretation of data, writing of the manuscript, or the decision to submit the article for publication.

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Availability of data: The anonymised measurement data supporting the findings of this study are available from the corresponding author on reasonable request.

Author contributions. Conceptualisation, V.D.M.; methodology, V.D.M. and G.J.S.; investigation and data curation, V.D.M.; formal analysis, V.D.M.; writing of the original draft, V.D.M.; review and editing, G.J.S. Both authors have read and approved the final manuscript.

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1st CLINICAL **CASE**

BioSalus center





SDM
SPINAL DISORDERS METHODOLOGY

www.b-academyformazione.com

1st CLINICAL **CASE**

- T.L., woman, 37 Years Old, Employee
- Normal physical constitution
- **No surgical** operations or diseases worthy of note
- Practice motor activity

SPINAL DISORDERS METHODOLOGY

1st CLINICAL **CASE**

- Reporting **pain** and lumbar **functional** limitation since one year
- Functional impotence right leg with Radiculopathy since March 2025
- Previous Surgeon suggest medical therapy with corticosteroids
  that caused dysentery and hospitalisation
- Shows up April 19/2025 evaluation presence of **clinical symptoms**
- The clinic has severe heel deficits in the presence of right caudal hernia L4-L5
- We recommend the Surgery if the deficit has not improved within a month

1st CLINICAL **CASE**

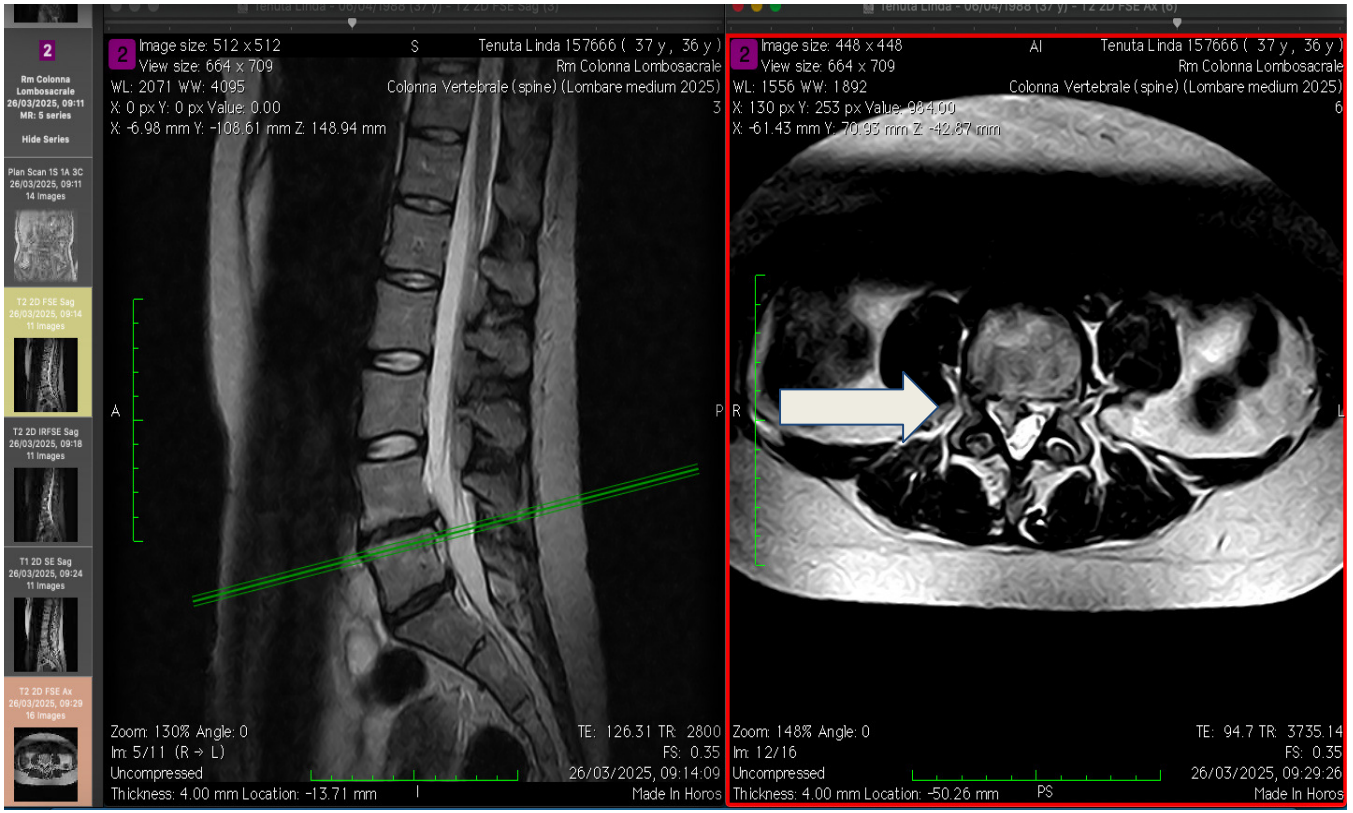
[redacted]

Paziente TENUTA LINDA (06.04.1988)

RM COLONNA LOMBOSACRALE

Esame condotto con tecnica SE e TSE; immagini pesate in T1 e T2 secondo piani di scansione sagittale ed assiale.
Ridotto grado della fisiologica lordosi con tendenza alla rettilineizzazione, in clinostatismo.
Patologia degenerativa delle unità disco-somatiche, con dischi intersomatici L4-L5 ed L5-S1 che appaiono ipointensi in T2 in relazione a fenomeni di disidratazione degenerativa.
Segni di degenerazione zigoapofisaria con minimo disallineamento dei corpi vertebrali
Osteocondrosi L4-L5
L5-S1:ernia discale posteriore mediana
L4-L5:ernia discale posteriore preforaminale dx a ridosso/contatto della radice nervosa corrispondente
I suddetti reperti improntano il sacco durale.
Canale vertebrale di dimensioni nei limiti della norma.
Cono midollare in fisiologica posizione e con normale intensità di segnale.
Aspetto ipotrofico dei muscoli paravertebrali posteriori.

MRI March 26/2025

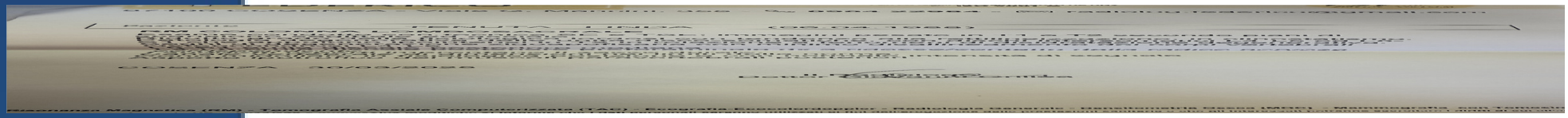


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1st CLINICAL **CASE**

BioSaluS center

BEFORE SDM DUO

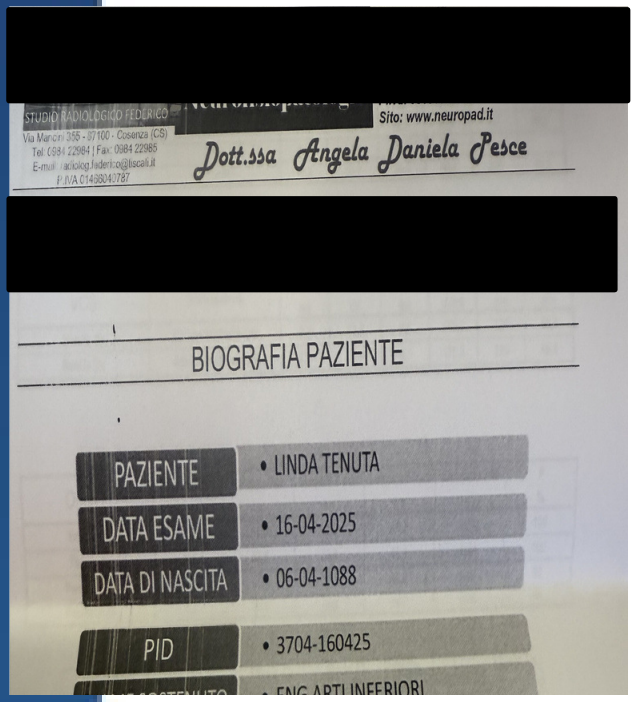


L4-L5: disc **herniation** expelled in the **right preforaminal** area which causes **conflict** with the emerging **nerve roots**.

SDM SPINAL DISORDERS METHODOLOGY

1st CLINICAL **CASE**

BEFORE SDM DUO: Electromyography





SPINAL DISORDERS METHODOLOGY

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1st CLINICAL **CASE**

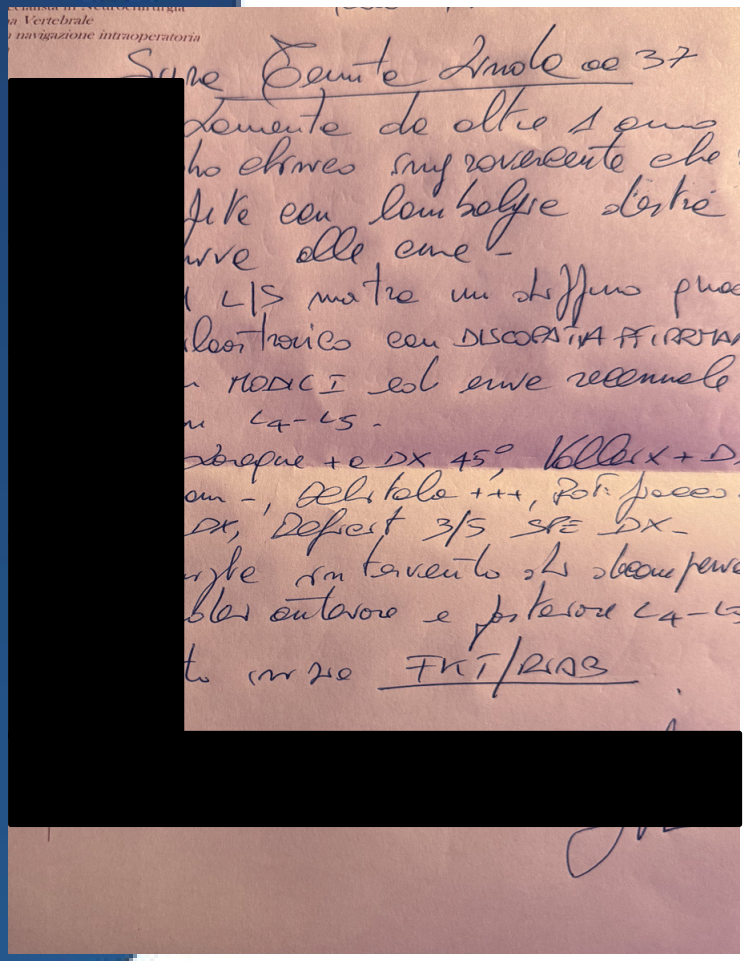
BEFORE SDM DUO : Electromyography



Electrophysiological signs of axonal suffering of SPE and right unilateral sural

SPINAL DISORDERS METHODOLOGY

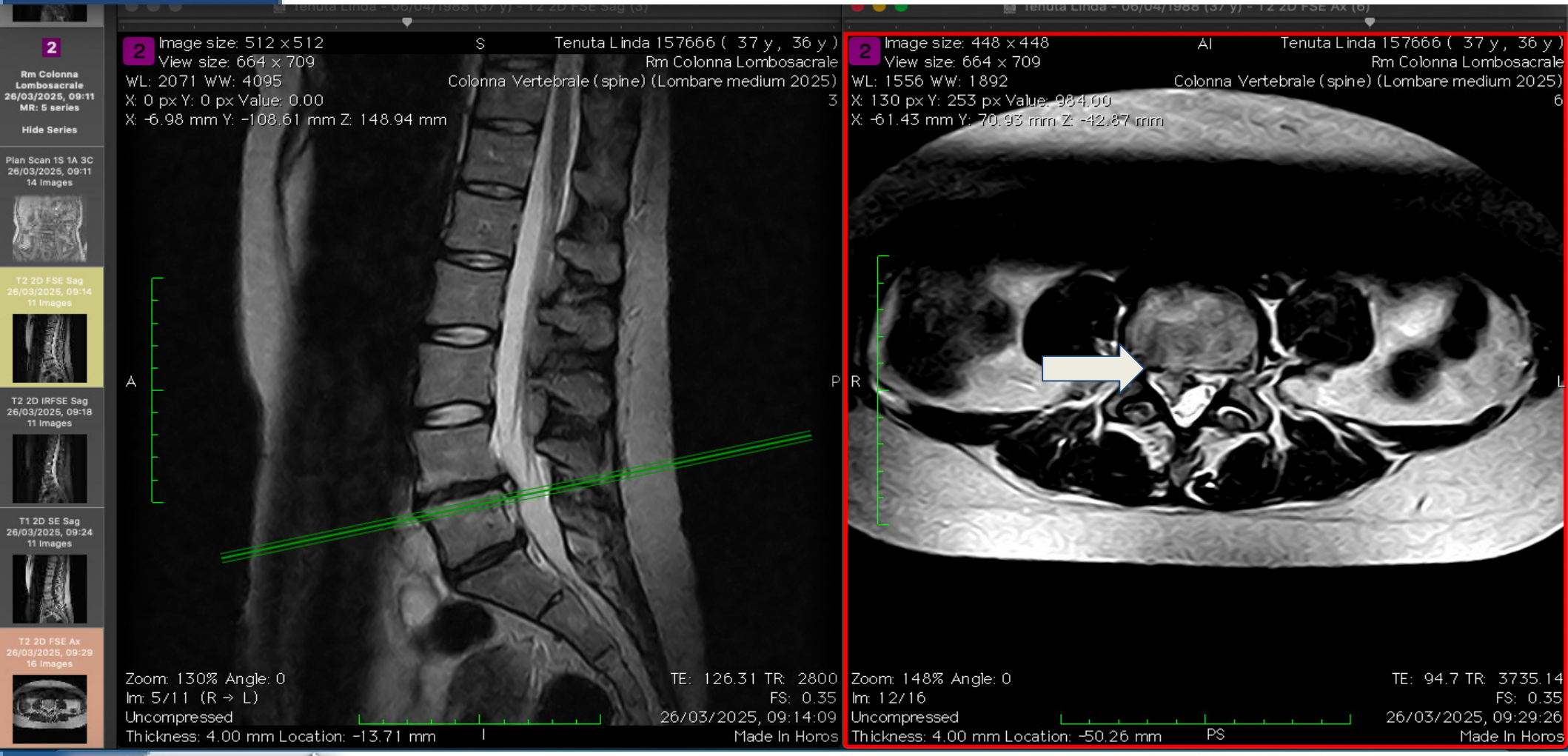
1st CLINICAL **CASE**



BEFORE SDM DUO

Specialised diagnosis of the neurosurgeon with surgical indication if the deficit of walking on the heels had not recovered by the following month

1st CLINICAL **CASE**



1st CLINICAL **CASE**



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SPINAL DISORDERS METHODOLOGY

1st CLINICAL **CASE**

BioSalus center





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1st CLINICAL **CASE**

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CLINICAL EVALUATION:

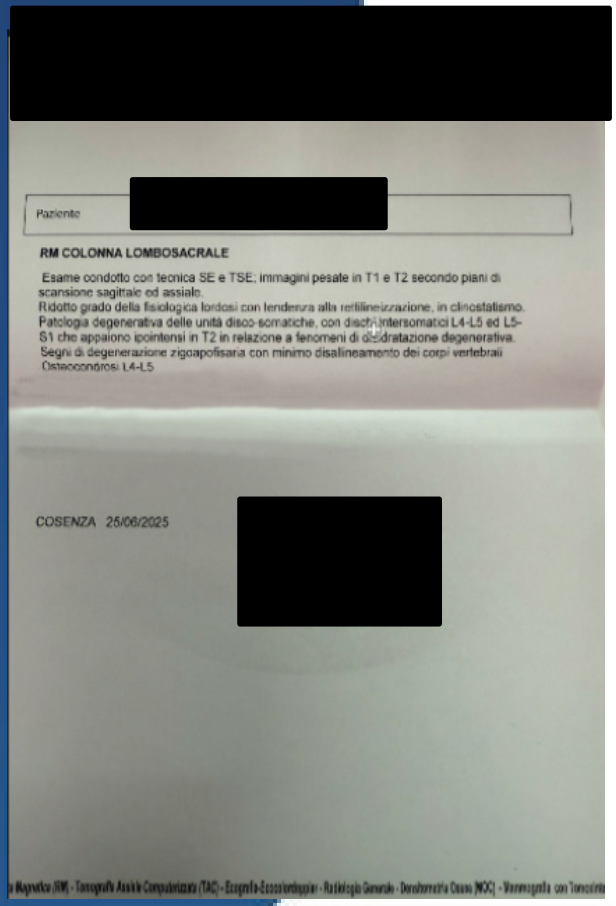
APRIL 19.25	MAY 21.25
DELITALA: ++	-
LASEGUE : ++	-
WASSERMANN: ++	-
FABER: ++	-
FADIR: ++	-
MINGAZIINI: -	-
TOE AND HEEL WALKING : DEFICIT ON HELLS	SOLVED
VALLEIX: ++	-
VAS: 10/10	0/10
ROT: HYPOELECTABLE	NORMO REFLEXION



SDM
SPINAL DISORDERS METHODOLOGY

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1st CLINICAL **CASE**


[redacted]

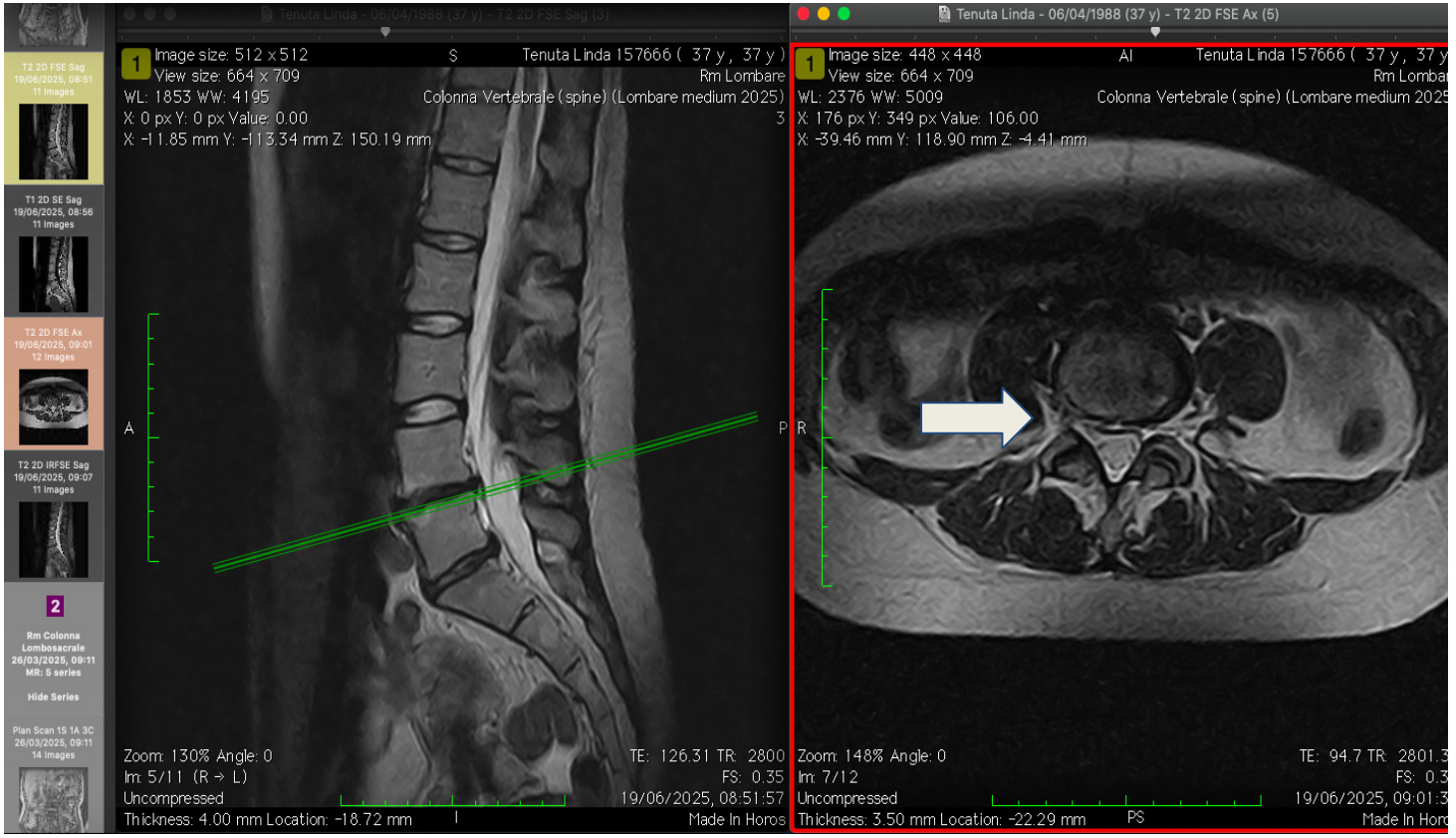
Paziente [redacted]

RM COLONNA LOMBOSACRALE

Esame condotto con tecnica SE e TSE; immagini pesate in T1 e T2 secondo piani di scansione sagittale ed assiale.
Ridotto grado della fisiologica lordosi con tendenza alla retrilinearizzazione, in clinostatismo.
Patologia degenerativa delle unità disco-somatiche, con dischi intersomatici L4-L5 ed L5-S1 che appaiono ipointensi in T2 in relazione a fenomeni di disidratazione degenerativa.
Segni di degenerazione zigoapofisaria con minimo disallineamento dei corpi vertebrali
Osteocondrosi L4-L5

COSENZA 25/06/2025 [redacted]

MRI MAY 19 2025



SPINAL DISORDERS METHODOLOGY

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1st CLINICAL **CASE**

AFTER SDM DUO

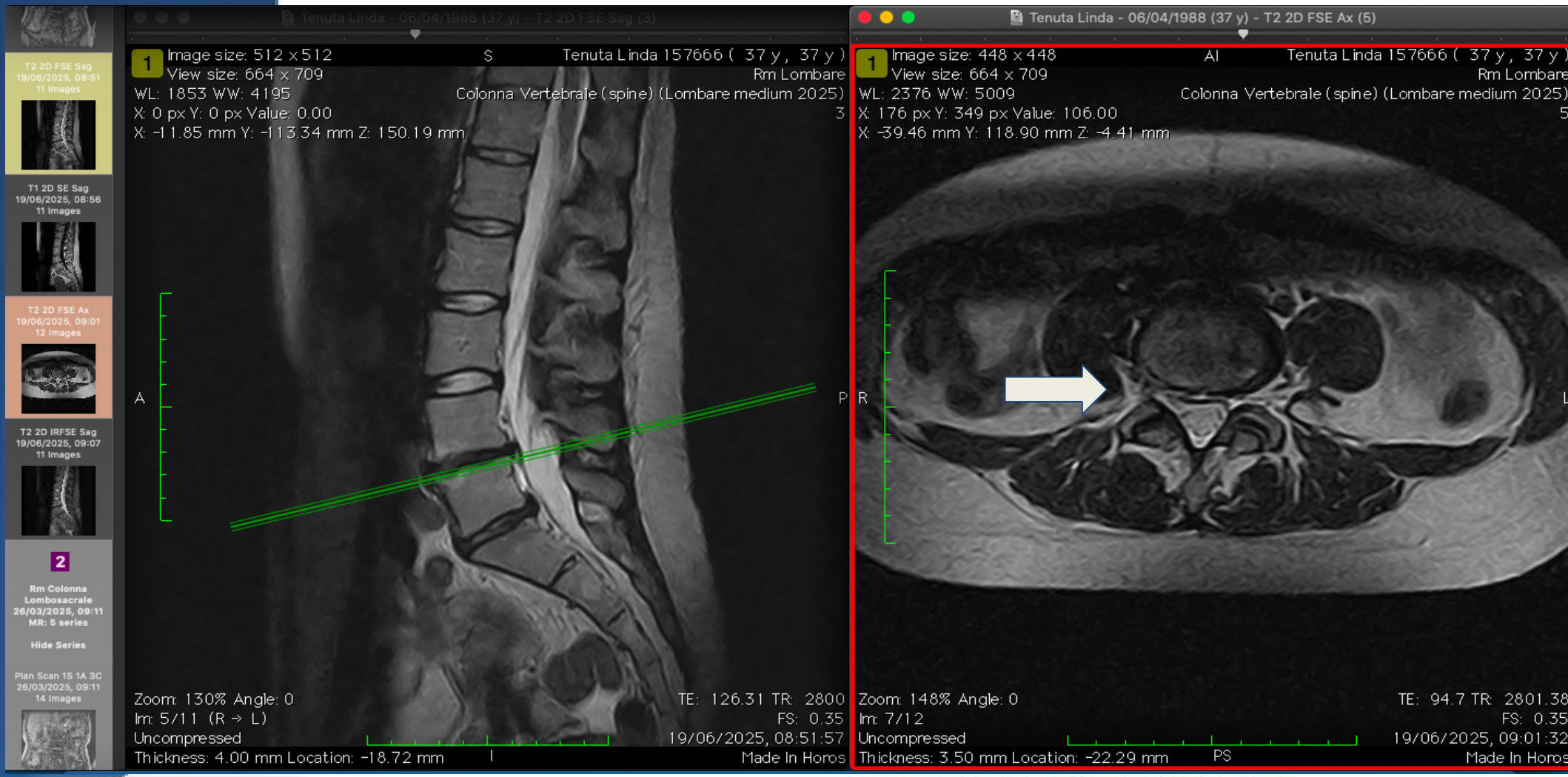
Patologia degenerativa delle unità disco-somatiche, con dischi intersomatici L4-L5 ed L5-S1 che appaiono ipointensi in T2 in relazione a fenomeni di disidratazione degenerativa.

L4-L5- S1 : Degenerative pathology of the somatic disc units in relation to degenerative dehydration phenomena

SPINAL DISORDERS METHODOLOGY

1st CLINICAL CASE

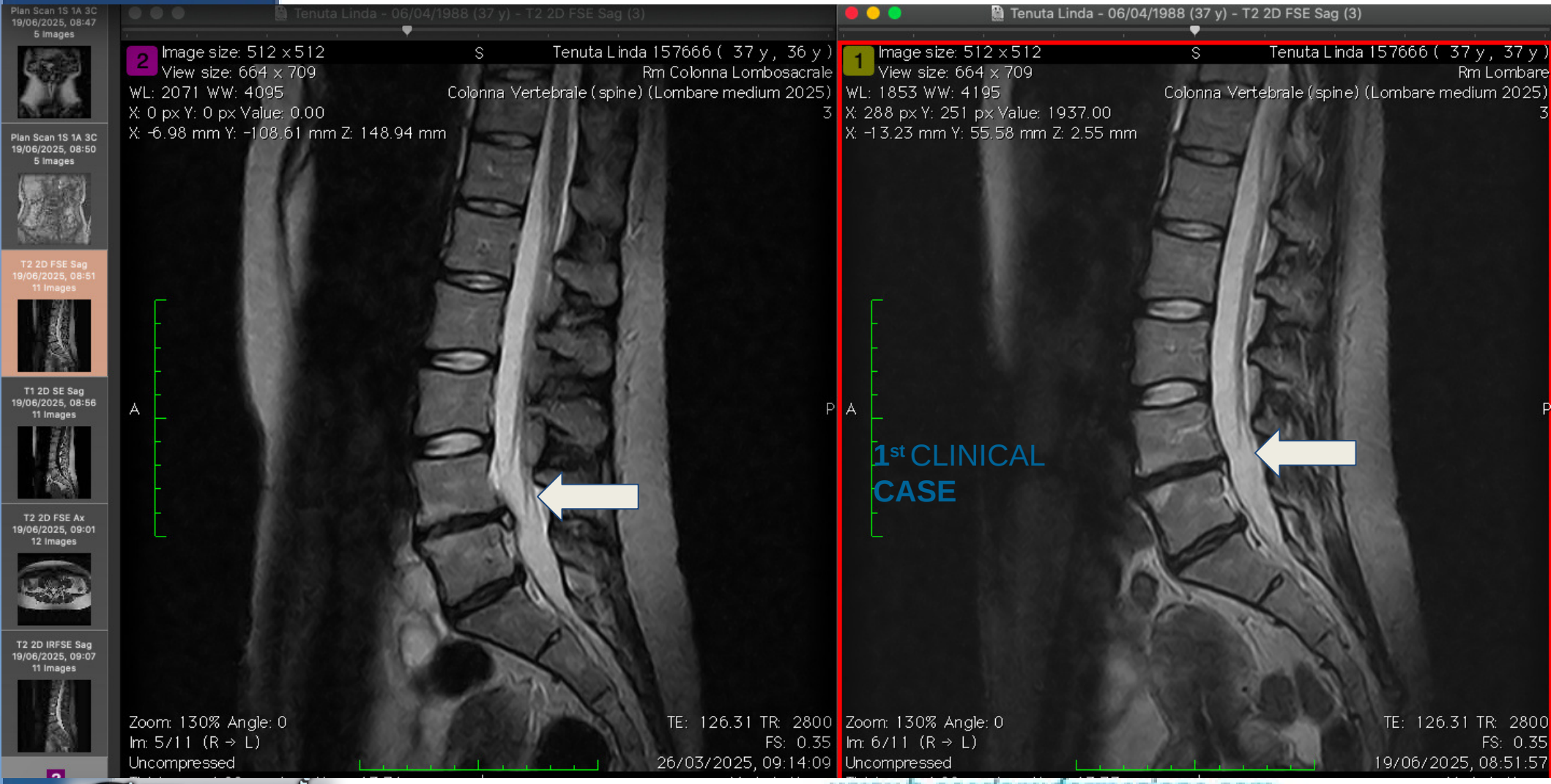
BioSaturs center



SDM SPINAL DISORDERS METHODOLOGY

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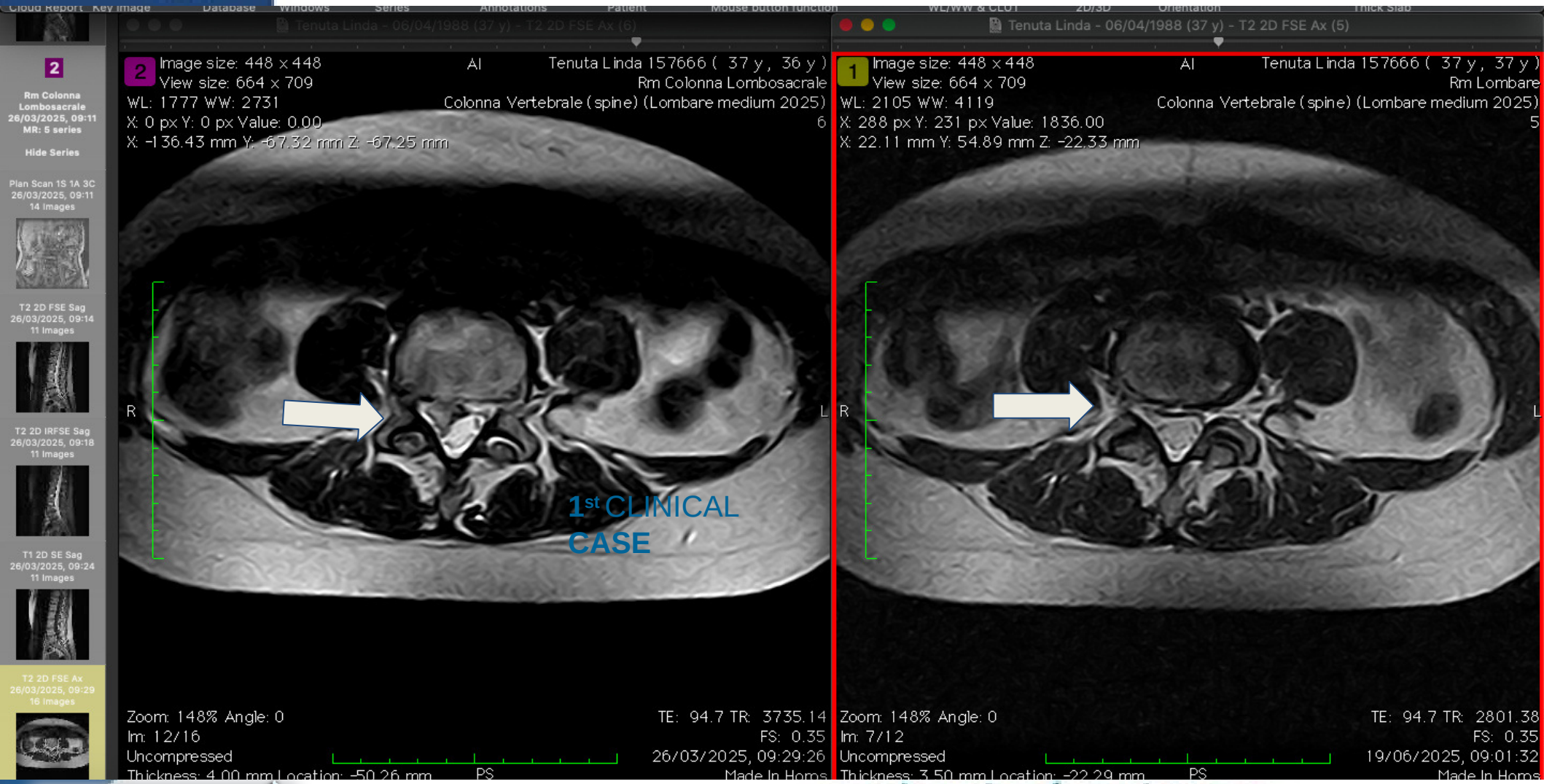
1st CLINICAL CASE



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1st CLINICAL CASE

BioSalus center



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SDM SPINAL DISORDERS METHODOLOGY

1st CLINICAL **CASE**

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AFTER SDM DUO

Deficit recovered in a single month of entertainment with SIS DUO

Hernia resolved in just two months with the help of SIS DUO



SDM SPINAL DISORDERS METHODOLOGY

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6th CLINICAL **CASE**





SPINAL DISORDERS METHODOLOGY

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6th CLINICAL **CASE**

- P.J., woman, 35 Years Old, Employee
- Normal physical constitution
- **No surgical** operations or diseases worthy of note
- Practice motor activity

6th CLINICAL **CASE**

Reporting **pain** and lumbar **functional** limitation

- Functional impotence left leg with Radiculopathy since September 2025
- She remains bedriden for a month without results from the prescribed pharmacological treatments
- Inability to walk and maintaining upright position
- Shows up October 31/2025 evaluation presence of **clinical symptoms**
- The clinic has severe tips & heels deficit in the presence of left cranial hernia L5-S1
- We recommend the Surgery if the deficit has not improved within a month

6th CLINICAL **CASE**

BEFORE SDM DUO

[redacted]

Accettazione: 20251000585 data acc: 13/10/2025 14:50:16

Tecnico Esecutore: Di Stefano Giovanni

RISONANZA ALTO CAMPO COLONNA LOMBOSACRALE, SEDAZIONE

Motivo dell' indagine: lombosicatalgia sinistra.

L' esama si caratterizza per la presenza di un voluminoso nucleo di tessuto molle situato posteriormente all' emisoma sinistro di L5, come da frammento erniario espulso e derivante dalla sottostante protrusione erniaria paramediana-subarticolare sinistra, alla base di una chiara compressione radicolare su S1.
Sempre in L5-S1 si apprezza un' ulteriore fcoalità erniaria in sede paramediana-subarticolare destra.
Ernia a larga base di impianto mediana-paramediana, tendente alla migrazioen caudale, in L4-L5.
Questi stessi dischi appaiono disidratati con L5-S1 che mostra una moderata riduzione in altezza del suo muro posteriore.
Canale vertebrale ampio.
Cono midollare regolare per morfologia e segnale.

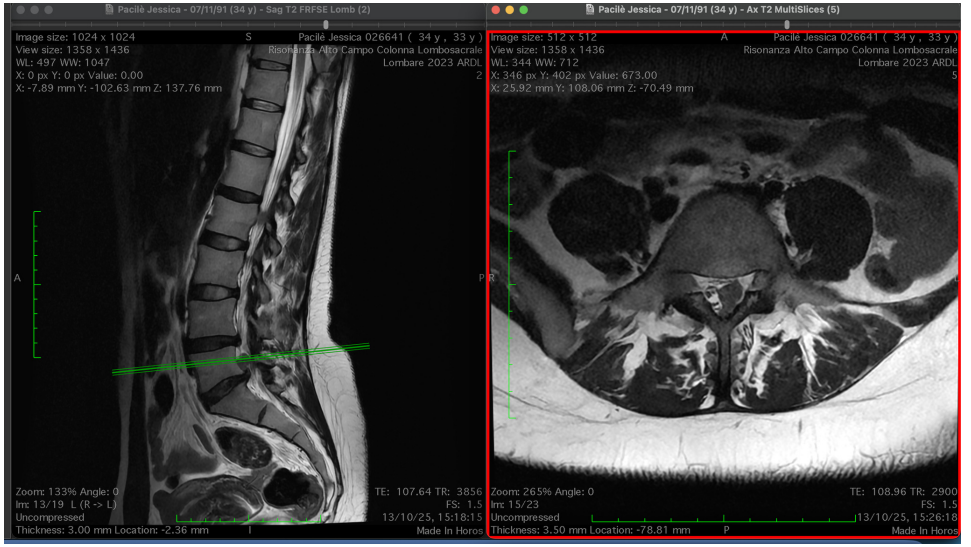
Castrolibero, 15/10/2025

Il Radiologo
Dott. Tommaso De Bartolo

page 1/1

CENTRO CLINICO SAN VITALIANO SRL | Sede legale: Via Tommaso Campanella 60 - 88100 Catanzaro

MRI October 13/2025

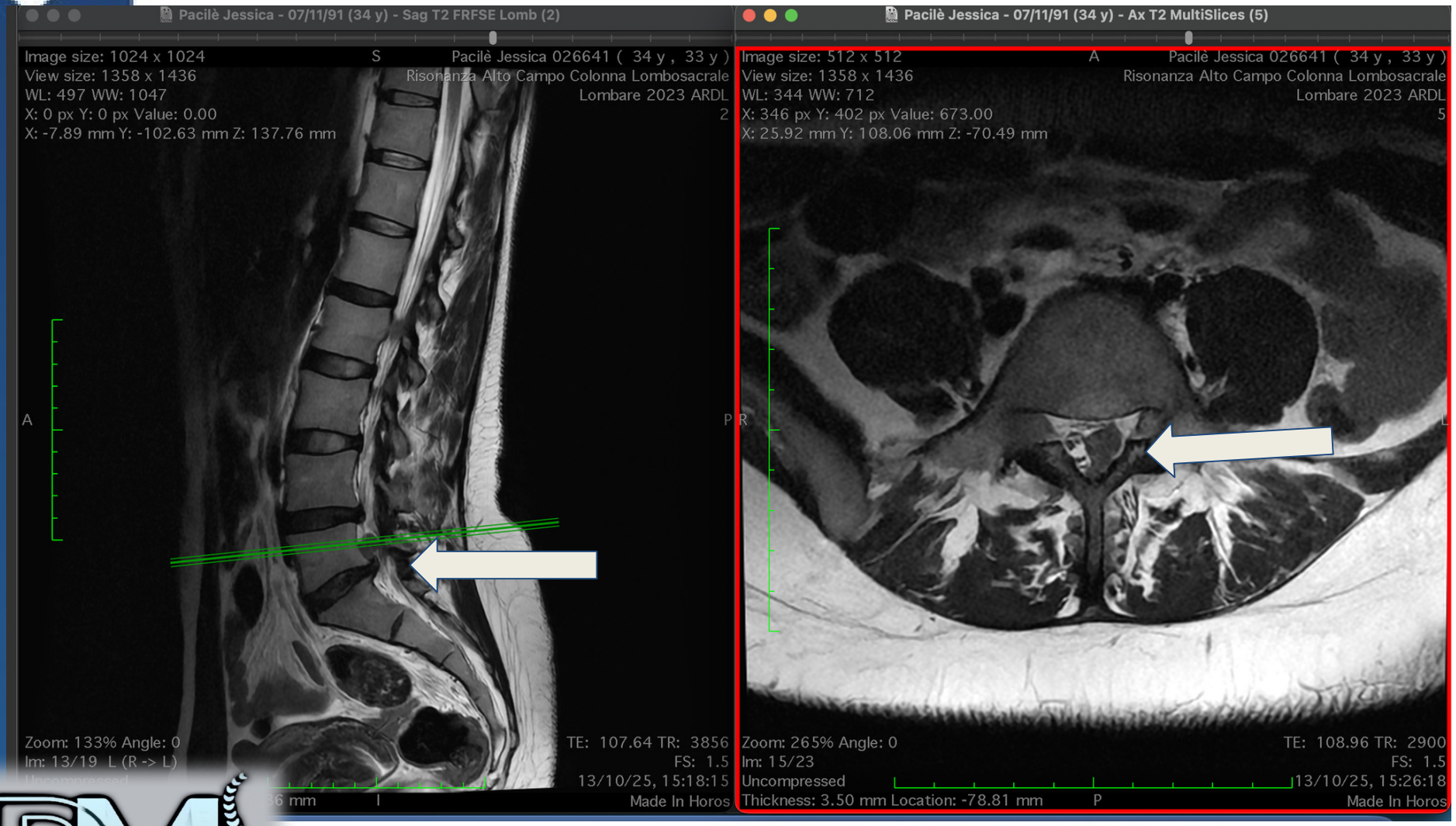


SPINAL DISORDERS METHODOLOGY

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6th CLINICAL **CASE**

MRI October 13/2025



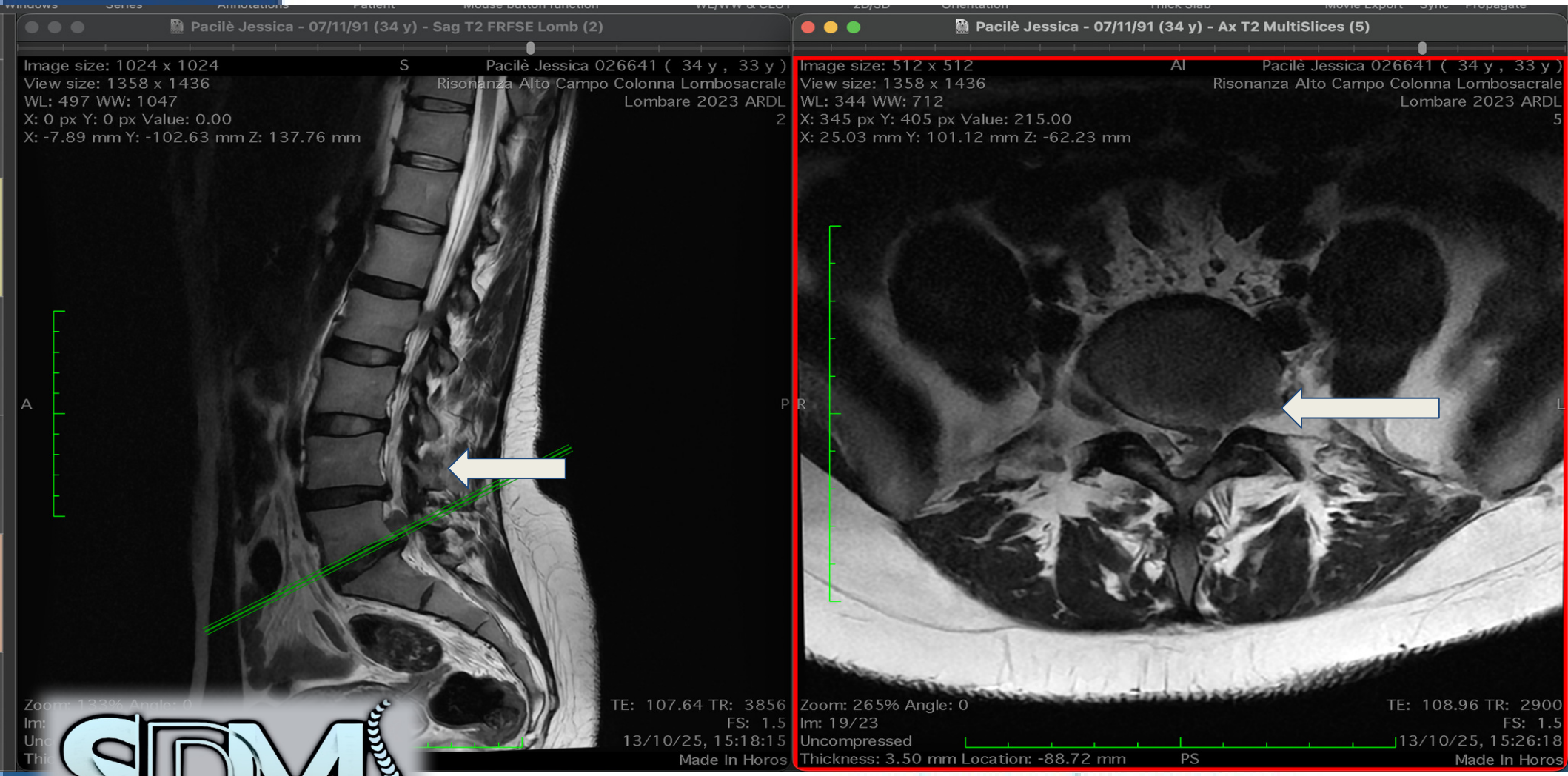
SPINAL DISORDERS METHODOLOGY

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Bio Salus center

6th CLINICAL **CASE**

MRI October 13/2025

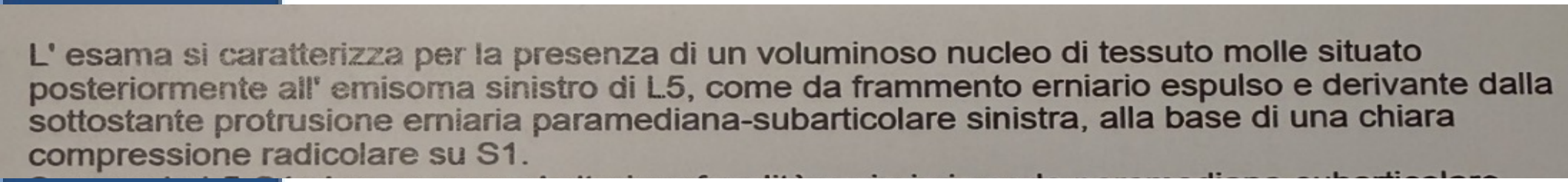


SDM SPINAL DISORDERS METHODOLOGY

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6th CLINICAL **CASE**

BEFORE SDM DUO

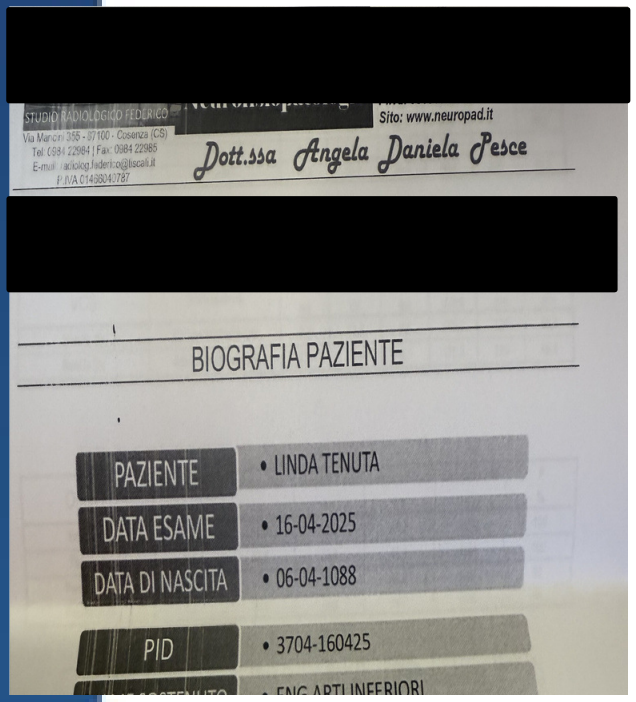

L' esama si caratterizza per la presenza di un voluminoso nucleo di tessuto molle situato posteriormente all' emisoma sinistro di L5, come da frammento erniario espulso e derivante dalla sottostante protrusione erniaria paramediana-subarticolare sinistra, alla base di una chiara compressione radicolare su S1.

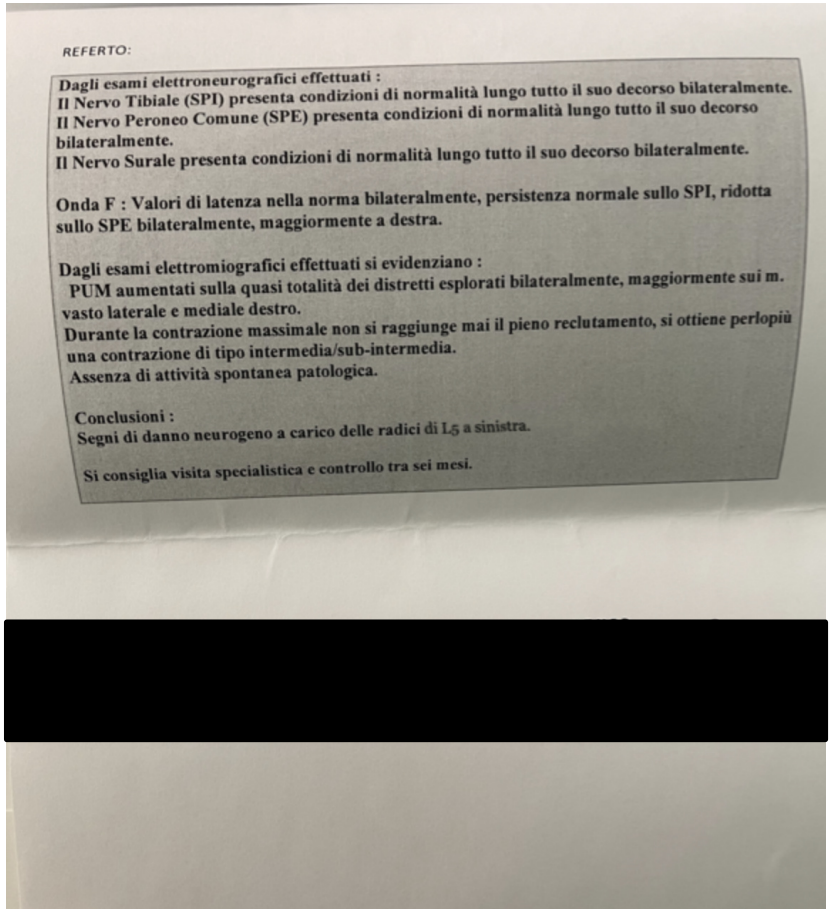
The examination is characterised by the presence of a voluminous soft tissue nucleus located posterior to the left hemisome of L5, as from an expelled hernial fragment and deriving from the underlying left paramedian-subarticular hernial protrusion, at the base of a clear Root compression on S1.

.

6th CLINICAL **CASE**

BEFORE SDM DUO: Electromyography





REFERTO:

Dagli esami elettroneurografici effettuati :
Il Nervo Tibiale (SPI) presenta condizioni di normalità lungo tutto il suo decorso bilateralmente.
Il Nervo Peroneo Comune (SPE) presenta condizioni di normalità lungo tutto il suo decorso bilateralmente.
Il Nervo Surale presenta condizioni di normalità lungo tutto il suo decorso bilateralmente.

Onda F : Valori di latenza nella norma bilateralmente, persistenza normale sullo SPI, ridotta sullo SPE bilateralmente, maggiormente a destra.

Dagli esami elettromiografici effettuati si evidenziano :
PUM aumentati sulla quasi totalità dei distretti esplorati bilateralmente, maggiormente sui m. vasto laterale e mediale destro.
Durante la contrazione massimale non si raggiunge mai il pieno reclutamento, si ottiene perlopiù una contrazione di tipo intermedia/sub-intermedia.
Assenza di attività spontanea patologica.

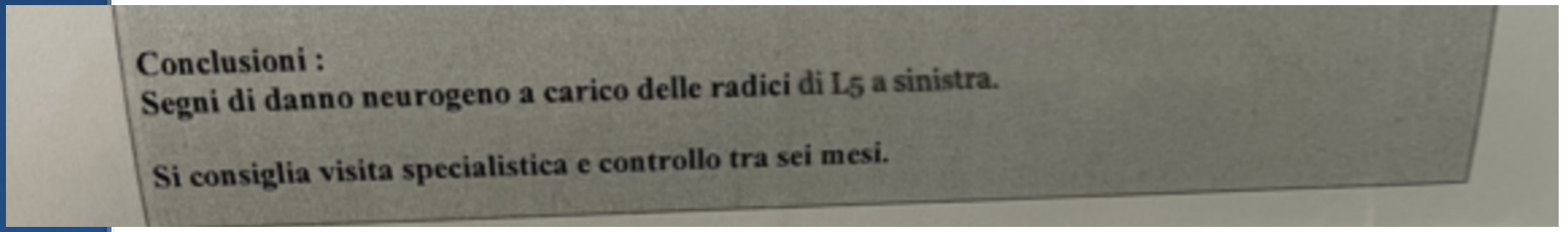
Conclusioni :
Segni di danno neurogeno a carico delle radici di L5 a sinistra.

Si consiglia visita specialistica e controllo tra sei mesi.

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6th CLINICAL **CASE**

BEFORE SDM DUO : Electromyography



Conclusioni :
Segni di danno neurogeno a carico delle radici di L5 a sinistra.

Si consiglia visita specialistica e controllo tra sei mesi.

Signs of neurogenic damage to the roots of L5 on the left

6th CLINICAL **CASE**





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SPINAL DISORDERS METHODOLOGY

6th CLINICAL **CASE**

CLINICAL EVALUATION:

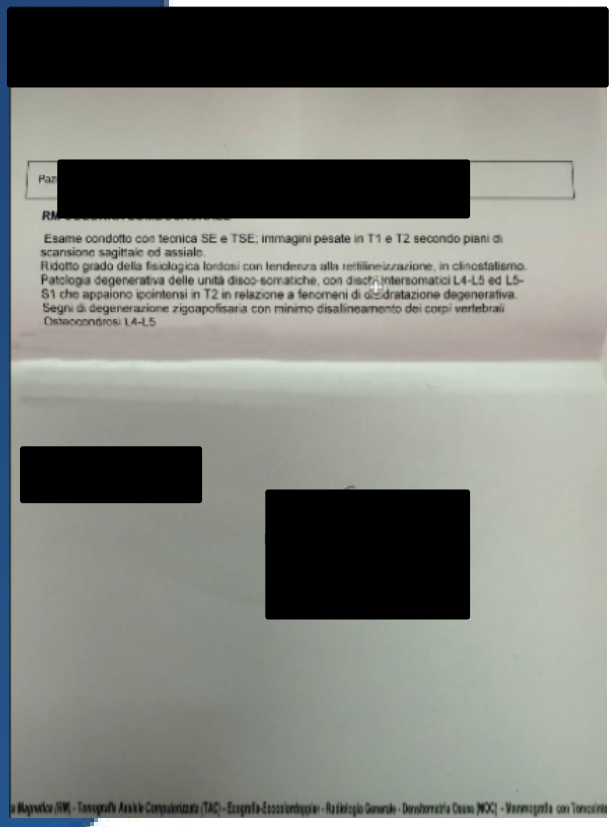
OCT 13.25	JAN 10.26
DELITALA: +++	-
LASEGUE : ++ 20	-
WASSERMANN: ++	-
FABER: ++	-
FADIR: ++	-
MINGAZIINI: -	-
TOE AND HEEL WALKING : DEFICIT	SOLVED
VALLEIX: ++	-
VAS: 10/10	0/10
ROT: HYPOELECTABLE	NORMO REFLEXION



SPINAL DISORDERS METHODOLOGY

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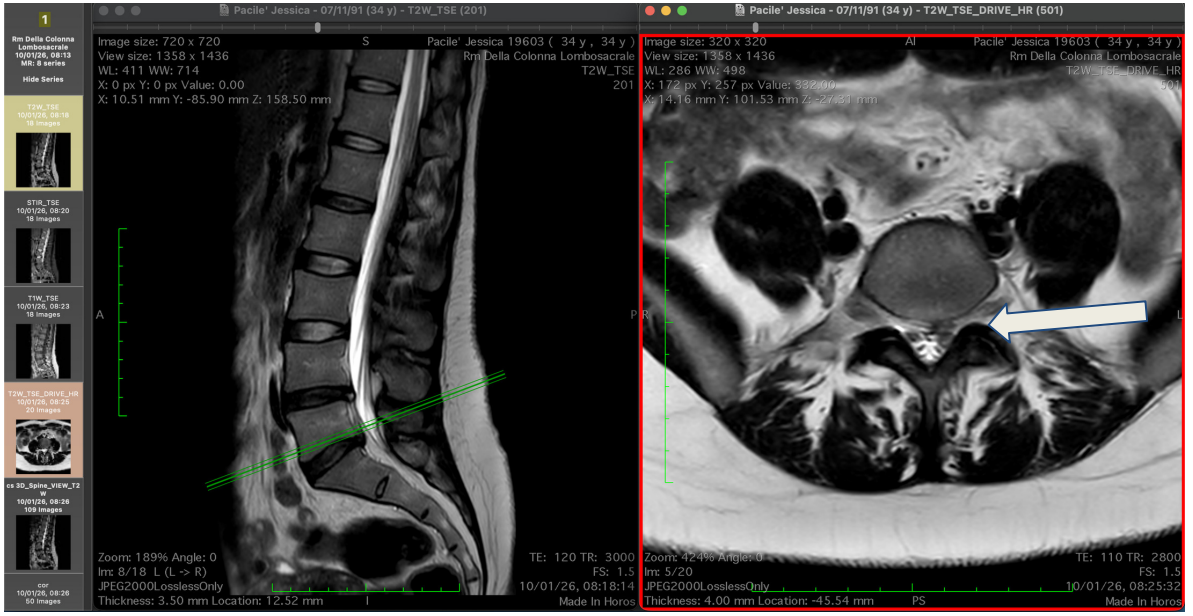
6th CLINICAL **CASE**


[redacted]

Esame condotto con tecnica SE e TSE; immagini pesate in T1 e T2 secondo piani di scansione sagittale ed assiale.
Ridotto grado della fisiologica lordosi con tendenza alla retrolinearizzazione, in clinostatismo.
Patologia degenerativa delle unità disco-somatiche, con dischi intersomatici L4-L5 ed L5-S1 che appaiono ipointensi in T2 in relazione a fenomeni di disidratazione degenerativa.
Segni di degenerazione zigoapofisaria con minimo disallineamento dei corpi vertebrali
Osteocondrosi L4-L5

[redacted]

MRI Jan 10 2026

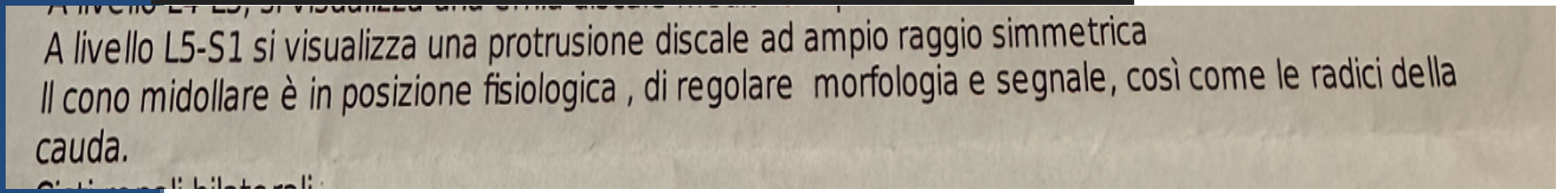


SPINAL DISORDERS METHODOLOGY

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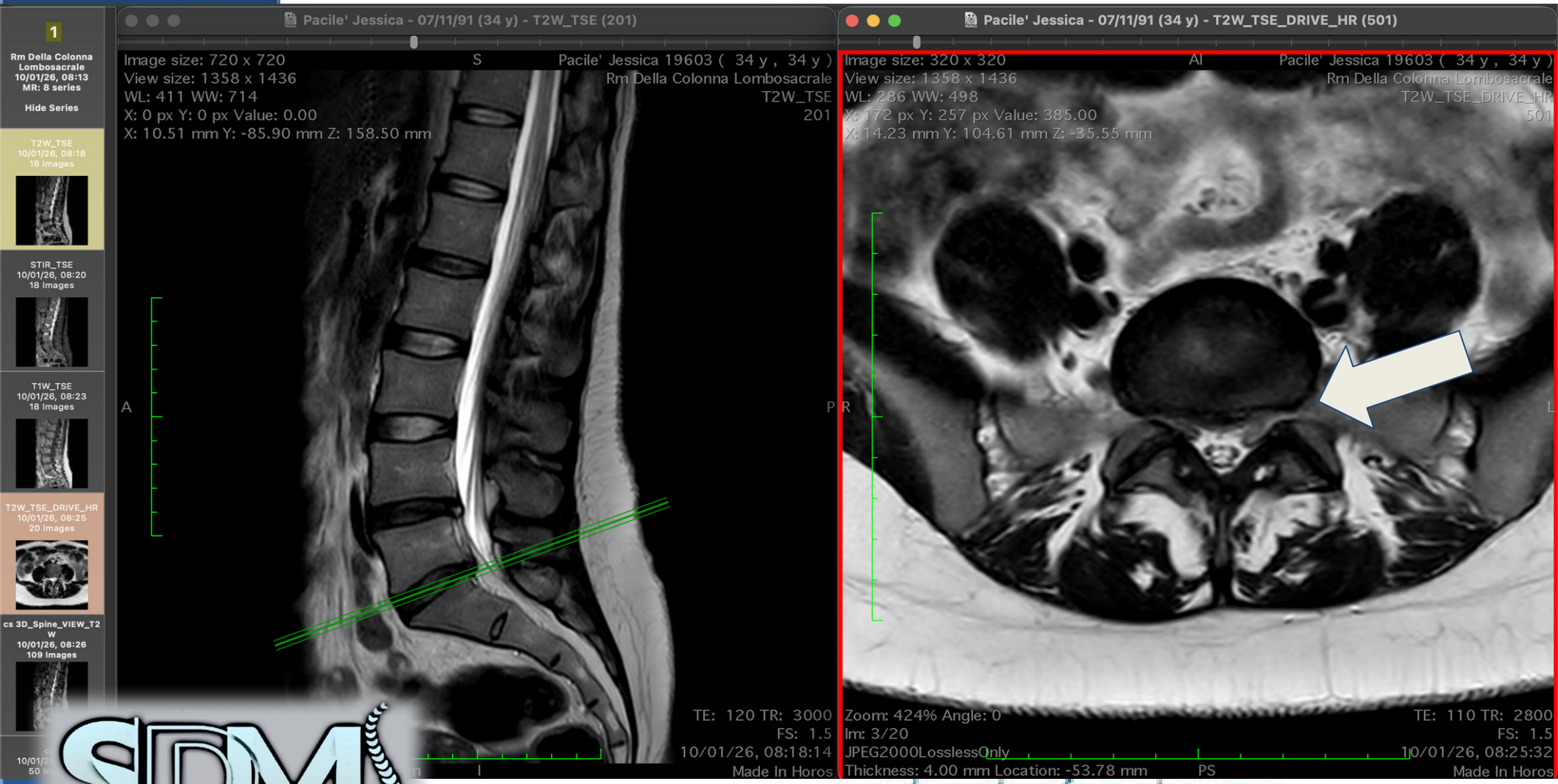
6th CLINICAL **CASE**

AFTER SDM DUO


A livello L5-S1 si visualizza una protrusione discale ad ampio raggio simmetrica
Il cono midollare è in posizione fisiologica , di regolare morfologia e segnale, così come le radici della cauda.

L5- S1 : At the L5-S1 level, a wide-range symmetrical disc protrusion is visualised.The medullary cone is in physiological position, of regular morphology and signal, as well as the roots of the cauda.

6th CLINICAL **CASE**



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6th CLINICAL **CASE**



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13th CLINICAL **CASE**





SPINAL DISORDERS METHODOLOGY

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13 th CLINICAL **CASE**

- A.O. , woman, 60 Years Old, teacher
- Normal physical constitution
- **No surgical** operations or diseases worthy of note
- Practice motor activity
- Bring in vision MRI

SPINAL DISORDERS METHODOLOGY

13th CLINICAL **CASE**

- Reporting **pain** and lumbar **functional** limitation since six months
- Functional impotence left leg with Radiculopathy since February 2026
- Previous Surgeon suggest medical therapy and discectomy if the treatments had not been decisive
- Shows up April 18/2026 evaluation presence of **clinical symptoms**
- The clinic has severe tips deficits in the presence of left hernia L5-S1
- We recommend EMG and the Surgery if the deficit has not improved within a month

SPINAL DISORDERS METHODOLOGY

13 th CLINICAL CASE

BEFORE SDM DUO

[redacted]

RM DELLA COLONNA LOMBO-SACRALE

Esame refertato in teleconsulenza su immagini teletrasmesse, per quanto valutabile si osserva:

Conservata la lordosi lombare in clinostatismo.
Disidratato il disco intersomatico L5-S1. A tale livello modesti fenomeni distrofici di tipo edematoso delle contrapposte limitanti somatiche.
In L5-S1 sembra apprezzarsi la presenza di grossolana ernia discale mediana-paramediana sinistra espulsa, che impronta lo spazio epidurale anteriore e riduce l'ampiezza del neuroforame corrispondente determinando segni di contatto disco-radicolare. Necessaria valutazione clinica e follow-up strumentale nel tempo.
Ampiezza del canale vertebrale lombare conservata.

Videat neurochirurgico

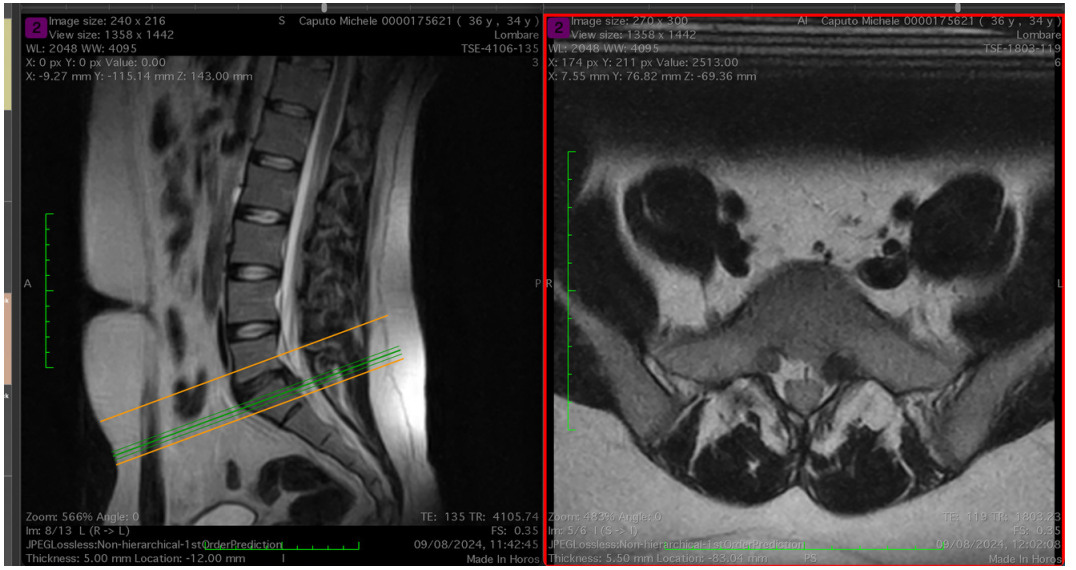
Si rimanda al curante di riferimento.

IL MEDICO RADIOLOGO
Francesco Pucciarelli

Data 14-08-2024

DIAGNOSTICO srl

MRI March 14/2026



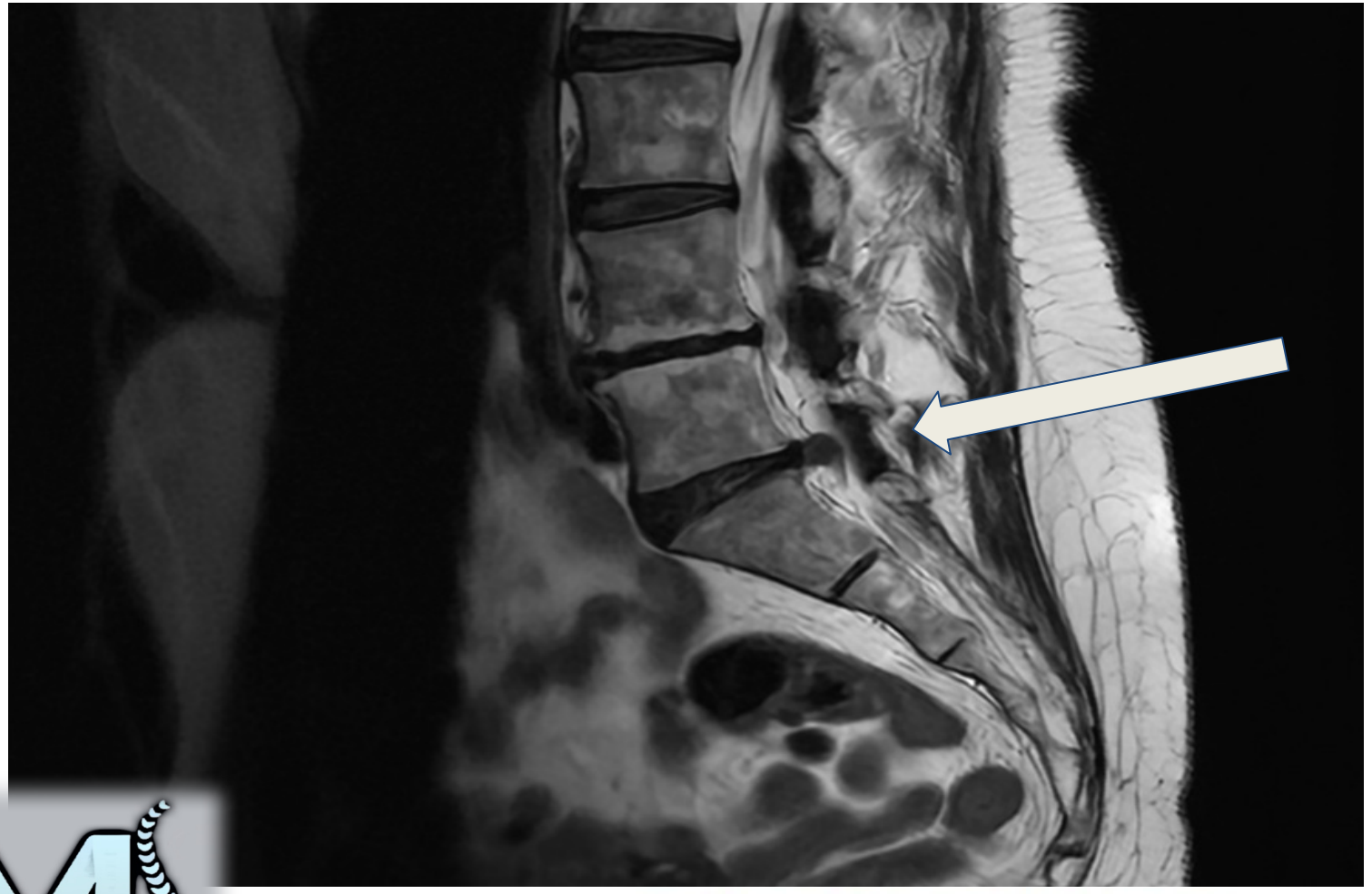
SPINAL DISORDERS METHODOLOGY

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13 th CLINICAL **CASE**

BioSalus center

MRI March 14/2026



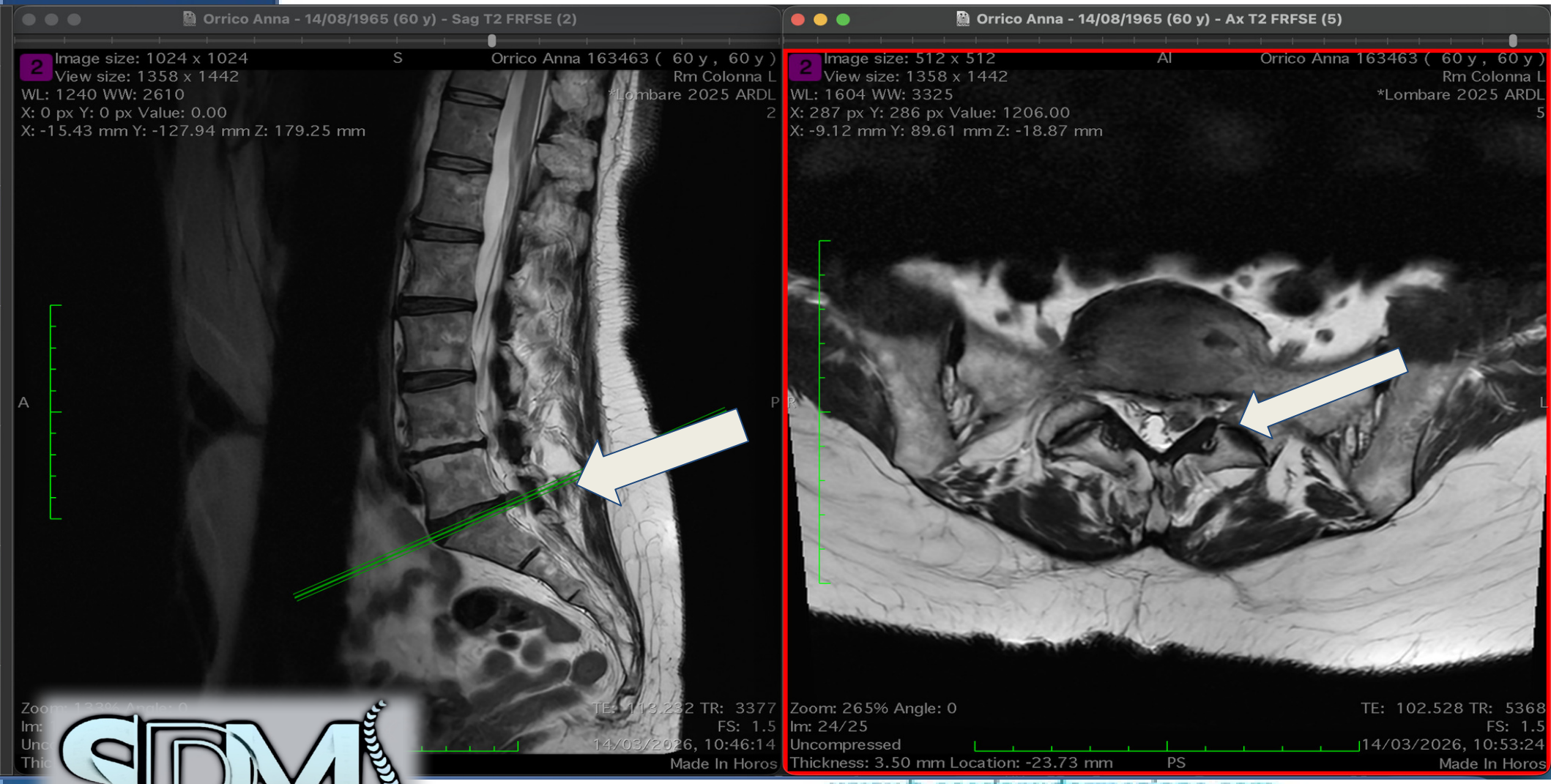
SDM SPINAL DISORDERS METHODOLOGY

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13 th CLINICAL **CASE**

BioSalus center

MRI March 14/2026



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13 th CLINICAL **CASE**

MRI March 14/2026



SPINAL DISORDERS METHODOLOGY

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13 th CLINICAL **CASE**

BEFORE SDM DUO



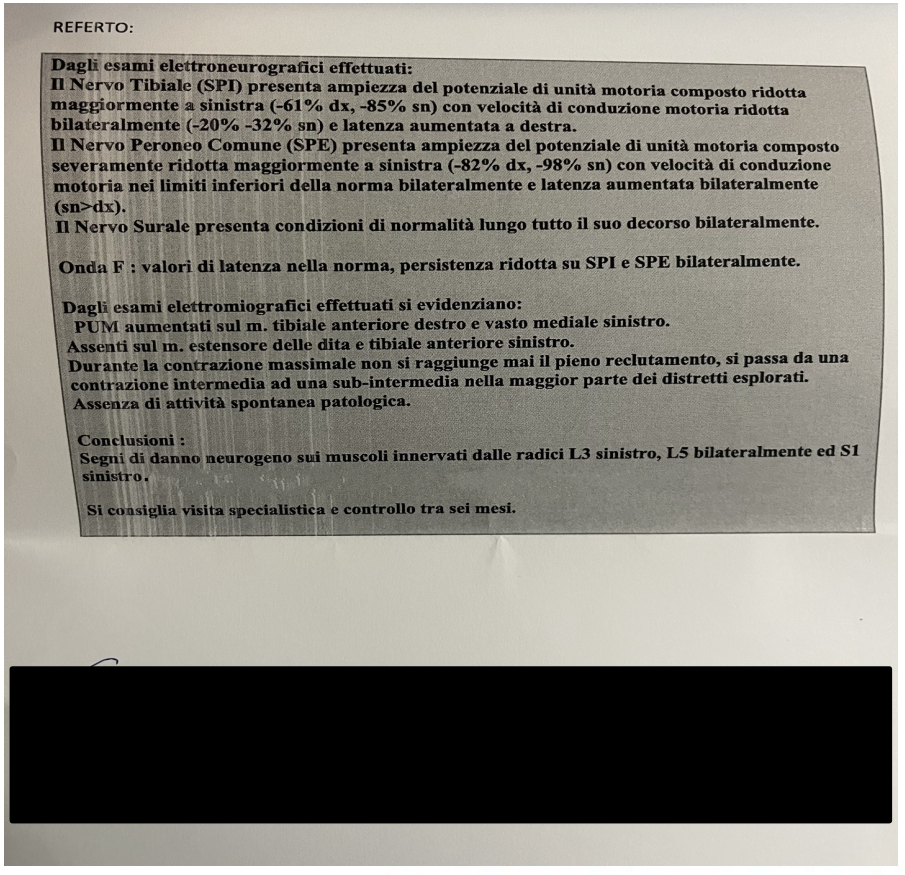
Left lateral disc herniation L5-S1 that reduces the corresponding recess by amplitude

SPINAL DISORDERS METHODOLOGY

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13th CLINICAL **CASE**

BEFORE SDM DUO : Electromyography



REFERTO:

Dagli esami elettroneurografici effettuati:
Il Nervo Tibiale (SPI) presenta ampiezza del potenziale di unità motoria composto ridotta maggiormente a sinistra (-61% dx, -85% sn) con velocità di conduzione motoria ridotta bilateralmente (-20% -32% sn) e latenza aumentata a destra.
Il Nervo Peroneo Comune (SPE) presenta ampiezza del potenziale di unità motoria composto severamente ridotta maggiormente a sinistra (-82% dx, -98% sn) con velocità di conduzione motoria nei limiti inferiori della norma bilateralmente e latenza aumentata bilateralmente (sn>dx).
Il Nervo Surale presenta condizioni di normalità lungo tutto il suo decorso bilateralmente.

Onda F : valori di latenza nella norma, persistenza ridotta su SPI e SPE bilateralmente.

Dagli esami elettromiografici effettuati si evidenziano:
PUM aumentati sul m. tibiale anteriore destro e vasto mediale sinistro.
Assenti sul m. estensore delle dita e tibiale anteriore sinistro.
Durante la contrazione massimale non si raggiunge mai il pieno reclutamento, si passa da una contrazione intermedia ad una sub-intermedia nella maggior parte dei distretti esplorati.
Assenza di attività spontanea patologica.

Conclusioni :
Segni di danno neurogeno sui muscoli innervati dalle radici L3 sinistro, L5 bilateralmente ed S1 sinistro.

Si consiglia visita specialistica e controllo tra sei mesi.

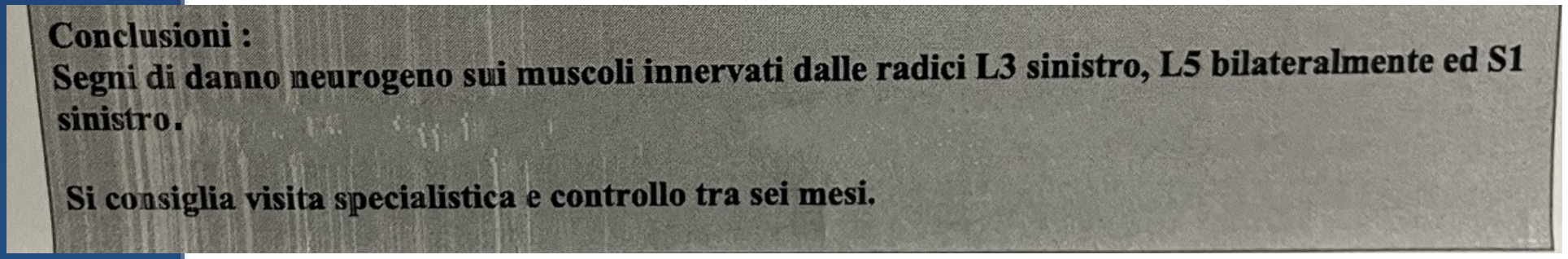
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SPINAL DISORDERS METHODOLOGY

13th CLINICAL **CASE**

BEFORE SDM DUO : Electromyography



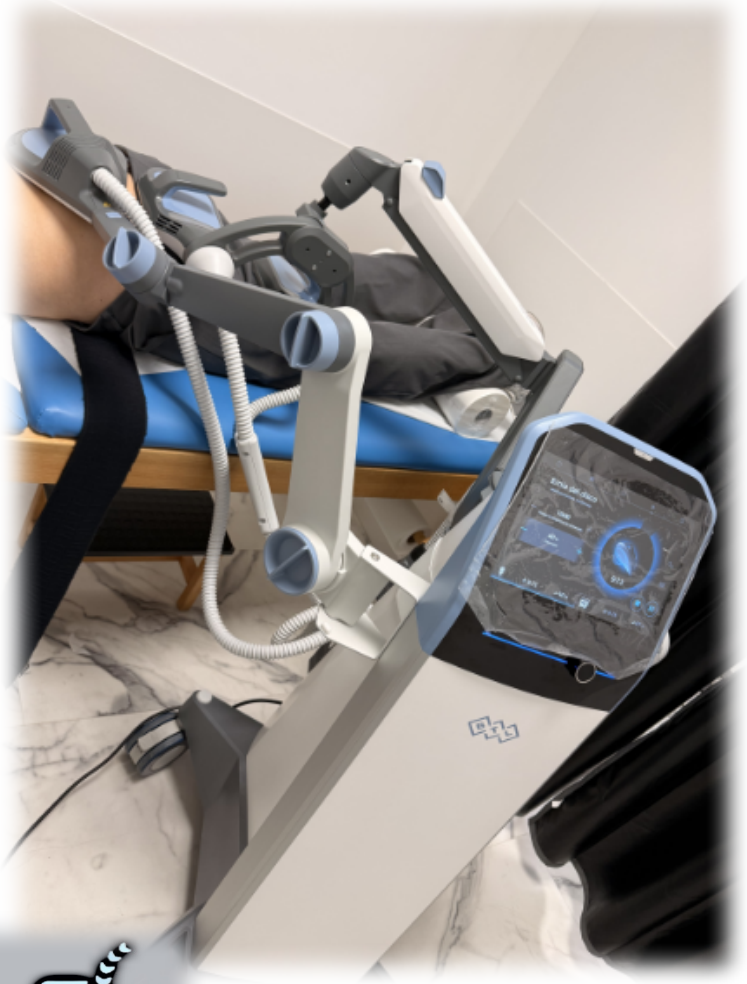
Conclusioni :
Segni di danno neurogeno sui muscoli innervati dalle radici L3 sinistro, L5 bilateralmente ed S1 sinistro.

Si consiglia visita specialistica e controllo tra sei mesi.

Signs of neurogenic damage in the muscles innervated by the roots L3 left, L5 bilaterally and S1 left.

SPINAL DISORDERS METHODOLOGY

13 th CLINICAL **CASE**





SPINAL DISORDERS METHODOLOGY

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13 th CLINICAL **CASE**



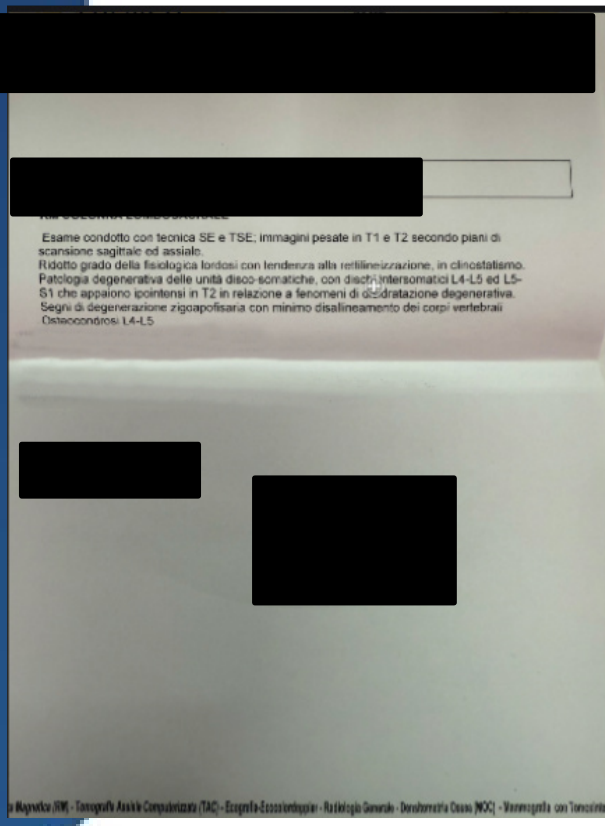
CLINICAL EVALUATION:

APR 18.26	MAY 16.26
DELITALA: +++	-
LASEGUE : +++	-
WASSERMANN: +++	-
FABER: ++	-
FADIR: ++	-
MINGAZIINI: -	-
TIPS WALKING : DEFICIT	SOLVED
VALLEIX: +++	-
VAS: 10/10	0/10
ROT: LEFT HYPOELECTABLE	NORMO REFLEXION

SPINAL DISORDERS METHODOLOGY

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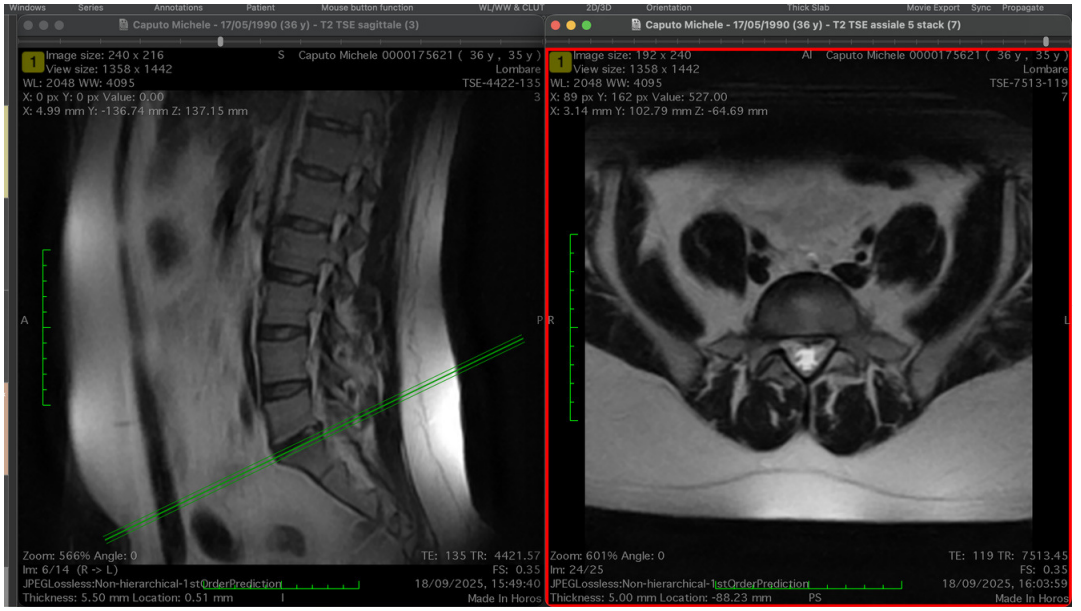
13 th CLINICAL **CASE**


[redacted]

Esame condotto con tecnica SE e TSE, immagini pesate in T1 e T2 secondo piani di scansione sagittale ed assiale.
Ridotto grado della fisiologica lordosi con tendenza alla rettilineizzazione, in clinostatismo.
Patologia degenerativa delle unità disco-somatiche, con disco intersomatici L4-L5 ed L5-S1 che appaiono ipointensi in T2 in relazione a fenomeni di disidratazione degenerativa.
Segni di degenerazione zigoapofisaria con minimo disallineamento dei corpi vertebrali
Osteocondrosi L4-L5

[redacted]

MRI MAY 25 2026



SPINAL DISORDERS METHODOLOGY

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13 th CLINICAL **CASE**

AFTER SDM DUO

In L5-S1 protrusione discale a base ampia postero-mediana .

At the L5-S1 level, Protrusion of discs with a wide posteromedian base

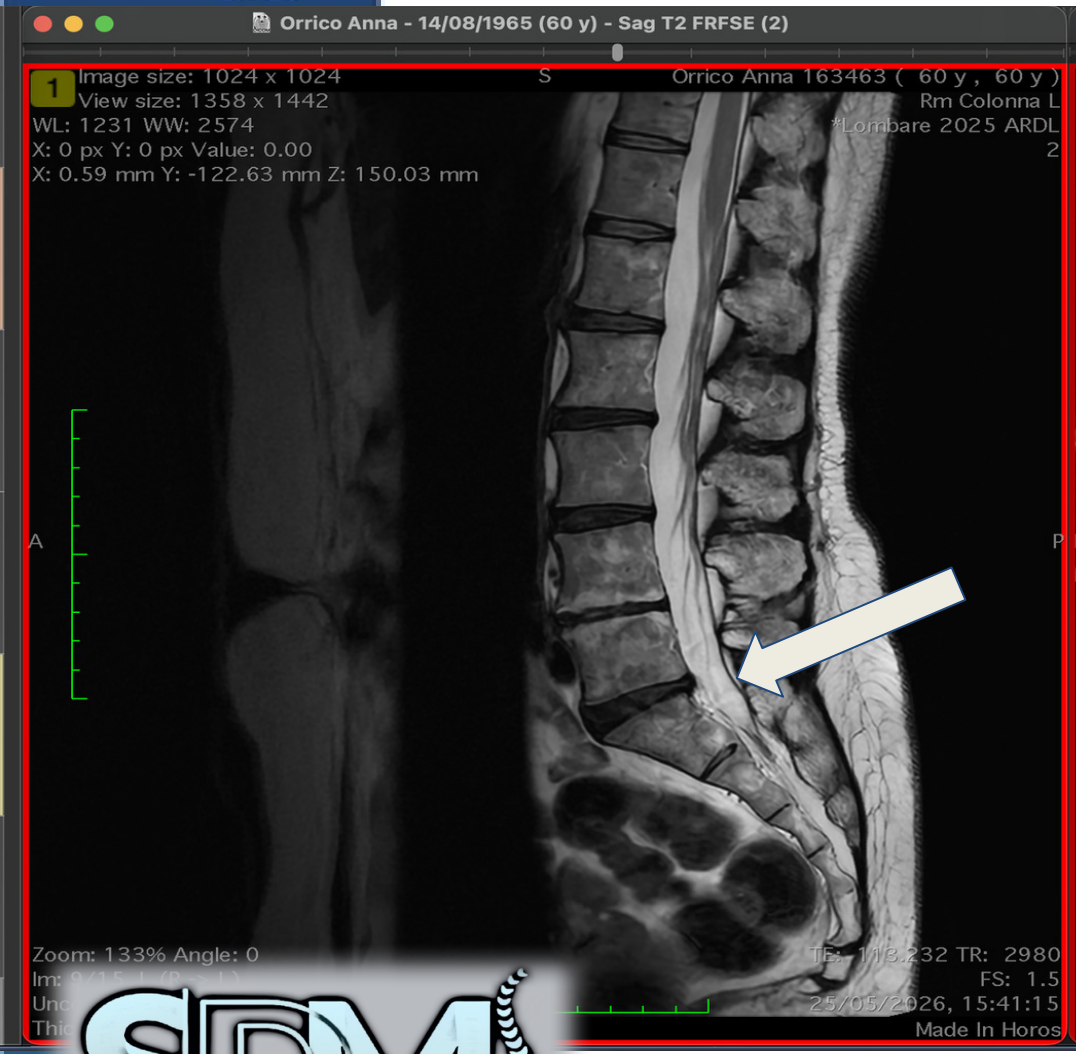


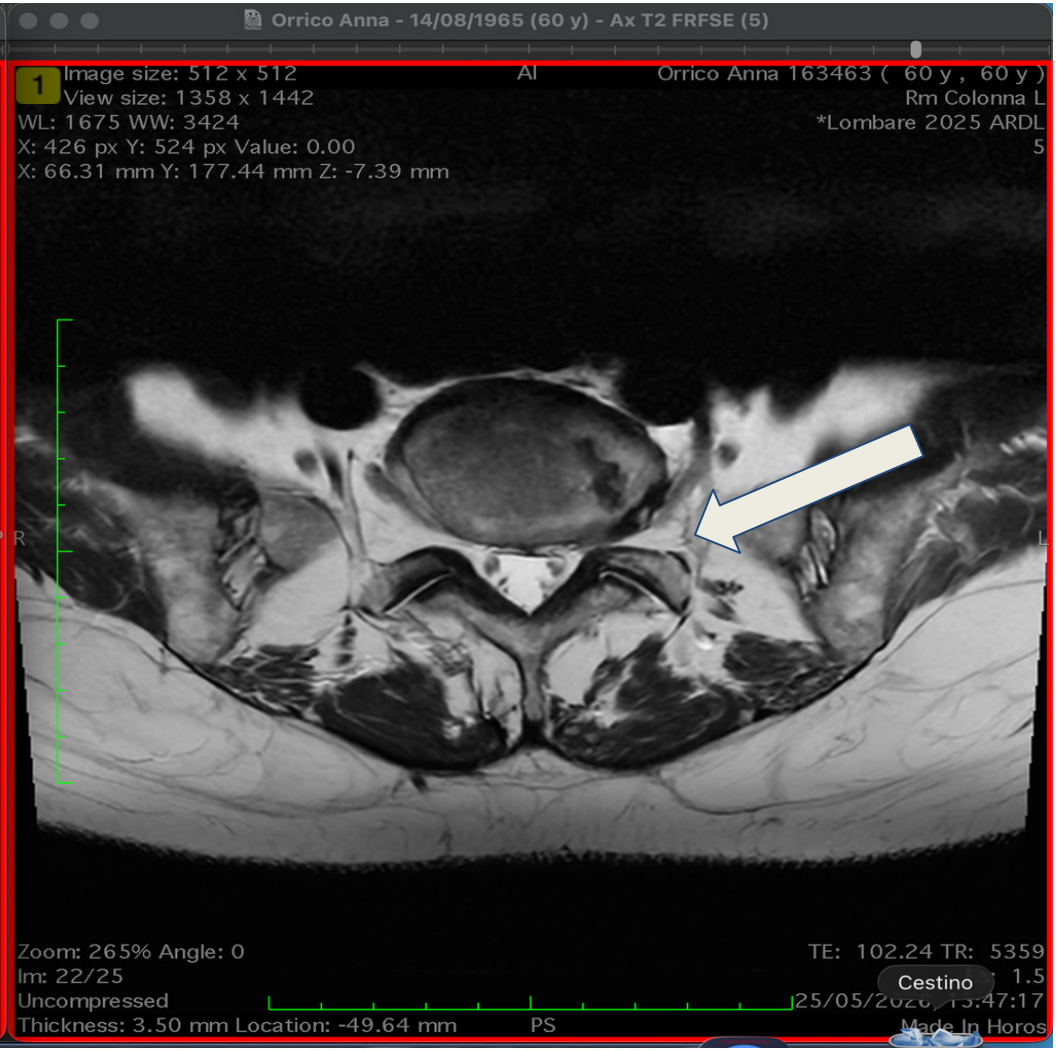
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13 th CLINICAL **CASE**

BioSalus center

MRI May 25/2026



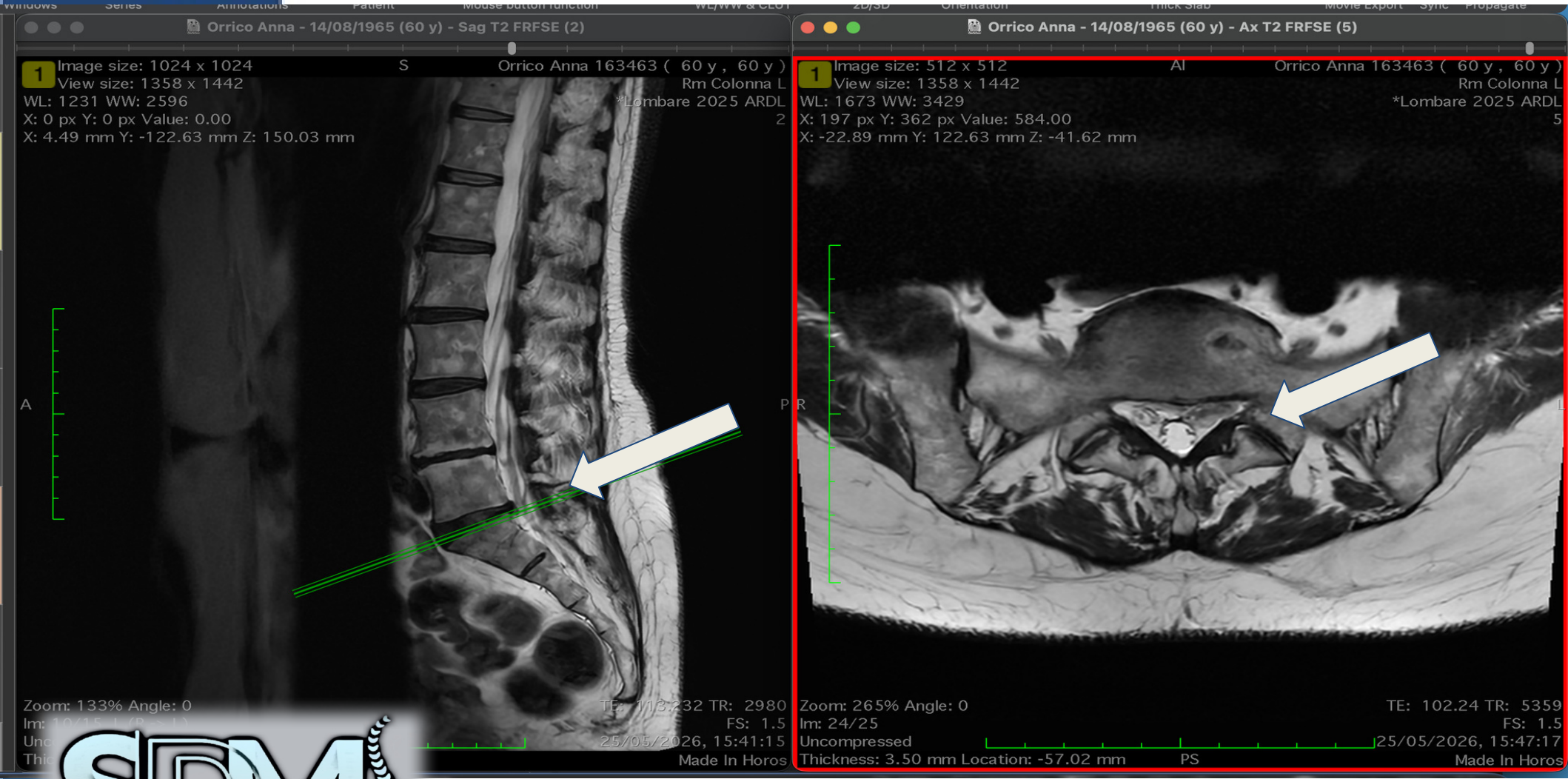


SDM SPINAL DISORDERS METHODOLOGY

www.b-academyformazione.com

13 th CLINICAL **CASE**

MRI May 25/2026



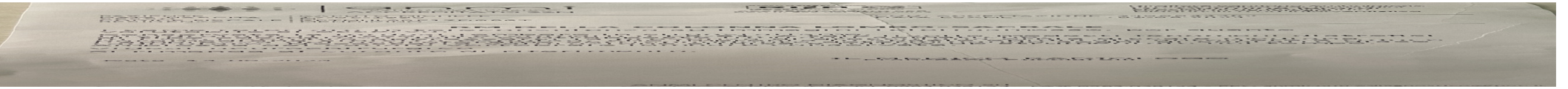
SPINAL DISORDERS METHODOLOGY

www.b-academyformazione.com

10°9°7° CLINICAL **CASES**

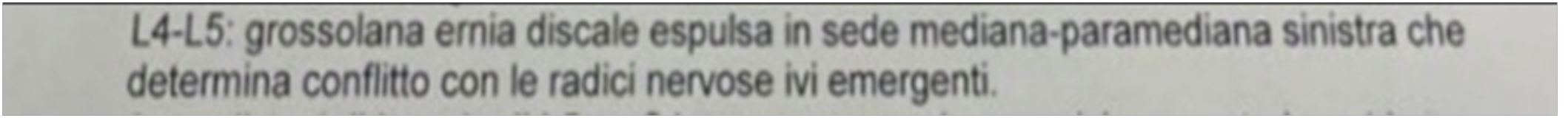
BEFORE SDM DUO

9° CC : MRI



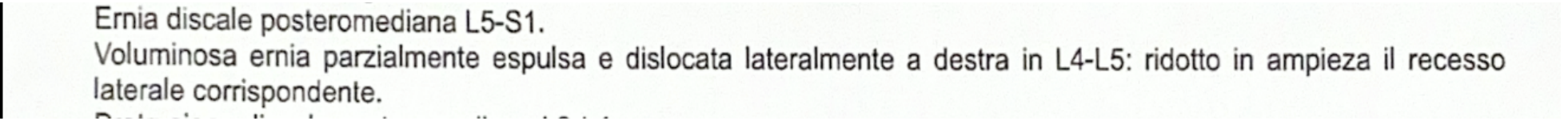
In L5-51, the presence of expelled left median-paramedian disc herniation seems to be appreciated, which imprints the anterior epidural space and reduces the amplitude of the corresponding neuroforamen, causing signs of disc-radicular contact. Necessary clinical evaluation and instrumental follow-up over time

10° CC :MRI



L4-L5: gross disc **herniation** expelled in the **left median-paramedian** area which causes **conflict** with the emerging **nerve roots**.

7° CC :MRI

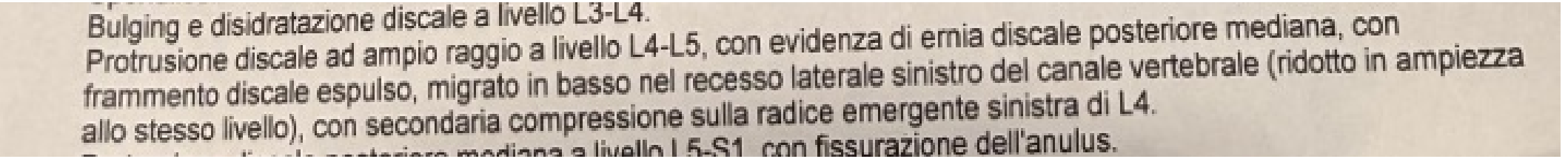


Hernia posterior median L5-S1.
Voluminous hernia partially expelled and dislocated laterally to the right in L4-L5 : reduced in amplitude the corresponding lateral recess.

11°12°14° CLINICAL CASES

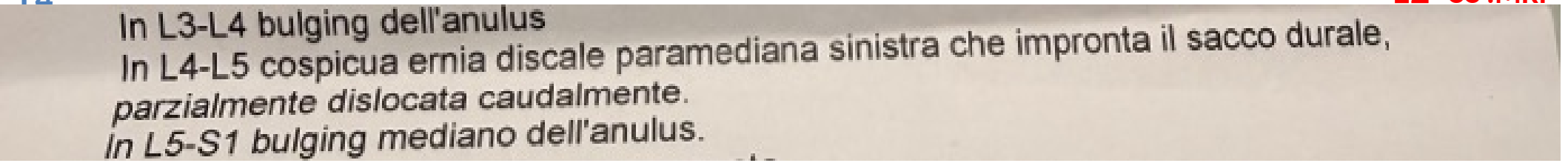
BEFORE SDM DUO

11° CC :MRI


Bulging e disidratazione discale a livello L3-L4.
Protrusione discale ad ampio raggio a livello L4-L5, con evidenza di ernia discale posteriore mediana, con frammento discale espulso, migrato in basso nel recesso laterale sinistro del canale vertebrale (ridotto in ampiezza allo stesso livello), con secondaria compressione sulla radice emergente sinistra di L4.
con fissurazione dell'anulus.

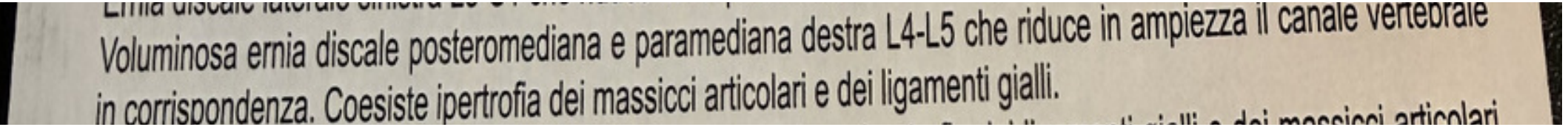
Wide-radius disc protrusion at L4-L5 level, with evidence of medial posterior disc herniation, with expelled disc fragment, migrated downwards into the left lateral recess of the vertebral canal (reduced in amplitude at the same level), with secondary compression on the left emerging root of L4

12° CC :MRI


In L3-L4 bulging dell'anulus
In L4-L5 cospicua ernia discale paramediana sinistra che impronta il sacco durale,
parzialmente dislocata caudalmente.
In L5-S1 bulging mediano dell'anulus.

L4-L5: Conspicuous left paramedian disc herniation that imprints the Dural Sac partially dislocated caudally.

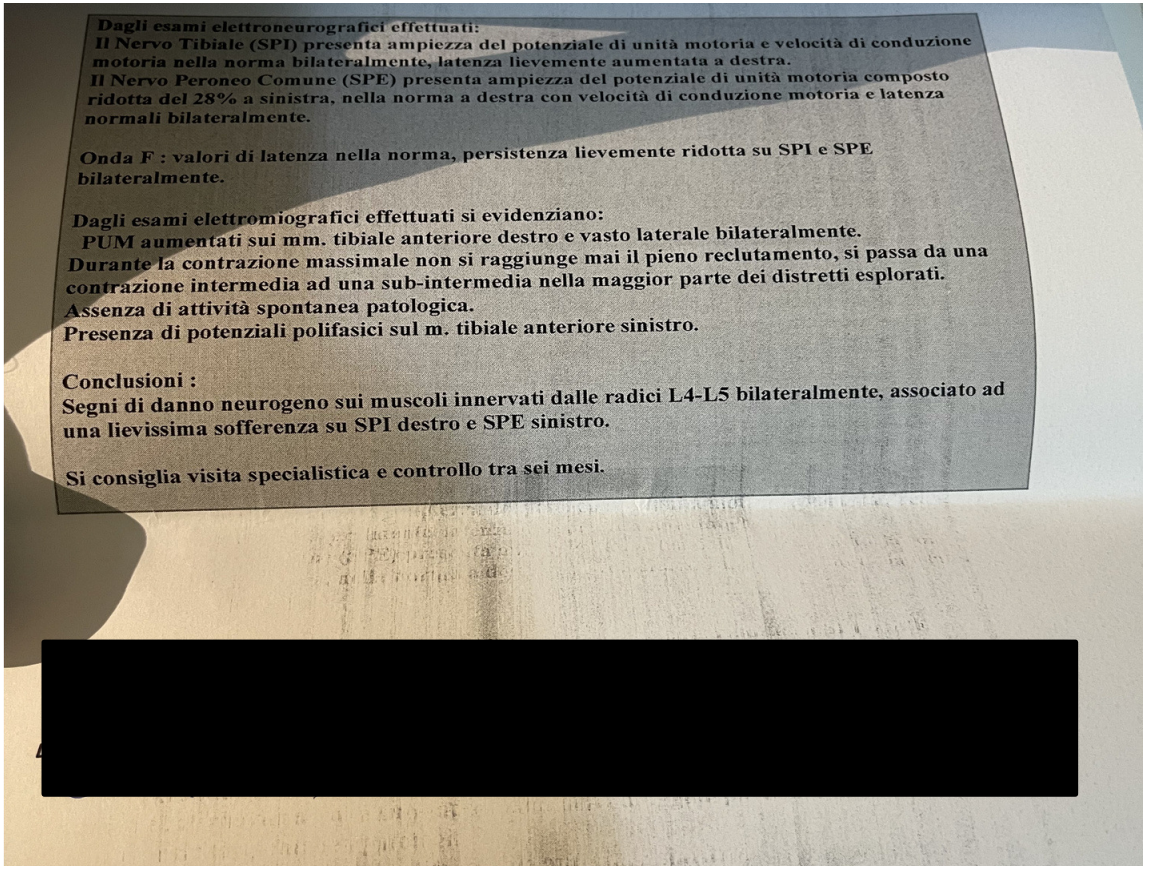
14° CC :MRI


Voluminosa ernia discale posteromediana e paramediana destra L4-L5 che riduce in ampiezza il canale vertebrale
in corrispondenza. Coesiste ipertrofia dei massicci articolari e dei ligamenti gialli.

Large posterior central and right paramedian L4–L5 disc herniation, causing narrowing of the spinal canal at that level.

7-9-10-11-12-14th CLINICAL **CASE**

BEFORE SDM DUO : Electromyography



Dagli esami elettroneurografici effettuati:
Il Nervo Tibiale (SPI) presenta ampiezza del potenziale di unità motoria e velocità di conduzione motoria nella norma bilateralmente, latenza lievemente aumentata a destra.
Il Nervo Peroneo Comune (SPE) presenta ampiezza del potenziale di unità motoria composto ridotta del 28% a sinistra, nella norma a destra con velocità di conduzione motoria e latenza normali bilateralmente.

Onda F : valori di latenza nella norma, persistenza lievemente ridotta su SPI e SPE bilateralmente.

Dagli esami elettromiografici effettuati si evidenziano:
PUM aumentati sui mm. tibiale anteriore destro e vasto laterale bilateralmente.
Durante la contrazione massimale non si raggiunge mai il pieno reclutamento, si passa da una contrazione intermedia ad una sub-intermedia nella maggior parte dei distretti esplorati.
Assenza di attività spontanea patologica.
Presenza di potenziali polifasici sul m. tibiale anteriore sinistro.

Conclusioni :
Segni di danno neurogeno sui muscoli innervati dalle radici L4-L5 bilateralmente, associato ad una lievissima sofferenza su SPI destro e SPE sinistro.

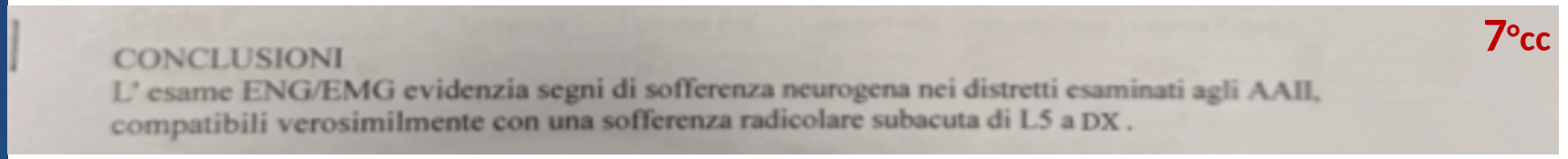
Si consiglia visita specialistica e controllo tra sei mesi.

[redacted]

7-9-10-11-12-14th CLINICAL **CASE**

BEFORE SDM DUO : Electromyography

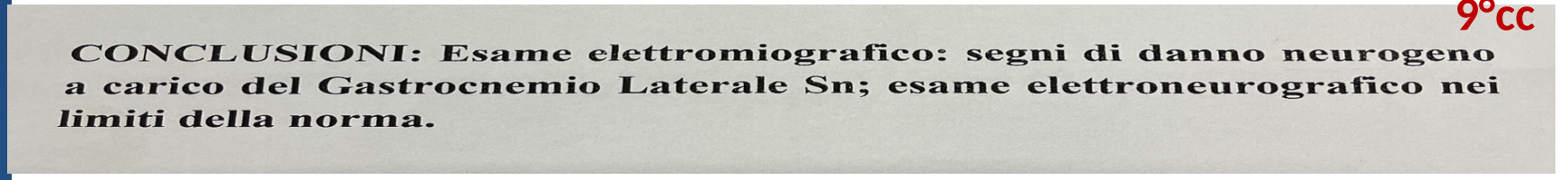
7°cc



CONCLUSIONI
L' esame ENG/EMG evidenzia segni di sofferenza neurogena nei distretti esaminati agli AAII, compatibili verosimilmente con una sofferenza radicolare subacuta di L5 a DX .

Signs of neurogenic and subacute root suffering of L5 on the right

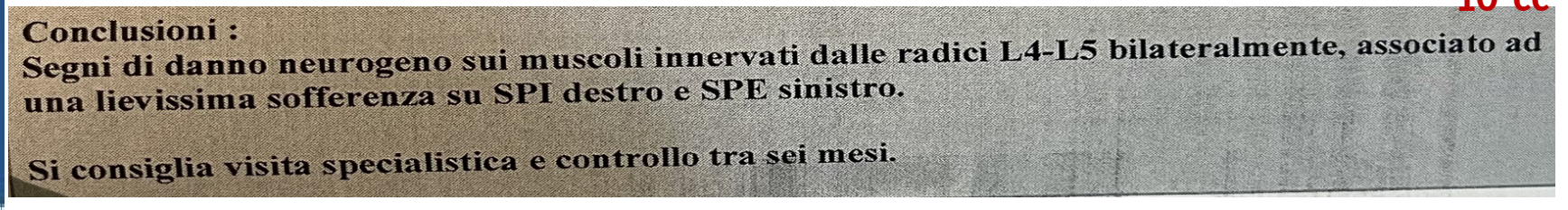
9°cc



CONCLUSIONI: Esame elettromiografico: segni di danno neurogeno a carico del Gastrocnemio Laterale Sn; esame elettroneurografico nei limiti della norma.

Signs of neurogenic damage to the left gastrocnemia

10°cc



Conclusioni :
Segni di danno neurogeno sui muscoli innervati dalle radici L4-L5 bilateralmente, associato ad una lievissima sofferenza su SPI destro e SPE sinistro.

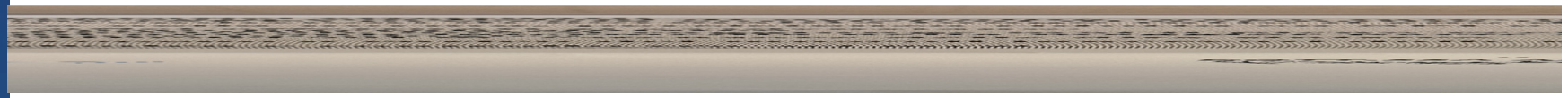
Si consiglia visita specialistica e controllo tra sei mesi.

Signs of neurogenic damage to the muscles innervated by the L4-L5 roots bilaterally, associated with very slight suffering on the right SPI and left SPE.

7-9-10-11-12-14th CLINICAL **CASE**

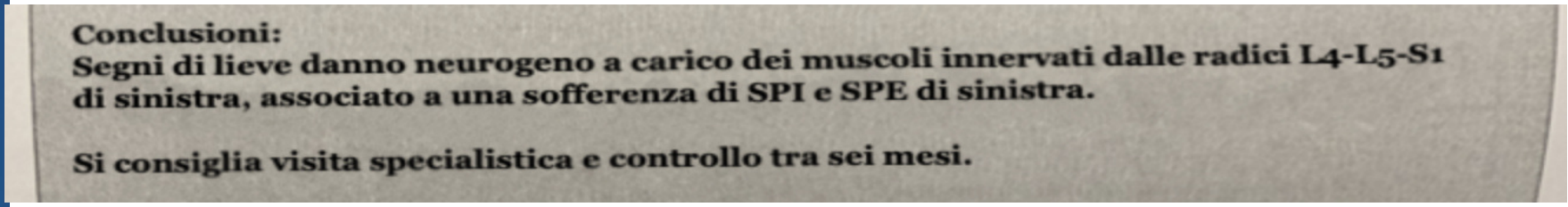
BEFORE SDM DUO : Electromyography

11°cc



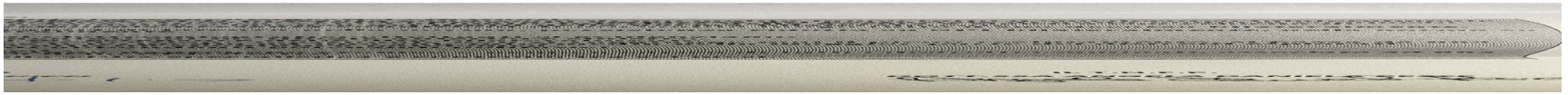
Signs of neurogenic and subacute root suffering of L5 on the right

12°cc



Signs of neurogenic damage to the muscles innervated by the left L4-L5-S1 roots with suffering of left SPI and SPE.

14°cc



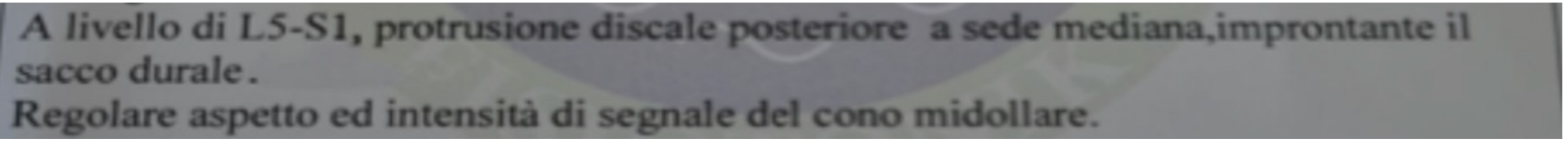
Signs of chronic and acute neurogenic damage of all districts examined associated with suffering of the right SPE.

10°-9-°7° CLINICAL **CASES**

BioSalus center

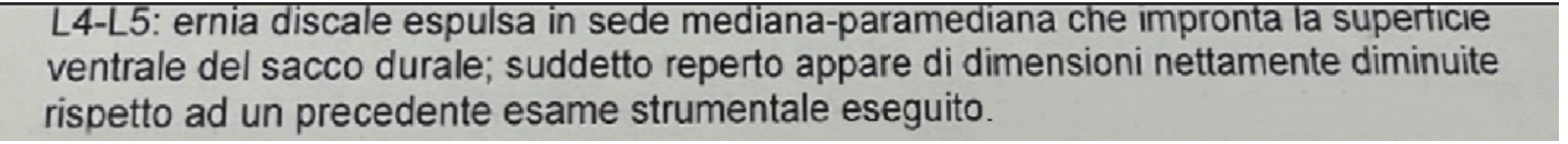
AFTER SDM DUO

9°cc MRI


A livello di L5-S1, protrusione discale posteriore a sede mediana,improntante il sacco durale.
Regolare aspetto ed intensità di segnale del cono midollare.

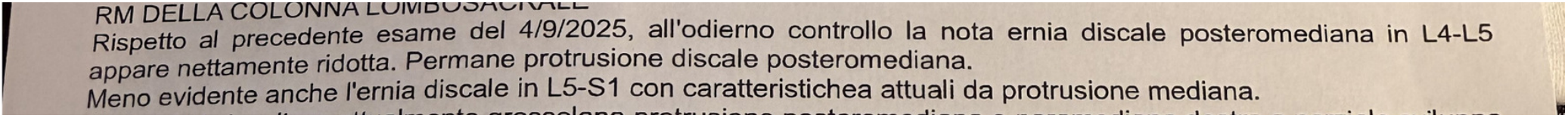
At the L5-S1 level, posterior disc protrusion with a median site, imprinting the dural sac.

10°cc MRI


L4-L5: ernia discale espulsa in sede mediana-paramediana che impronta la superficie ventrale del sacco durale; suddetto reperto appare di dimensioni nettamente diminuite rispetto ad un precedente esame strumentale eseguito.

L4-L5: disc herniation expelled in the median-paramedian area which imprints the ventral surface of the dural sac; the aforementioned finding appears to have clearly decreased in size compared to a previous instrumental examination performed .

7°cc MRI

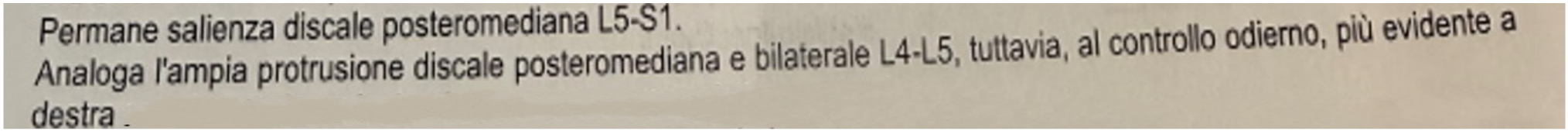

RM DELLA COLONNA LOMBOSACRALE
Rispetto al precedente esame del 4/9/2025, all'odierno controllo la nota ernia discale posteromediana in L4-L5 appare nettamente ridotta. Permane protrusione discale posteromediana.
Meno evidente anche l'ernia discale in L5-S1 con caratteristichea attuali da protrusione mediana.

Compared to the previous examination of 4/9/2025, the well-known posteromedian disc herniation in L4-L5 appears significantly reduced. Posteromedian disc protrusion remains.
Less evident is also the herniated disc in L5-S1 with current characteristics of median protrusion.

11°-12°-14°CLINICAL **CASES**

AFTER SDM DUO

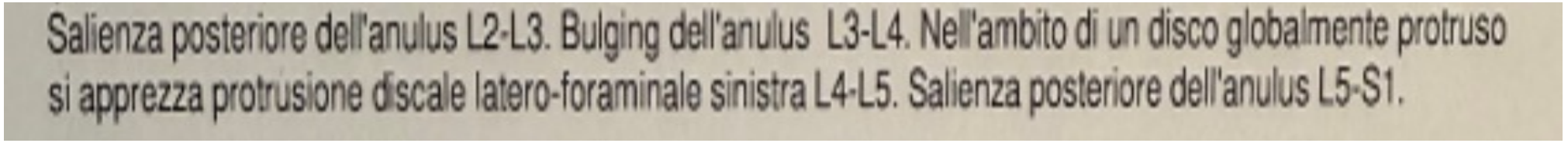
11°cc MRI


Permane salienza discale posteromediana L5-S1.
Analoga l'ampia protrusione discale posteromediana e bilaterale L4-L5, tuttavia, al controllo odierno, più evidente a destra .

Postomedian disc protrusion L5-S1 remains.

The wide posteromedian and bilateral L4-L5 disc protrusion is similar, however, at today's control, more evident on the right.

12°cc MRI


Salienza posteriore dell'anulus L2-L3. Bulging dell'anulus L3-L4. Nell'ambito di un disco globalmente protruso si apprezza protrusione discale latero-foraminale sinistra L4-L5. Salienza posteriore dell'anulus L5-S1.

Left lateral-foraminal disc protrusion L4-L5 is appreciated

14°cc MRI


Ampia protrusione discale L4-L5.
Salienza discale posteromediana L5-S1.

Large disc protrusion L4-L5

CLINICAL EVALUATION:

Before	After
DELITALA: ++	-
LASEGUE : ++	-
WASSERMANN: ++	-
FABER: ++	-
FADIR: ++	-
MINGAZIINI: -	-
TOE AND HEEL WALKING : DEFICIT	SOLVED
VALLEIX: ++	-
VAS: 10/10	0/10
ROT: HYPOELECTABLE	NORMO REFLEXION



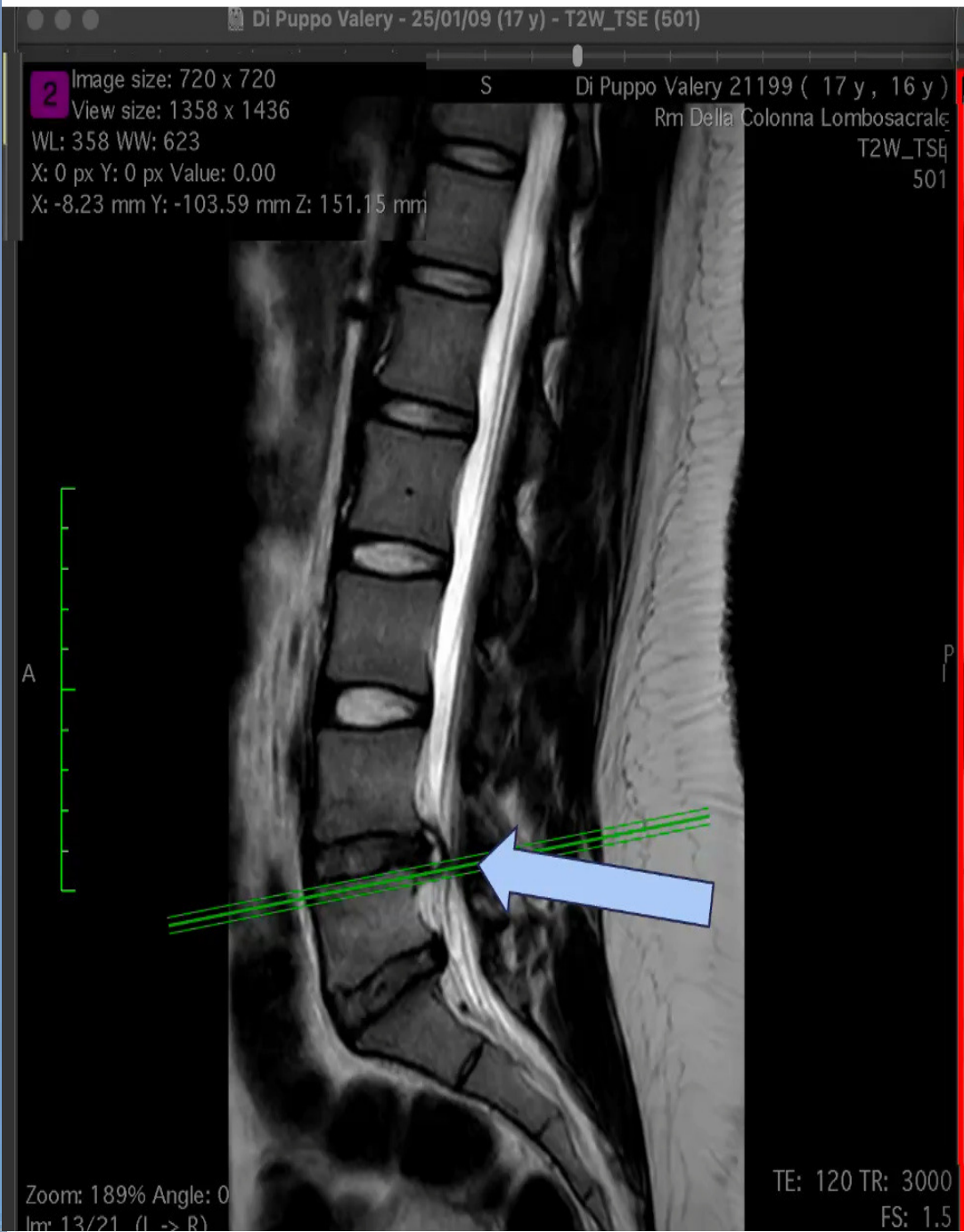
Bio Salus center

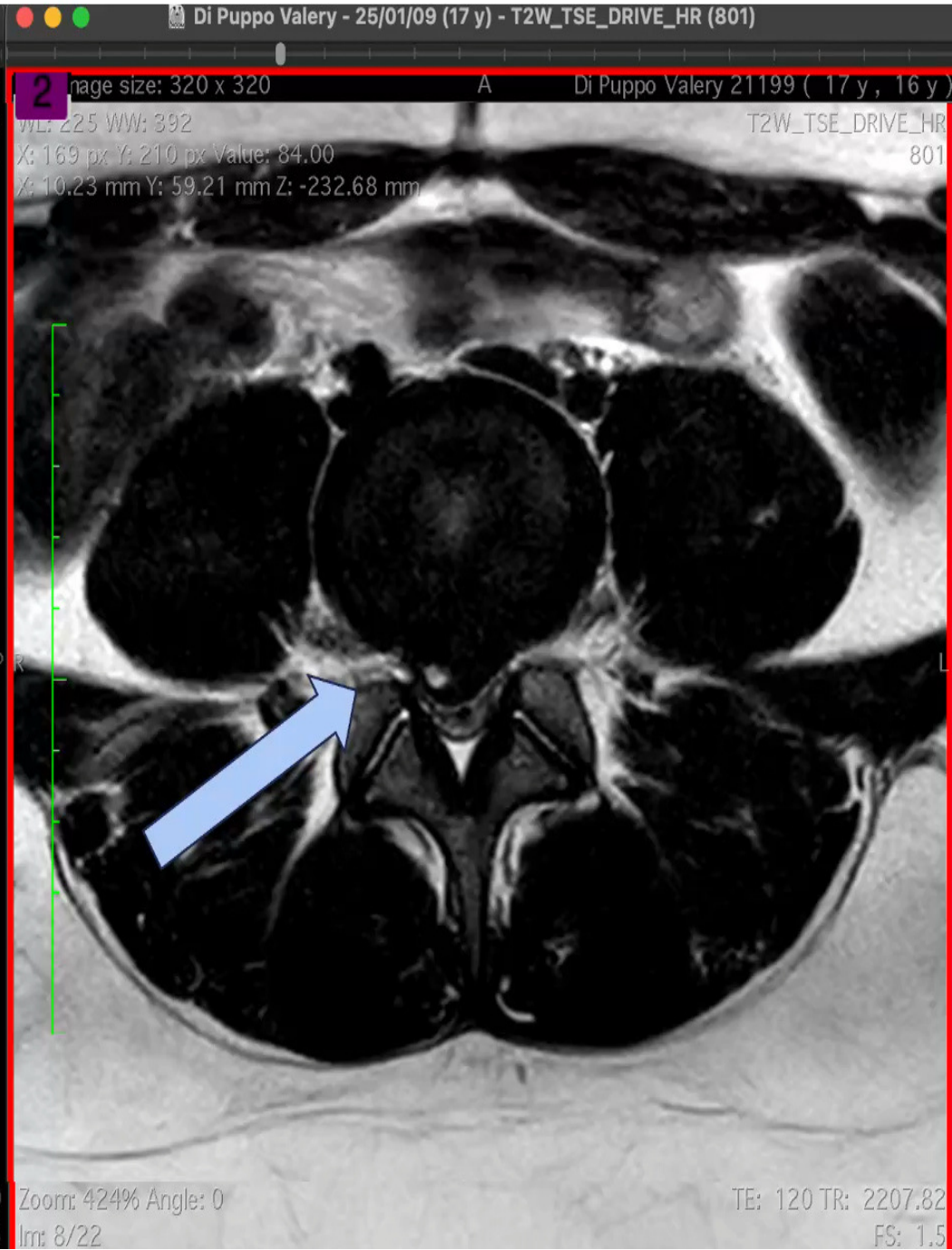
SDM SPINAL DISORDERS METHODOLOGY

7 th CLINICAL CASE

BEFORE SDM DUO

Bio Salus center





1-6-7-9-10-11-12-13-14 st CLINICAL **CASE**

CONCLUSIONS:

With the previous methodology, subject of our scientific publications, in which SIS ONE was used, the timings were as follows:

About two months for radiculopathy

About three months for expelled hernias.

Today we are able thanks to SIS DUO to continue to guarantee the same results but with shorter time:

1 Month for Radiculopathy

2 Months for Expelled Hernias





Si ringrazia per l'attenzione

ACADEMY

10/11 OTTOBRE 2026
TIVOLI TERME - ROMA