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Keyhole Interlaminar Dorsal Rhizotomy: Assessing the Feasibility, Efficacy, and Innocuity of the Technique in one Center

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■ OBJECTIVE: **The objective of this article was to study the feasibility, efficacy, and innocuity and explore the nature of the complications of the keyhole interlaminar dorsal rhizotomy (KIDr) technique in the pediatric neurosurgery department in Nancy between 2018 and 2023.**

■ METHODS: **We carried out a retrospective analysis of 62 children, who were operated on at our institution between January 2018 and December 2023, using a KIDr technique. We noted the duration of the surgery, as well as the intraoperative difficulties faced, which would help assess the feasibility of the surgical modality used. We also controlled the evolution of the spasticity using the Modified Ashworth Scale before and one year after the surgery, as well as the Gross Motor Function Classification System. We finally assessed the complications that occurred during the year that followed the procedure.**

■ RESULTS: **In our series of 62 patients analyzed over 5 years, the average length of surgery was 250.3 minutes with a real learning curve. We had no complications during the procedure, except in 1 patient with a particular morphology. Prolonged electrophysiological monitoring was required in 8 patients but had no surgical consequences. During the first year that followed the surgery, we had a similar rate of complications to that of other selective dorsal rhizotomy (SDR) techniques described in the literature. The surgical efficacy was evaluated using the Gross Motor Function Classification System at one year, with 8 patients improving, with the others remaining clinically stable. The spasticity, which was assessed with the Modified Ashworth Scale at one year, showed a real improvement, going from an average score of 2.8 before the surgery to 0.53 afterward.**

■ CONCLUSIONS: **The KIDr shows similar results to other previously described SDR techniques in terms of operating time, intraoperative, and postoperative complications, functional results, and when it comes to the assessment of the spasticity at one year. It could be considered as a real surgical alternative to perform an SDR.**

INTRODUCTION

The selective dorsal rhizotomy (SDR) is now a well-known and widespread surgical procedure[1] that is able to treat incapacitating spasticity, which leads to impaired mobility and causes discomfort through particularly significant muscle pain or joint deformity, notably during the growth phase.[2]

It is used in the majority of cases to treat cerebral palsy (CP), one of the most frequent neurological disorders in the world.[3] The goal of the surgery is to improve or prevent functional degradation that occurs over time while improving patient comfort.[4] It can therefore be offered to patients with a relatively

Key words
- Dorsal
- Interlaminar
- Keyhole
- KIDr
- Rhizotomy
- Spasticity

Abbreviations and Acronyms
CP: Cerebral palsy
EMG: Electromyography
GMFCS: Gross Motor Function Classification System
GMFM-66: Gross Motor Function Measure — 66 items
KIDr: Keyhole interlaminar dorsal rhizotomy
MAS: Modified Ashworth Scale
SDR: Selective dorsal rhizotomy

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preserved functional status,[5] but also to those that are severely affected.[6]

Many new technical modalities have emerged in recent years.

Peacock et al.[7] mentioned a broad surgical approach with extended laminotomy and exhaustive neuromonitoring to cut pathological roots and rootlets. Alternatively, Park and Johnston[8] used a 1-level laminotomy overlying the conus to perform the cut with electrophysiological control. Funk and Haberl[9] described a 1-level approach under the conus with laminoplasty, which was included in a recent illustrated review of operative techniques published in 2020 by Warsi et al.,[10] as well as the keyhole interlaminar dorsal rhizotomy (KIDr) procedure, which was published by Sindou and Georgoulis[11] in 2015.

We report, for the first time on a large population of patients, the feasibility, efficacy, and innocuity of the SDR performed according to the KIDr technique, which is recognized and well-described but often criticized as an unnecessarily difficult and time-consuming procedure.

MATERIALS AND METHODS

Patients' Selection and Surgical Planning

The study period spanned between January 2018 and December 2023, with 66 children benefiting from an SDR by the same operator (A.J.). A total of 4 were excluded after being operated on using different surgical modalities: 2 patients with a very poor status benefited from a 1-level surgery without monitoring in order to decrease the time of the surgery, and 2 others benefited from an S1 rhizotomy only. The remaining 62 cases encompassed many etiologies: CP, genetic diseases, and postmeningitis.

All surgical indications were set during a multidisciplinary consultation that included a pediatric neurosurgeon, a rehabilitation physician, a physiotherapist, an orthopedic surgeon, and the patient's family.

The functional or comfort objectives were well detailed in every case, with the depiction of a chart before the surgery, where the risks and limitations were clearly stated.

A surgical planning, with a quantification of the cutting percentage of the dorsal rootlets to be sectioned for each spinal nerve root, was discussed and validated during this multidisciplinary meeting.

A functional evaluation was done using the Gross Motor Function Classification System (GMFCS) and Gross Motor Function Measure — 66 items (GMFM-66), and the spasticity of the lower limbs was assessed according to the Modified Ashworth Scale (MAS). The results of the GMFM-66 test are not reported in this article and are the subject of another work in progress.

Patients also benefited from an assessment of their urinary function using a voiding calendar, as well as the ultrasound quantification of the postvoid residual urine volume and a urinalysis.

Surgical Procedure

The selected candidates underwent surgery using the KIDr technique. The interest of this surgical procedure is the association between the anatomical precision of the root section at the dural sheath, the complete and reliable nature of the neurophysiological monitoring, and the respect of the spinal architecture.

Electrophysiological Monitoring. Each patient underwent electrophysiological monitoring, which was concomitant with a clinical evaluation done by a physiotherapist. The technique was described in a previous publication.[12]

Electromyography (EMG) was performed on multiple muscles to assess nerve root response:

- o Adductor longus (L2, L3)
- o Quadriceps' rectus femoris (L3, L4)
- o Tibialis anterior (L4)
- o Extensor digitorum longus (L5)
- o Biceps femoris (L5, S1, S2)
- o Triceps surae (S1, S2)
- o Anal sphincter (S2)

Bipolar needle electrodes were used for nerve root stimulation.[13]

During his clinical assessment, the physiotherapist also measured the contraction of the psoas muscle (L2), as well as that of the gluteus maximus.

Surgical Approach. We performed a midline lumbar skin incision and bilateral subperiosteal dissection with preservation of the interspinous ligaments[11] from L1 to S1 in the vast majority of cases in order to access and control the L2, L3, L4, L5, S1, and S2 roots bilaterally.

We mostly selected 3 interlaminar spaces: the L1-L2 level to gain access to the L2 and L3 nerve roots, the L3-L4 level to gain access to the L4 and L5 nerve roots, and the L5-S1 level to gain access to the S1 and S2 nerve roots. The details can be seen in the Figure 1 below.

After opening the dura on each level, we reached out for the contralateral roots at their spinal entry zone by following and dissecting the dural sheath for each nerve.

We first identified, under direct vision, the ventral (motor) root, which we stimulated to confirm its nature and the level of interest and to obtain a real-time live mapping, which could vary between patients.[14]

We then stimulated the dorsal (sensory) root using the same parameters (2 Hz and 200 mA) to confirm the lack of response and perform a correct identification of the root to be sectioned and the one to be preserved.

Afterward, we restimulated the dorsal (sensory) root using other parameters (20 Hz, 1 mA) and graded the responses as recommended by Fasano et al.[15,16,17] The excitability is excessive when responses are sustained outside the myotome.

This testing resulted in the confirmation—and in some circumstances the modification—of the nerve root sectioning percentage established in the preoperative program.

The mean radicular sectioning percentage was as follows:

- L2: 62%
- L3: 63%
- L4: 50%

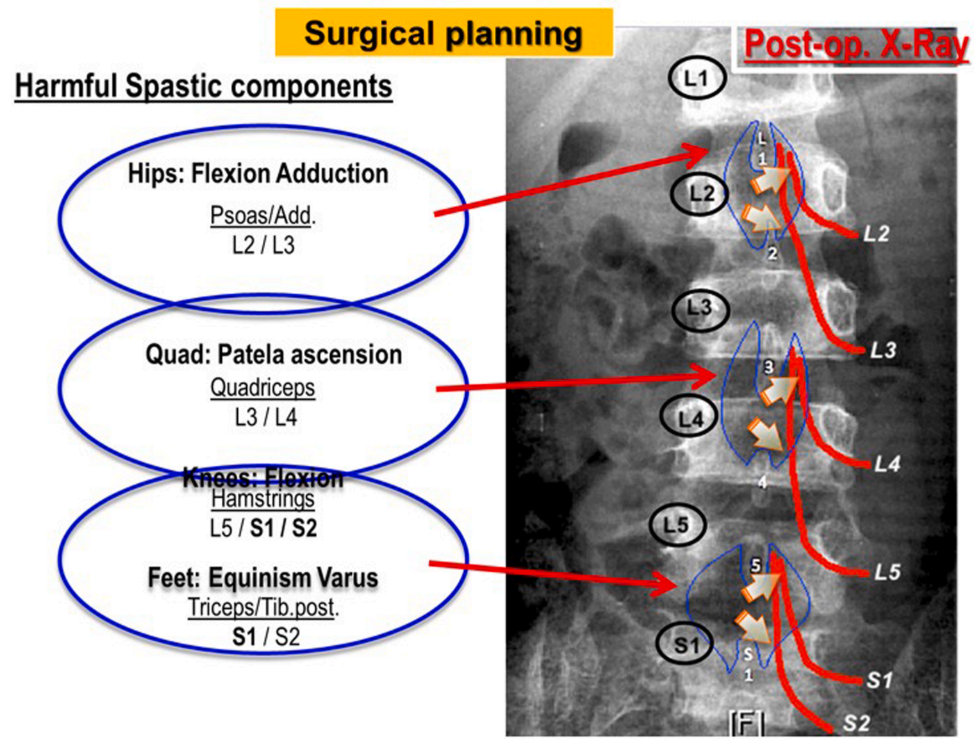

Figure 1. Example of postoperative X-ray of the lumbar spine (anteroposterior view) showing (enlarged) interlaminar (IL) fenestrations (with preservation of spinous processes) according to the tailored surgery performed in this child with typical spastic diplegia (patient W.L.). Roots L2 and L3 targeted at the L1–L2 IL space for treatment of spastic hip and thigh in flexion-adduction. Roots L4 and L5 targeted at the L3–L4 IL space for treatment of spastic quadriceps with patella ascension. Roots S1 and S2 targeted at the L5–S1 IL space for treatment of spastic foot with equinism and spastic hamstring muscles. The arrows designate the exit of the ventral root from/entry of the dorsal root to the corresponding dural sheath. (copied with permission from Sindou M., Georgoulis G. Keyhole interlaminar dorsal rhizotomy for spastic diplegia in cerebral palsy. Acta Neurochir (Wien). 2015;157:1187–1196.)

- L5: 33%
- S1: 70%
- S2: 20%

A previous study[18] on the first 24 patients of this cohort described how intraoperative neuromonitoring influenced root sectioning decisions.

The surgical principles of the KIDr are detailed in Figure 1.

Postoperative Management

After the procedure, the children were addressed to a specialized rehabilitation center for 3 to 6 weeks, depending on the established program and the functional objectives, before returning to their usual care program.

They were then systematically seen at one month, undergoing a clinical and neurological evaluation. We voluntarily did not carry out any functional assessment during this first neurosurgical consultation, considering the timing too early after a radical change in muscle tone.

All patients were then evaluated during a multidisciplinary consultation at 6 months and one year following the surgery. They all benefited, a few days before these meetings, in the same specialized center, and by the same rehabilitation team, from a functional evaluation using the GMFCS, and their spasticity was assessed via the MAS and the GMFM-66 score sheets. At one year, we carried out x-rays of the spine, and a new urinary evaluation was performed using the same preoperative modalities, as well as through a questionnaire.

Study Design

We included the files of 62 patients for this retrospective single-center study, found between January 2018 and December 2023. The institutional review board number is 00011687.

All children benefited from an SDR by the same operator (A.J.), using the same operative technique (KIDr), which was previously published and described.[11,12]

During the same period, 4 patients were operated on using a different surgical approach and were hence excluded from the study.

The surgical feasibility of the procedure was appraised on the basis of the easiness and difficulties to individually access all the programmed targeted nerve roots, ranging from L2 to S2 included, and on the accuracy of the respective identification of their ventral and dorsal components. The duration of the procedure for each patient was also considered, as well as its compatibility with safe anesthesiological management.

Its innocuity was estimated by taking into account not only the early postoperative complications ranked by the neurosurgical and anesthesiological conditions themselves but also the lasting neurological deficits as well.

For the efficacy, we reported the evolution of the spasticity, measured according to the MAS, as well as the GMFCS, one year after the surgical procedure. The GMFM-66, which is more complete for evaluating functional evolution, is not reported in this article and is the subject of another work in progress.

Statistical Analysis

We used RStudio version 2024.12.1 + 563 for the statistical analysis. We integrated the data of all 62 patients, including their age, the preoperative, and the one-year postoperative MAS values, as well as the GMFCS preoperative score and the muscle groups involved. We separated the variables between quantitative and ordinal qualitative ones. We performed the Wilcoxon test on those whose values did not follow a normal distribution according to the Shapiro-Wilk test and the t-student on those whose values followed a normal distribution. The result was noted as significant when the calculated P value was less than 0.05. The data were presented in tables and figures that included a pie chart, an XY diagram, and a bar graph.

RESULTS

A total of 62 patients were included between January 2018 and December 2023. Fifty-eight patients suffered from CP, 3 had genetic diseases, and one had neonatal bacterial meningitis caused by *Escherichia coli* during the first month of life. 42 patients were males, and 20 were females. The mean age was 8.34 years, and the median one was 8.

The preoperative GMFCS classification is shown in **Figure 2**.

Feasibility

The average intervention length was 250.89 minutes. The values of all the cases can be summed up in the XY diagram below (**Figure 3**).

The same technique (KIDr) was carried out each time, except for the 4 patients who benefited from a different approach, which was chosen during the planning phase. This was done to limit the duration of the surgery as much as possible for these particular children and was not due to a technical difficulty.

Six patients who benefited from SDR using the KIDr technique were, however, limited to 1 or 2 interlaminar spaces instead of three due to a less extensive root targeting in their cases. The average surgical time was understandably significantly shorter for them compared to the other children, with an average of 162.7 minutes per intervention. The goal here was only to address the nerve roots L4, L5, and S1, as well as S2 in 2 of the cases.

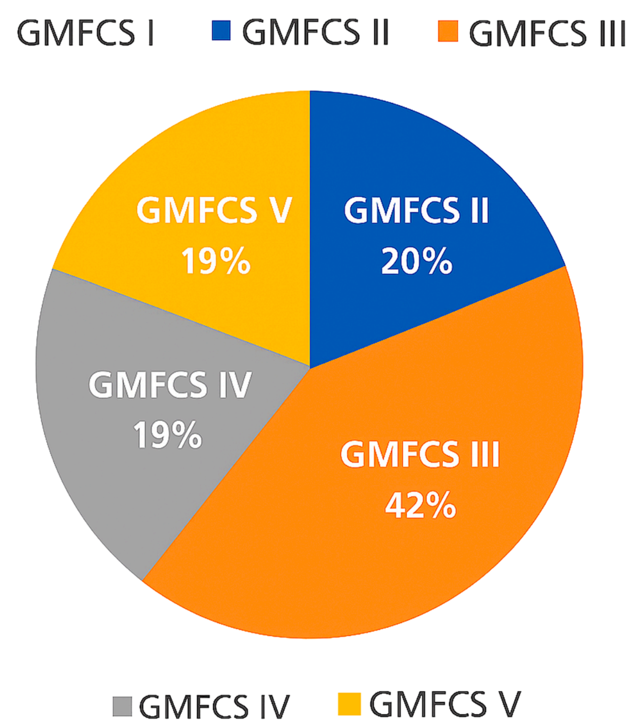

Figure 2. Pre-operative GMFCS classification for our series of patients.

The average duration of an entire, classic KIDr procedure, with the opening of the three interlaminar spaces (L1-L2, L3-L4, and L5-S1) and a bilateral dorsal root section from L2 to S2, was 259.7 minutes.

This surgical approach includes, as with every new surgical technique, a real learning curve. The average duration for the first 15 patients with a complete procedure was 306 minutes, compared to only 239 minutes for the last 15 patients. Progressive improvement in the surgical time was linked to the gradually smaller interlaminar fenestrations done, the accesses becoming just large enough to allow the visualization and the reach of 2 nerve roots using each of the 3 windows created, while preserving the spinous ligaments and articular surfaces at these levels.

The duration of the intervention is mainly determined by two main factors, the first of which is the ability to access all roots and rootlets by opening the three spaces. It also varies according to the proportions of the child (more difficult in adolescents than in small children) and depending on the severity of the spinal deformity, if present. The other main parameter that influences it is the performance of the electrophysiological monitoring during the surgical intervention.

In some patients, 8 in total in our series, monitoring was sometimes disrupted, with a reduction or even a temporary absence of nerve response during neurophysiological stimulation. In all cases, frequent irrigation of the nerve roots with warm serum quickly allowed the return of responses to stimulation. This was never associated with real hypothermia (the monitored body temperature never got lower than 35.5°C). For these 8

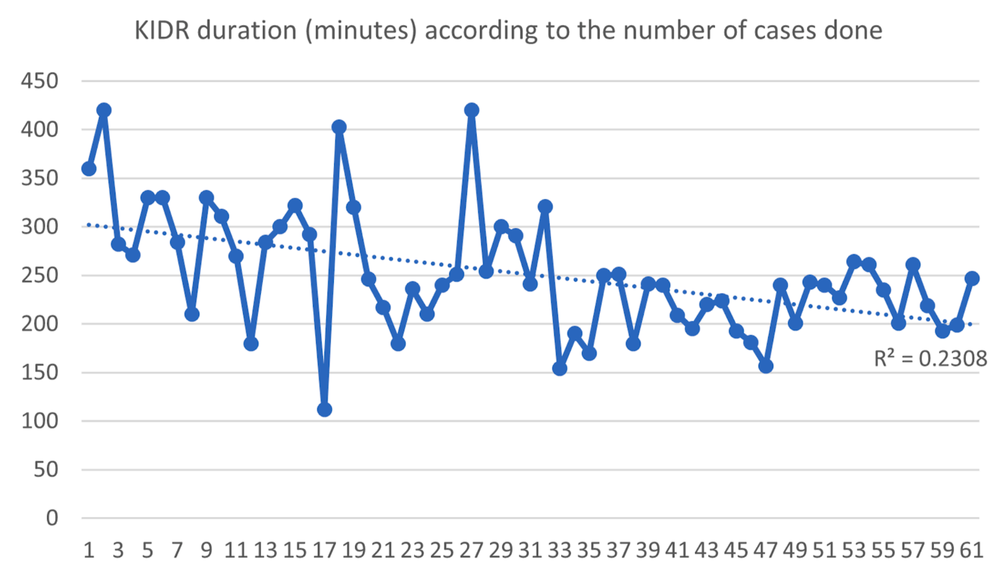

Figure 3. The evolution of the KIDR technique duration in minutes, depending on the number of cases operated on.

patients in particular, the duration of the procedure was understandably longer, reaching an average of 316 minutes.

Since this observation, we systematically use warm serum (heated at 40°C) for irrigation in order to limit this problem.

Blood loss was always moderate, with an estimated average of 113 ml per surgery, without the need for a transfusion, even for the youngest of patients and for the longest of procedures.

Figure 3 details the surgical duration for all 62 cases.

Innocuity

To evaluate the innocuity of the KIDr technique, we recorded all the complications that occurred during the first year. They can be summed up in **Table 1** below.

One patient (#11) had a local postoperative *Pseudomonas aeruginosa* bacterial infection, which required a quick surgical reintervention, associated with an intravenous antibiotic therapy for 3 weeks.

A total of 3 also had a postoperative pseudomeningocele, 2 of whom required a surgical revision.

Only one patient (#17) had a real postoperative neurological motor deficit distal to the L4 nerve root without sphincter disorder. This deficit completely recovered within 6 months of rehabilitation. The main characteristic of this specific case was a very difficult exposure of the nerve roots, with significant manipulation, in a particularly old (16 years of age) and tall (1.82 meters) patient.

On the other hand, we had no urinary complications, despite sectioning up to 50% of the S2 dorsal rootlets in some cases, when the hamstrings were considered very deleterious and when there was no response from the anal sphincter to the S2 stimulation. We only experienced a urinary retention in 2 patients, who needed to maintain a urinary Foley catheter for at least one week postoperatively. In one case, the catheter was able to be removed 3 weeks after the surgery, and in the second, at 2 months. For these children, the urinary investigations before the surgical intervention had shown a hypertonic bladder. Their urodynamic assessment at one year from surgery was the same as before the procedure.

Table 1. Complications Occurring During the First Year After the KIDr Surgery

Postoperative Complications	Sex Ratio (M/W)	Mean Age (years)	GMFCS II	GMFCS III	GMFCS IV	GMFCS V	Total (/62)
Meningocele	1/2	9.3	0	2	1	0	3 (4.8%)
Surgical site infection	0/1	4	0	1	0	0	1 (1.6%)
Motor deficit	1/0	15	1	0	0	0	1 (1.6%)
Scar problem	0/1	16	0	0	0	1	1 (1.6%)
Urinary retention	0/2	15	0	0	1	1	2 (3.2%)

GMFCS, Gross Motor Function Classification System.

All patients received a treatment for neuropathic pain with Clonazepam (Rivotril) during 5 days postoperatively. We had no episodes of persistent refractory lower back pain 1 month after the surgery. In order to limit this, we meanwhile used a small lumbar brace for two weeks, when the child was mainly mobilized.

Ease

To study the efficacy of the procedure, we collected the GMFCS of every child preoperatively and compared it to one year after the surgery.

The patients, averaging 8.4 years of age, with a sex ratio of 42/20 (M/W), were divided into four groups (**Figure 2**), with 12 children classified preoperatively as GMFCS II (19.35%), 26 as GMFCS III (41.94%), 12 as GMFCS IV (19.35%), and 12 as GMFCS V (19.35%).

Only one patient (#14), who suffered the postoperative motor neurological deficit, had his GMFCS worsen at 6 months, temporarily going from level II to level III, before returning to level II at one year postoperatively.

In total, 8 patients (13%) improved their GMFCS during the year that followed the surgery: 6 moved from GMFCS IV to III, including 4 at the 6-month assessment, with the other 2 positively evolving as well at the 1-year assessment. The last 2 patients moved from GMFCS III to II, 6 months after the surgery. No GMFCS II or V patient changed level or class after surgery. These numbers can be detailed in **Table 2** below.

To study the efficacy of the KIDr technique on spasticity, we also collected the MAS score before the surgery (during the month that preceded the procedure) and at one year.

For 52 of 62 patients, we retained this value on the hip adductors, and when these data were missing (for 10 patients), we collected them on the quadriceps (7 cases) or on the soleus (3 cases) muscles.

The MAS average score thus went from 2.8 on average before the procedure to 0.53 at one year, which is statistically highly significant with a P value of 9.11×10^{-12} (**Table 3**).

We also found consistent results, depending on the GMFCS subgroups, with the evolution of the spasticity on the MAS score, the most spastic patients often being the most affected functionally. For each GMFCS class, surgery significantly improved spasticity at one year.

The results are reported in **Table 4** and **Figure 4**.

DISCUSSION

The SDR has been described since the beginning of the 20th century and is currently gaining a lot of popularity after a period of limited knowledge. Its principles and implementation are nowadays rapidly spreading throughout the world.

Table 2. GMFCS Score Evolution at one Year from the Surgery

	GMFCS II	GMFCS III	GMFCS IV	GMFCS V
Number of patients before the surgery	12	26	12	12
Number improved after the surgery	0 (0%)	2 (8%)	6 (50%)	0 (0%)

GMFCS, Gross Motor Function Classification System.

Table 3. The Improvement of the Spasticity According to the MAS Score, Depending on the Muscles Evaluated

Muscles	Preoperative MAS	Postoperative MAS at one Year	*P* Value
Hip adductors	2.7	0.56	4.820911e−10
Other muscles (quadriceps or soleus)	3.4	0.4	0.005143764
All muscles combined	2.8	0.53	9.11×10^{-12}

MAS, Modified Ashworth Scale.

Multiple surgical procedures and techniques have been described since the early 1980s, but the principles of partial sectioning of the dorsal roots or rootlets to limit excessive spasticity in children are unanimously established.

Many modalities for carrying out SDR have been published.

The first in the recent period was described by Peacock et al.,[7] and corresponded to partial L2-L5 laminectomies with preservation of the facet joints. After dural opening, the dorsal roots from L2 to S1 are identified, separated, and prepared for electrical stimulation. The nerve root sectioning's grading is done according to the Fasano et al.[16,17] criteria. The surgical approach is large and allows for precise anatomical visualization of each nerve root, enabling it to be easily stimulated using electrophysiology.

More recently, and with the aim of limiting the surgical approach and the operating time, many other techniques have been developed.

Park and Johnston[8] described a limited dorsal midline incision overlying the conus medullaris and cauda equina. A laminotomy is performed using a craniotome and is followed by a careful separation of the dorsal and ventral nerve roots before monitoring them using EMG.

Bales et al.[19] and Funk and Haberl[9] modified this technique, respectively, limiting the approach to a single level under the conus medullaris, with the identification of the nerve roots for electrical stimulation, and using a two-level laminoplasty.

Our technique is the only one to combine several elements that seem important to us: it allows access to the nerve roots directly at the foramen, which makes it much easier to safely identify the level of the root and carry out electrophysiological monitoring without significant manipulation or traction on the nerves. This happens to be less important than what is carried out during a single-level procedure. Our surgical intervention also helps maintain the integrity of the spinous processes and interspinous ligaments.

The choice of this particular technique is to combine the preservation of the spinal architecture of the limited approaches described by Park and Johnston,[8] as well as Funk and Haberl,[9] with an identification of the nerve roots at the level of the foramen, performed by Peacock et al.[7] This latter approach allows us to carry out neuromonitoring while limiting the

Table 4. The Improvement of the Spasticity According to the MAS Score, Depending on the GMFCS Category

GMFCS	Mean Age (years)	Preoperative MAS	Postoperative MAS at one Year	*P* Value	Statistical Test
II (12)	10.7	2.41	0.05	4.224e−06	T student
III (26)	7.9	2.65	0.61	9.066e−11	T student
IV (12)	8	2.83	0.25	0.0023	Wilcoxon
V (12)	7.1	3.25	0.66	0.0021	Wilcoxon

MAS, Modified Ashworth Scale; GMFCS, Gross Motor Function Classification System.

intraoperative manipulations of the roots, which can impact the results and interpretations of the EMG.

We did not have any particular intraoperative complication or difficulty while using the KIDr technique, except in one case, related to the child being very tall. The surgical procedure was more complex but included, just like the other modalities described, a laminotomy[20] or a laminoplasty. Sometimes the electrophysiological monitoring took longer to be completed, but it could be achieved in all of the cases. We never had to interrupt the procedure or change the technique during the surgery.

When we studied the complications for all of the above-mentioned modalities in the literature, we observed that these were relatively low (Table 5).

In the same way, we found no difference in the average surgical duration between our technique and that of Wach et al.[25] (250.89 minutes in our case and 246.4 minutes in theirs, respectively). The probable reason is that, for these modalities, we used electrophysiological guidance, which is the parameter that increased the most the surgical duration.[28] In fact, we found no real difference in the surgical feasibility with other modern techniques.

The efficiency of SDR is well documented on the short-term follow-up, even if in the long term, this is more questionable.[29-32]

The GMFCS levels were available for all the patients, and once more, just like the findings of the literature, they remained unchanged at one year in the majority of the children and improved by one level for a minority of them, just like Sargut et al.[33] reported, with 20% improving, 2% deteriorating, and 78% remaining unchanged.

One of the most consistent elements is the greater functional impact of SDR on patients with a better functional evaluation (GMFCS II and III) before the surgery, compared to those whose impairment is more severe (GMFCS IV and V),[4] even if the higher GMFCS grade still stands to benefit from SDR.[6,34] Only Kan et al.[35] found different results, with 35 of 71 patients increasing their GMFCS level at one year, even for severe patients.

When we studied the spasticity itself at one year using the MAS scale, we found a real efficacy to decrease spasticity for our patients, similarly to a lot of authors.[4,32,33]

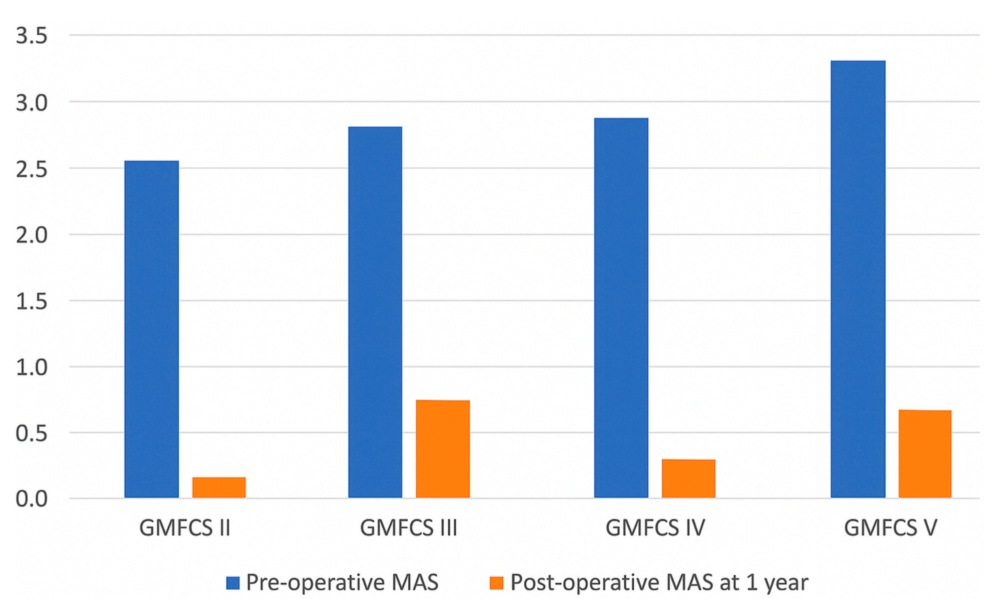

Figure 4. The MAS score evolution of the patients of our series, before and after the surgery, depending on their GMFCS score.

Table 5. Short-Term Postoperative Complications in Comparison with the Literature

Study	Dysesthesia (%)	Urinary Retention (%)	CSF Leak (%)	Infection (%)	Motor Deficit (%)	Postoperative Pain (%)
Abbott (1992)[21]	40%	-	-	-	-	58%*
Steinbok and Schrag (1998)[22]	7.6%	4.4%	0.6%	0.6%	-	-
Trost et al. (2008)[23]	4%	8%	-	7%	3%	-
Nordmark et al. (2008)[24]	-	11.4%	11.4%	-	-	11.4%
Wach et al. (2021)[25]	-	-	2.9%	1.4%	-	10.7%†
Spazzapan et al. (2022)[26]	100%	0%	0%	0%	-	-
Mishra et al. (2023)[27]	6.6%	2.4%	-	-	-	-
Our study‡	0%	3.2%	4.8%	1.6%	1.6%	-

SSI, surgical site infection; CSF, cerebrospinal fluid.
*Severe postoperative pain, probably in relation to the large surgical approach.
†The most frequent complication was prolonged pain management with a spinal epidural catheter, lasting 4—5 days in 10.7% of cases.
‡In our series, we found no difference in the occurrence of postoperative complications compared to the different modalities described, with 1.6 % of SSI, 1.6% of neurological deficit, and 3.2% of transient urinary retention. Only our postoperative meningocele rate was a little higher, with a total of 3 patients (4.8%), only two of whom needed a surgical revision.

Park et al[36] even found that spasticity is greater after SDR for CP than for able bodies, and this results in an increase in the postoperative muscle strength. Another publication by the same authors confirmed that after SDR, hip adductor spasticity decreased while its strength increased.

In fact, like other surgical techniques, the efficacy and direct action on spasticity, measured both by the GMFCS and the MAS evolution one year after the surgery, are real and objectively found with the KIDr modality.

Limitations of the Study

The limitations of this study are the retrospective nature as well as the analysis, which is currently limited to one year after the procedure. The 3-year analysis of complications and results on spasticity is not reported in this article, as well as the GMFM-66, which is more precise for measuring the functional evolution. They are the subject of another work in progress.

CONCLUSION

SDR is a well-established surgical technique for managing spasticity in children, particularly those with CP. Various procedural approaches have been described, all sharing the fundamental goal of selectively cutting dorsal nerve rootlets to reduce muscle spasticity and enhance motor function.

The KIDr technique, although previously described, had not been extensively evaluated in a large cohort until now.

Our study provides strong evidence that KIDr is:

- Feasible: The technique was successfully applied in all cases with an observable learning curve that reduced operative time.
- Safe: The complication rate was similar to other SDR approaches, with no permanent neurological deficits and minimal dysesthesia.
- Efficient: MAS scores significantly improved across all GMFCS levels, confirming the technique's efficacy in reducing spasticity. Thirteen percent of patients improved their GMFCS classification, particularly in GMFCS IV patients.

Given these findings, KIDr should be considered as a valid alternative to other SDR techniques for pediatric spasticity management.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Anthony Joud: Writing — review & editing, Writing — original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Fred Bteich:** Writing — review & editing, Writing — original draft, Validation. **Fanny Dalmont:** Validation. **Irene Stella:** Validation. **Olivier Klein:** Validation. **Marc Sindou:** Validation, Supervision.

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