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ORIGINAL ARTICLE

Minimum of 10-year follow-up of V-rod technique in lumbar spondylolysis

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Abstract

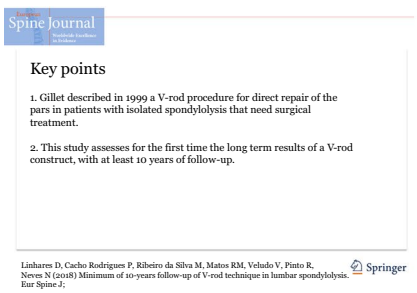
Purpose To describe and analyze the use of the V-rod technique described by Gillet to repair spondylolysis in both early and late postoperative periods.

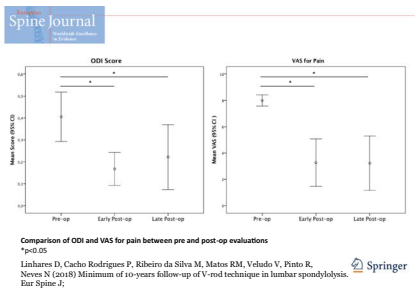
Methods Patients submitted to surgical correction of lumbar spondylolysis with a V-rod system were selected upon exclusion of adjacent disk degenerative changes and high-grade spondylolisthesis. A preoperative clinical (ODI and VAS) and radiological evaluation was performed, along with assessments on the early (clinical evaluation—up to 1 year) and late (clinical and radiological—at least 10 years) postoperative periods.

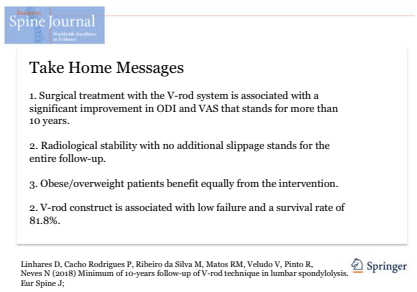
Results Twenty-two patients were included, 21 with L5 spondylolysis. Fifty percent had grade I spondylolisthesis. A significant decrease in ODI and VAS was observed from pre- to early and late post-op evaluation (all $p < 0.05$) but not during post-op evaluations. Changes from pre- to postoperative of both ODI and VAS were significantly higher than the minimal clinically important difference. Preoperative ODI and VAS were significantly higher in overweight/obese but similar postoperatively. No additional instability was found in late postoperative X-rays. Three patients needed revision surgery, with a survival rate of 81.8% for Gillet instrumentation at a mean follow-up of 687.7 ± 60.0 weeks.

Conclusions Surgical treatment with V-rod system is associated with a significant improvement in ODI and VAS and radiologic stability, with an equal benefit in obese/overweight patients. This study reports for the first time an improvement that is maintained even 10 years after the initial intervention, associated with a low rate of failure.

Graphical abstract These slides can be retrieved under Electronic Supplementary Material.







Keywords Spondylolysis · Spondylolisthesis · Lumbar vertebrae · V-rod technique · Lumbar back pain

Introduction

Spondylolysis (SL) is a bony defect in the pars interarticularis of a vertebra, without slippage of the adjacent vertebra [1, 2]. It can be complete or incomplete, bilateral or unilateral, more commonly complete bilateral [3]. SL is

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often asymptomatic but it is quite prevalent among young adults and teenagers with low back pain (LBP) [4, 5]. These patients are usually treated conservatively with pain medication, lumbar orthosis, activity restrictions, and physical therapy, and surgery is only performed when pain and activity limitations persist despite aggressive conservative options [6, 7].

The raising concern on achieving a minimal impact in spine mobility, preventing excessive mechanical stress at the adjacent levels in this young population [8], turns the focus to the repair of the pars interarticularis, with removal of the pathologic soft tissue and bone grafting of the defect to restore the stabilizing role of the posterior arch, with the emergence of multiple surgical procedures [9, 10]. These are to be used in patients with SL without associated disk disease and without spondylolisthesis and possibly in selected cases of low-grade spondylolisthesis [9]. In 1968, Kimura described the use of an isolated bone graft, with direct repair of the isthmic defect of the pars interarticularis without instrumentation, preserving segmental motion, but requiring a postoperative cast and prolonged bed rest [11]. Later, Scott proposed the use of wires under the laminae and transverse processes [12], a technique which was modified along the years by several authors [10, 13]. In 1970, Buck described the first direct repair of the defect with internal fixation with screws and bone grafting [14], and subsequently other approaches with special constructs [15] and temporary fixations [16] were reported. In 1999, Gillet described an original technique using pedicle screws and a V-shaped rod resting against the inferior aspect of the spinous process and the posterior aspects of the laminae, associated with direct bone grafting of the pars defect [17]. The author highlighted the importance of preserving the capsuloligamentous structures of adjacent facet [9]. With the use of pedicle screws, this construct allows adequate space for bone grafting and decreases the complexity of the procedure, differing from the placement of screws on the pars, described by Buck [14]. It also avoids postoperative bracing, contrasting with Kimura [11] and Scott [12] techniques, and since the fixation is permanent, there is no need for implant removal [9, 17].

Few studies are available on the literature on the use of Gillet's technique [17]. A recent report on 21 patients showed promising results [18]. However, this study included patients with degenerative disk changes and spondylolisthesis, not matching the selection criteria for pars repair postulated by the author [9]. As far as we know, no study is available with long-term follow-up. The aim of this study is to describe and analyze the use of Gillet's technique to repair SL in both early and late postoperative periods.

Materials and methods

A longitudinal observational prospective study was conducted. Patients submitted to surgical correction of lumbar SL with a V-rod system in a Portuguese tertiary care hospital with a dedicated spine unit between June 2001 and December 2005 were considered.

Inclusion criteria were (1) patients with SL with or without spondylolisthesis of 0 and I grades, (2) presenting severe LBP, with or without sciatic, or functional limitation refractory to conservative treatment, and (3) capable—patient and/or legal tutor—of understanding and signing an informed consent. Patients were excluded upon adjacent degenerative disk changes, higher graded spondylolisthesis or spina bifida. Also, patients without SL, even in the presence of spondylolisthesis, were excluded.

All were submitted to three evaluations: preoperative, early (up to 1 year) and late (at least 10 years) postoperative. In all study times, patients were submitted to a clinical evaluation, and in early and late postoperative, a radiological assessment was also performed. Three spine-specialized orthopedic surgeons performed all the procedures.

Clinical evaluation

In all three study endpoints, an orthopedic surgeon performed a medical evaluation, and data were gathered on functional—Oswestry Disability Index (ODI)—and lumbar pain complaints—Visual Analog Scale (VAS). In preop evaluation, demographic and biometric data were also collected, and in the early post-op evaluation, patients were questioned on satisfaction and recommendation, the last according to a Likert scale.

Although no consensus is yet available in respect of minimal clinically important difference for ODI and VAS in lumbar pain, based on previous reports, we decided to consider a conservative cutoff of 50% change for ODI and a 2.4 variation for VAS as Refs. [19, 20]. An orthopedic physician, blinded to the patient radiological evaluation, recorded all the data.

Radiological evaluation

Preoperatively, all patients were submitted to anteroposterior, lateral and flexion–extension plain radiographs and CT scan. In the late post-op evaluation, anteroposterior, lateral, and flexion–extension plain radiographs were repeated. A spine-specialized orthopedic surgeon blinded to the patient's clinical data evaluated all the X-rays.

Surgical technique

Briefly, as described by Gillet [9, 17], the patient is positioned prone, and the involved vertebra is approached through midline with cautious dissection to preserve capsuloligamentous structures on the adjacent facet joints. The pars defect is identified and debrided. Pedicle screws are placed in the affected vertebra, and the defect is filled with properly trimmed corticocancellous autologous iliac crest bone graft. The interspinous ligament connecting the affected vertebra with the one below is removed, and a 6-mm rod bent in a V shape is connected to the pedicle screws and fixed under the spinous process, against the laminae, compressing the graft and stabilizing the posterior arch (Fig. 1).

Statistical analysis

SPSS® v24 was used for data analysis, and statistically significance was settled as $p < 0.05$.

Normality was assessed based on histogram analysis, complemented by Kolmogorov–Smirnov test. *T*-student and ANOVA tests and nonparametric counterparts were used for continuous variable comparisons. Cross-tabs analysis and Qui-square test were used for comparisons on categorical variables. Survival analysis was retrieved with Cox regression analysis, and Kaplan–Meier curves were computed.

Results

Twenty-two patients with bilateral SL were included, all with LBP radiating to the lower limbs. Patient demographic data are available in Table 1. Fifty percent of the included subjects were male ($n = 11$), age ranging from 11 to 47 years old, with a median of 25.5 years at the time of the first surgical intervention.

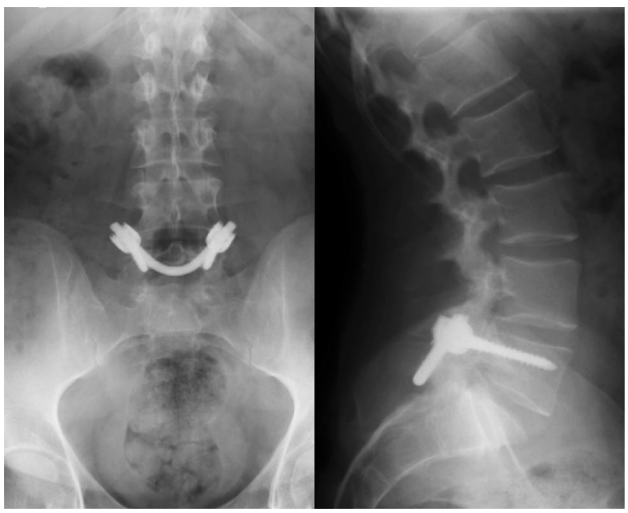

Fig. 1 Gillet construct in a patient with L5 spondylolysis

Table 1 Demographic data of included patients

Demographics	*N* (%)
Age at surgery (mean ± SD)	28.28 ± 11.4
Male	11 (50%)
Smokers	3 (18.8%)
Spondylolysis	
L4	1 (4.5%)
L5	21 (95.5%)
Spondylolisthesis (meyerding grade I)	
Present	9 (40.9%)
Absent	13 (59.1%)
Body mass index (mean ± SD)*	25.50 ± 4.70
Underweight	0 (0.0%)
Normal	8 (50.0%)
Overweight	3 (18.8%)
Obese	5 (31.3%)
Would recommend the surgery*	
Yes	15 (93.8%)
No	1 (6.3%)
Would repeat the surgery*	
Yes	13 (81.3%)
No	3 (18.8%)
General satisfaction*	
Not satisfied	0 (0%)
Somewhat satisfied	1 (6.3%)
Satisfied	3 (18.8%)
Very satisfied	7 (43.8%)
Extremely satisfied	5 (31.3%)
Revision surgery	
No	18 (81.9%)
Fusion	3 (13.6%)
Hardware removal	1 (4.5%)

Results are presented as *N* available (%), otherwise indicated

*Data available from 16 patients (missing data from six patients)

Of the patients, 18.8% were actual smokers at the time of inclusion. Fifty percent were rated as overweight/obese, according to their body mass index (BMI), and the remaining had a normal BMI.

In the pre-op radiological evaluation, SL was present at L5 in 21 patients and at L4 vertebrae in one. 40.9% ($n = 9$) were classified as presenting a Meyerding grade I spondylolisthesis.

No significant differences were found when comparing the presence of spondylolisthesis among genders ($n = 4$ in females and $n = 5$ in males, $p = 0.67$).

A mean VAS for pain of 8.1 ± 1.1 and a mean ODI of 43.5 ± 21.0% were registered in the pre-op evaluation (Table 2). Pre-op ODI was significantly higher in

Table 2 Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) for pain results according to different groups of patients

Timing to surgery	ODI			VAS		
	Pre- (%)	Early post (%)	Late post (%)	Pre-	Early post	Late post
General	43.5 ± 21.0	13.1 ± 11.7	20.9 ± 22.1	8.06 ± 1.09	3.33 ± 3.18	3.12 ± 2.91
BMI						
Normal	30.0 ± 16.1	12.5 ± 9.2	19.4 ± 15.7	7.75 ± 2.80	4.13 ± 2.80	3.0 ± 3.46
Overweight/obese	57.3 ± 17.9	10.8 ± 12.0	15.4 ± 18.2	8.38 ± 0.74	1.25 ± 1.83	2.5 ± 2.29
Spondylolisthesis						
Present	46.7 ± 20.1	11.3 ± 8.7	16.5 ± 20.0	8.27 ± 0.79	3.08 ± 3.37	3.06 ± 2.96
Absent	38.0 ± 23.3	16.3 ± 16.2	26.0 ± 24.9	7.67 ± 1.51	3.83 ± 2.99	3.21 ± 3.08
Revision surgery						
Yes	42.0 ± 0.0	22.0 ± 19.8	32.0 ± 32.9	8.0 ± 0.0	4.0 ± 5.66	5.50 ± 2.50
No	43.7 ± 22.4	11.9 ± 10.7	18.2 ± 19.5	8.07 ± 1.16	3.25 ± 3.04	2.54 ± 2.78

ODI results are presented as a score (i.e., percentage of maximum total possible) and VAS as a numeric value between 0 and 10

overweight/obese when compared with patients with normal BMI (57.3% vs. 30.0%, $p = 0.006$). VAS was similar between the two groups. No significant differences on pre-op VAS and ODI were found when comparing patient with SL with and without spondylolisthesis ($p = 0.287$ and $p = 0.440$, respectively).

Follow-up

A significant decrease in ODI score was observed from pre- to early and late post-op evaluation ($p < 0.001$ and $p = 0.04$, respectively) but not between post-op evaluations ($p = 0.27$). The same was found in VAS for pain ($p < 0.001$, $p = 0.001$ and $p = 0.699$, respectively) (Fig. 2).

Late post-op ODI and VAS were similar when comparing overweight/obese patients and those with normal BMI ($p = 0.720$ and $p = 0.795$, respectively).

No medical or implant-related complication was recorded during the period studied. Three patients needed revision fusion surgery due to persistent pain; one was submitted to hardware removal upon surgeon's choice, after a CT showing fusion. All three revisions had listhesis in the pre-op X-ray. None of the remaining patients had additional surgery due to LBP.

After excluding patients submitted to revision surgery, the mean change in disability was of 68.3 ± 30.1% from pre- to early post-op and of 45.0 ± 58.2% to late post-op. The mean ODI change from pre- to early post-op was significantly higher than 50% (MCID).

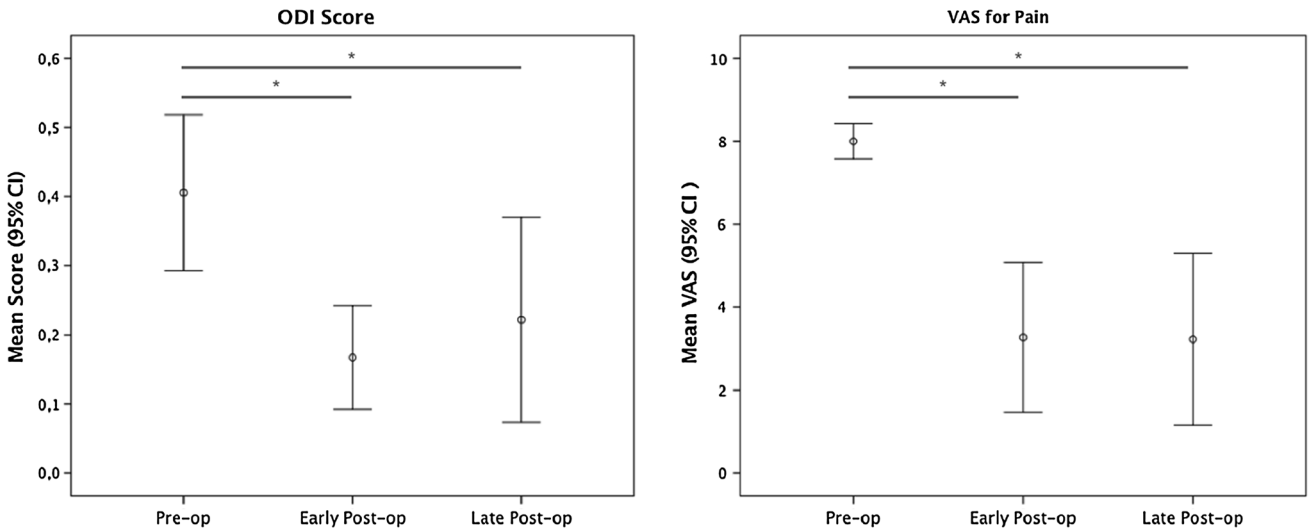

Fig. 2 Comparison of ODI and VAS for pain between pre- and post-op evaluations. *$p < 0.05$

The mean change in VAS from pre- to early and late post-op was of 5.2 ± 2.9 and 5.3 ± 3.2, respectively, both significantly higher than 2.4 (MCID).

No significant differences in evolution of ODI and VAS were found among gender, smoking status, or pre-op radiological classifications.

In late post-op, X-ray was obtained for 16 patients, all showing no signs of instability in dynamic lateral views or additional listhesis. From those, 81.3% would repeat the surgery and 93.8% would recommend it. No patient was dissatisfied, and 75% were very or extremely satisfied with the procedure.

At a mean follow-up of 687.7 ± 60.0 weeks, a Cox regression showed a survival rate of 81.8% for Gillet instrumentation (Fig. 3).

Discussion

This study presents the long-term follow-up of patients with SL/IS treated with a V-rod system, as described by Gillet, finding a significant improvement in both pain and disability, along with radiologic stability and low rate of failure.

As previously reported in the literature, SL reparable with V-rod system affects more commonly young patients, mainly at L5 level [3].

ODI functional score and VAS pain scores were found significantly reduced, both up to 1 year and 10 years after the initial procedure. However, no significant differences in pain or disability were observed during the follow-up period (Fig. 2). These results showed for the first time that the maximum improvement from SL/IS repair is achieved earlier in the follow-up. Although no improvement was recorded during the subsequent follow-up, the patients stayed stable, showing the long-term effect of this repair. One can argue that this may reflect the effect of this technique in spinal biomechanics, as also proposed for other repairs [18, 19]. Also, the mean reduction of VAS and ODI was significantly higher than the MCID defined in the literature, with improvements in VAS of more than 2.4 and with ODI variations of more than 50% [20, 21]. Although the real value for MCID in spine surgery is still under debate, we decided to use the highest MCID variation proposed for disability score [20], and these results reinforce the effectiveness of this technique.

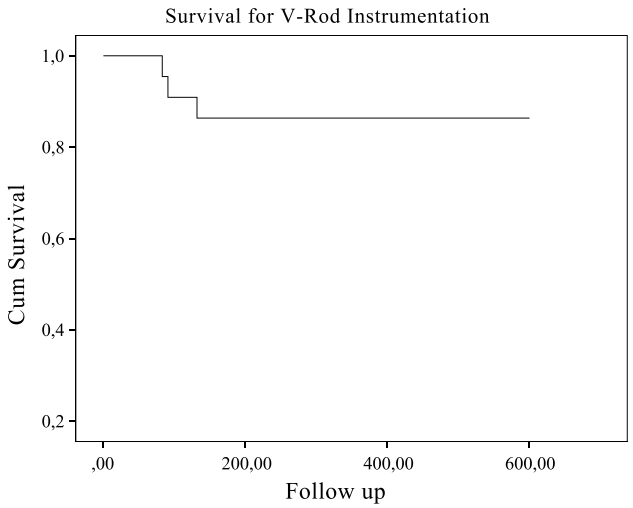

Fig. 3 Kaplan-Meier estimates for survival of V-rod instrumentation

Cheng et al. described in 2013 a series of 21 patients treated with a universal pedicle screw V-rod system. These authors performed a retrospective analysis and found a significant reduction in VAS scores. Although some patients were evaluated 24 months after the procedure, no results on significance are available [18]. Nevertheless, our work supports their findings, now in a prospective fashion, with a significant reduction in VAS scores both 12 and 120 months after the initial procedure. Our results also go along with previous reports on SL/IS direct repair with other techniques [22].

Our study has some limitations. CT scan is very useful to assess a pars defect and associated spondylolisthesis. However, in the correct diagnosis of degenerative disk disease, it has a limited value, and magnetic resonance imaging (MRI) is the modality of choice [23]. Since in our setting only a handful of patients underwent MRI in the preoperative assessment, these data were not displayed, and some degenerative disk changes could have been left undiagnosed. The oldest patient in our series was 47 years old at the time of the surgery, and five patients (22.7%) were more than 40 years old (data not shown). Gillet himself endorsed the use of the V-rod system in patients up to 48 years old, after degenerative disk disease has been ruled out [9]. However, degeneration is present in over 50% of individuals at the age of 40 [24], and although some authors defended that repair systems should not be used after the second decade [25], the efficacy of this technique was already demonstrated in patients with degenerative spine changes [18].

In our series, no patient showed radiological instability in the last post-op evaluation. As referred above, this reinforces previous reports, referring that this system prevents additional displacement of vertebra, improving the loading environment of the diseased and adjacent intervertebral disks and spinal biomechanics, with stability over the years [18, 19].

This work showed that surgical treatment with the system described by Gillet [17] is associated with a significant improvement in ODI and VAS and radiologic stability, both in early and late post-op, and stands for more than 10 years. For the first time, a study with more than 2 years

of follow-up reports a benefit from the V-rod construct [17], associated with a low rate of failure.

Compliance with ethical standards

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. This study protocol was submitted to and approved by a central ethics committee.

Conflict of interest Daniela Linhares, Pedro Cacho Rodrigues, Manuel Ribeiro da Silva, Rui Matos, Vitorino Veludo, Rui Pinto and Nuno Neves declare no conflict of interests.

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