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# Surgical outcomes of unilateral painful foot drop secondary to lumbar disc herniation: a multicenter retrospective study

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**OBJECTIVE** Foot drop is characterized by weakness in ankle dorsiflexion, primarily due to failure of activation of dorsiflexor muscles secondary to neural compromise. The aim of this study was to evaluate surgical outcomes for unilateral painful foot drop secondary to lumbar disc herniation, specifically excluding cases with cauda equina syndrome.

**METHODS** This retrospective study spanned 7 centers, focusing on adult patients who underwent lumbar discectomies from September 2011 to September 2022 due to painful unilateral foot drop (Medical Research Council [MRC] grade ≤ 3). Clinical records were analyzed to identify patients matching the inclusion criteria, with data collection adhering to PROCESS guidelines. Outcomes were assessed based on the MRC scale for muscle strength, and statistical analysis was conducted to determine outcome predictors.

**RESULTS** This study included 75 patients (mean age 49.03 years, 1:1.007 male/female ratio). Early surgery in younger and less frail patients was associated with better outcomes, with no precise surgical timing cutoff identified. Improvement in MRC grades was seen in 41 patients (55%), with no change in 23 patients (31%) and worsening grades in 11 patients (15%). For every day delaying surgery, the likelihood of improvement decreased by 0.2%. The severity of foot drop was associated with a reduced likelihood of complete resolution, although some recovery was demonstrated. Functional recovery was consistently higher in patients with higher presenting MRC grades. Radicular pain consistently improved following surgical intervention irrespective of all other analyzed metrics.

**CONCLUSIONS** Prompt surgical intervention for patients with foot drop improved outcomes, especially in those who were younger and less frail. While the study did not identify a specific cutoff for the timing of surgery, the findings empha-

**ABBREVIATIONS** LDH = lumbar disc herniation; MRC = Medical Research Council.

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size the importance of early surgical consideration as delays were associated with reduced likelihood of recovery. Future research should focus on prospective studies to validate these findings and refine guidelines for surgical intervention in this patient population.

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**KEYWORDS** foot drop; lumbar disc herniation; degenerative

Foot drop is a term used to describe weakness of ankle dorsiflexion caused by disturbed neural supply to the dorsiflexor muscles of the ankle, mainly the tibialis anterior, which receives most of its supply from the L5 nerve root.[1] The L4 and S1 nerve roots might also contribute to innervation of the tibialis anterior.[2] Peripheral pathologies along the course of the superficial peroneal nerve, common peroneal nerve, sciatic nerve, or L4, L5, or S1 nerve roots could also lead to foot drop.[3]

Compressive pathology of the L5 nerve root might be related to a spectrum of degenerative diseases of the lumbar spine, such as disc herniation, degenerative spondylolisthesis, and spinal stenosis, with varying degrees of surgical urgency and strategies of surgical management.[3]

The presentation of foot drop in patients with lumbar degenerative disease often coincides with ipsilateral radicular pain of the leg (i.e., painful foot drop), although patients can also present with painless foot drop, less commonly. Painless foot drop is traditionally thought to be caused by irreversible nerve root ischemia and associated with poorer surgical outcomes, yet contemporary literature debates this.[4–6]

The role of surgery in relieving weakness in patients with foot drop is a matter of substantial discussion. While many cohort studies have demonstrated positive outcomes, particularly in those with symptoms due to disc herniation, the optimal timing of acute intervention is yet to be elucidated.[7–11]

A recent meta-analysis of patients undergoing surgical decompression for lumbar degenerative disease found, in general, that patients who underwent surgery within 1 month of foot drop presentation had superior recovery rates and improvement compared with those undergoing later surgery (beyond 1 month).[12]

The literature currently lacks evidence on the utility and timing of decompression for patients who present with painful foot drop, especially secondary to lumbar disc herniation (LDH). Most studies encompass retrospective outcome data for patients with degenerative spondylolisthesis and spinal stenosis. Inclusion of such pathology precludes accurate interpretation of outcome data due to associated multilevel disease processes, which might confound any direct causal link to foot drop outcomes.[12]

Furthermore, optimal time points for surgical intervention remain elusive for patients who present with foot drop secondary to LDH in the absence of cauda equina syndrome, which is a medical emergency and typically necessitates surgery within 48 hours of presentation regardless of whether foot drop is present.[13]

Therefore, we performed this multicenter study to determine the utility and timing of decompression for patients who present with painful foot drop, specifically secondary to LDH, but without cauda equina syndrome. We believe that these patients stand to benefit most from surgery; however, defined cutoffs and definitive evidence that timely surgery leads to improved outcomes are lacking.

## Methods

This was a multicenter retrospective case series of adult patients with unilateral foot drop who underwent lumbar discectomies at 7 tertiary neurosurgical centers from September 2011 to September 2022. Clinical records were retrospectively analyzed to identify patients meeting our inclusion criteria, which were 1) having foot drop (Medical Research Council [MRC] grade ≤ 3 in ankle dorsiflexion), confirmed with testing of the extensor hallucis longus and the tibialis anterior; and 2) lumbar degeneration in the form of a disc herniation attributed to unilateral motor deficit. Exclusion criteria were prior spinal trauma, previous cauda equina syndrome, presence or history of spinal tumor, local aberrant vascular pathology that included malformations, and previous spinal surgery. Patients presenting with cauda equina syndrome and foot drop were analyzed separately. In our study, data were collected during routine clinical care of patients and analyzed retrospectively. Individual centers registered this study with their respective audit offices in accordance with trust policy. Improvement was defined as any increase in MRC grade; foot drop resolution was defined as a postoperative MRC grade > 3; and worsening was defined as any decrease in MRC grade. In addition, only patients with painful sciatica were included.

### Data Collection

Inpatient documentation, radiological reports, and outpatient clinical notes were used to collect data (Tables 1 and 2). For the study, the patients who were excluded from the main analysis were the patients admitted with cauda equina syndrome, defined according to the Society of British Neurological Surgeons–British Association of Spine Surgeons guidance. This case series has been reported in accordance with PROCESS (Preferred Reporting of Case Series in Surgery) guidelines.

### Outcomes

Improvement was defined as any increase in MRC-graded muscle strength of the extensor hallucis longus and the tibialis anterior.

Resolution was defined by the strength of ankle dorsiflexion as an MRC grade ≥ 4 after surgery. Therefore, for patients with a preoperative MRC grade < 3, this variable was more difficult to achieve than for those with less severe foot drop.

### Statistical Analysis

Data were collected using Microsoft Excel (version

**TABLE 1. MRC scale outcomes based on preoperative MRC grades**

| Preop MRC Grade | No. of Pts | Postop MRC Grade | | | | | | Mean Change |
|---|---|---|---|---|---|---|---|---|
| | | 5 | 4 | 3 | 2 | 1 | 0 | |
| 3 | 20 (27) | 3 (15) | 4 (20) | 6 (30) | 5 (25) | 1 (5) | 1 (5) | +0.2 |
| 2 | 20 (27) | 1 (5) | 4 (20) | 6 (30) | 5 (25) | 2 (10) | 2 (10) | +0.7 |
| 1 | 22 (29) | 2 (9) | 1 (5) | 6 (27) | 4 (18) | 9 (41) | 0 (0) | +1.3 |
| 0 | 13 (17) | 1 (8) | 1 (8) | 3 (23) | 0 (0) | 5 (38) | 3 (23) | +1.8 |
| Total | 75 (100) | 7 (9) | 10 (13) | 21 (28) | 14 (18) | 17 (23) | 6 (8) | — |

Pts = patients.
Values are presented as the number of patients (%), except where indicated otherwise.

16.76), and raw data were processed and analyzed using R (version 4.2.3, The R Foundation) and RStudio (2023.06.1-524, Posit). The MRC scale for muscle assessment was used to determine the overall strength of the muscles involved in foot drop, with grade 5 indicating normal function and grade 0 indicating no visible contraction. MRC grades were collected and analyzed at 4 time points: prior to admission to the neurosurgery department, immediately after surgery, at discharge, and at follow-up.

The Fisher exact test was used in subgroup analysis for discrete variables, and the paired t-test was used for continuous variables. Binomial logistic regression was also used to identify statistical significance and calculate odds ratios.

Variable selection for univariable and multivariable analyses was guided by a combination of clinical plausibility and statistical significance ($p < 0.05$). Recognizing the risks of overfitting inherent to small datasets, we lim-

**TABLE 2. Demographics and subgroup analysis based on improvement in MRC grade in patients with foot drop**

| | Total | Improvement | No Improvement | p Value (OR, 95% CI) |
|---|---|---|---|---|
| No. of pts | 75 | 41 | 34 | |
| Age, yrs | 49.03 ± 13.35 | 45.7 ± 13.6 | 53 ± 12.1 | 0.020* |
| Sex | | | | 0.818 |
| M | 37 | 21 | 16 | |
| F | 38 | 20 | 18 | |
| BMI | 28.47 ± 5.44 | 28.2 ± 5.22 | 28.8 ± 5.66 | 0.655 |
| Time from FD onset to op, days | 91.36 ± 166.67 | 52.7 ± 70.1 | 138 ± 229 | 0.043* |
| Time from admission to op, days | 49.21 ± 95.93 | 32.4 ± 67.1 | 69.5 ± 120 | 0.114 |
| Rockwood Frailty Scale score | 1.89 ± 1.16 | 1.63 ± 1.18 | 2.21 ± 1.07 | 0.030* |
| Length of stay, days | 5.09 ± 7.00 | 3.83 ± 2.74 | 6.62 ± 9.81 | 0.117 |
| Time from onset to op | | | | |
| <24 hrs | 1 | 0 | 1 | 0.459 |
| 24–48 hrs | 2 | 1 | 1 | >0.99 |
| 49–72 hrs | 3 | 0 | 3 | 0.092 |
| 73 hrs to 7 days | 12 | 11 | 1 | 0.004 (12.52, 1.52–102.94) |
| 8–14 days | 11 | 5 | 6 | 0.744 |
| 15–42 days | 15 | 8 | 7 | 0.935 |
| 43–180 days | 19 | 14 | 5 | 0.063 |
| >180 days | 12 | 2 | 10 | 0.007 (0.17, 0.035–0.64) |
| Preop MRC grade | | | | |
| 0 | 13 | 10 | 3 | Control |
| 1 | 22 | 13 | 9 | 0.463 (0.45, 0.09–2.05) |
| 2 | 20 | 11 | 9 | 0.278 (0.39, 0.07–1.78) |
| 3 | 20 | 7 | 13 | 0.032* (0.18, 0.03– 0.81) |
| Postop improvement in sciatica | 59 | 33 | 26 | 0.780 |

FD = foot drop.
Values are presented as the number of patients or mean ± SD, except where indicated otherwise.
* Indicates a statistically significant difference.

ited the number of variables in the final model to maintain a reasonable ratio of events per variable. Bootstrapping (1000 replicates) was performed to assess model stability. A catalog of all variables considered, alongside univariable results, is provided in Table 2. The multivariable model was chosen based on clinical relevance, statistical significance, and model parsimony, with an emphasis on minimizing overfitting.

### Skewness of the Onset Variable

The onset variable, representing the time from symptom onset to surgery, exhibited extreme positive skewness (skewness = 3.51), with most values clustered near the lower range and a long tail of larger values. This degree of skewness violated the assumptions of normality required for parametric analyses.

To address this, a logarithmic transformation was applied. The log transformation compresses higher values more than lower values, thereby reducing the influence of outliers while preserving the relative order of the data, specifically: transformed value = log(onset+1).

The log transformation reduced the skewness of the onset variable from 3.51 to 0.289. Visual inspection of the transformed variable's histogram indicated a more symmetric distribution. The Shapiro-Wilk test for normality was used to confirm the transformed variable met the assumptions for parametric analyses.

## Results

Across 7 centers, we identified 75 patients with painful unilateral foot drop without cauda equina syndrome. The mean age was 49.03 years (range 24–74 years), with a 1:1.007 (37:38) male/female ratio. As shown in Table 1, only patients with an MRC grade ≤ 3 were included. Of the 75 patients, 41 experienced an improvement in MRC grade. Age (OR 0.96 per year [95% CI 0.923–0.994], p = 0.020) was a significant predictor of improvement. The amount of time from onset of foot drop to surgery was also a significant predictor of improvement (OR 0.998 per day [95% CI 0.997–0.996], p = 0.026), meaning for every day since symptom onset, the chance of improvement decreased by 0.2%. Patients who experienced an improvement in MRC grade had a mean symptom history of 53 days compared with 138 days for those who did not (p = 0.043); this distribution is shown in Figs. 1 and 2. The clinical frailty score was also a significant predictor of improvement (OR 0.898 per point on the Rockwood Frailty Scale [95% CI 0.816–0.989], p = 0.030). Patients with an MRC grade 3 were the least likely to experience absolute improvement (OR 0.18 [95% CI 0.03–0.81], p = 0.032) and this was the only grade to reach significance thresholds compared with patients with MRC grade 0, who were the most likely to experience improvement.

Eleven patients (15%) had a worsening MRC grade and 23 patients (31%) had no change in MRC grade. Of the 41 patients who experienced improvement, 17 experienced resolution of foot drop defined by an MRC grade > 3. Preoperative MRC grades of 2 or 3 accounted for 12 of the 17 resolutions (71%) but had the lowest mean change in grade of +0.7 and +0.2, respectively. Conversely, only 15% of patients with MRC grade 0 and 14% of patients with MRC grade 1 experienced resolution of foot drop, but they experienced the largest mean improvements of MRC grade at +1.8 and +1.3, respectively. Based on the preoperative grade, the median change was +1 for grade 0, +1 for grade 1, +1 for grade 2, and 0 for grade 3. Most patients (79%, 59/75) experienced improvement in preoperative sciatic pain, with no difference between subgroups.

Analyzing solely the resolution of foot drop, no variables reached significance thresholds. Patients were younger and had lower frailty scores, a shorter hospital length of stay, and approximately 50% shorter time from onset of symptoms to surgery compared with patients with no resolution of foot drop, as detailed in Table 3.

Analyzing pain and sciatica specifically, most patients benefited from surgery (79%), but no factors were found to be significant predictors. Again, patients with resolution of sciatic pain were younger and had a shorter history of symptoms, a short hospital length of stay, and lower BMI compared with those without resolution of sciatic pain. However, none of these factors reached significance thresholds, as shown in Table 4.

There was a large skew of 3.51 in the data (Fig. 3A). A log transformation was applied (Fig. 3B), and the model was reevaluated against this transformed data. This model was no longer significant (p = 0.252). Additionally, if the 3 longest times to surgery (> 1 year) were removed from the analysis, the time from onset to surgery was no longer a significant variable (p = 0.104), although there was still a clear difference in the time to surgery, with those experiencing improvement having a mean of 52.68 days and those not experiencing improvement having a mean of 77.35 days.

## Discussion

Our study in patients with painful foot drop secondary to lumbar disc herniation highlights a key difference in the time from onset to surgery between the cohort that experienced improvement and the cohort that did not. We identified additional factors that increased the likelihood of improvement and complete resolution of foot drop.

Foot drop is a term used to describe a symptomatic presentation arising due to a diverse range of pathologies,[9] including iatrogenic causes, peroneal nerve entrapment[14] (which itself can be caused by a variety of traumatic and atraumatic etiologies[14]), sciatic nerve lesions,[15] and central cord pathologies.[7,11,12] Foot drop simply refers to a weakness in ankle dorsiflexion.[8] A recent review of 1022 patients found that only 131 (12.8%) had foot drop caused by a noniatrogenic lumbosacral condition,[16] and most studies have encompassed LDH and lumbar spinal stenosis as well as other pathologies of the lumbar spine. To our knowledge, this is the largest cohort study in the literature to explore solely LDH leading to painful unilateral foot drop, encompassing 7 major neurosurgical centers.

We defined foot drop by an MRC grade ≤ 3 in line with most of the literature,[17–20] although some studies have defined it as MRC grade < 3.[21,22] Of the 75 patients, 41 (55%) experienced improvement. However, only 17 patients (23%) experienced complete resolution of their foot drop,

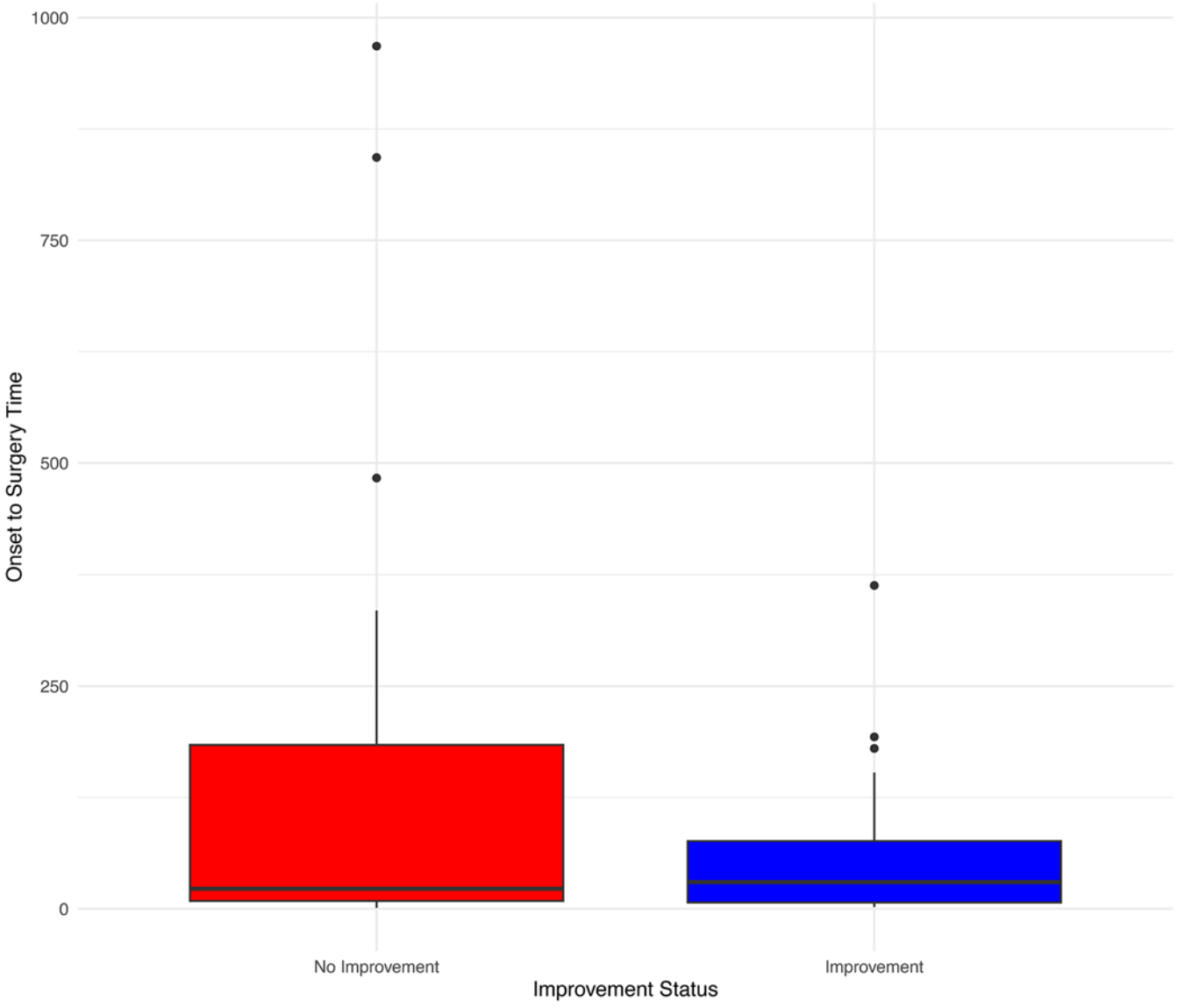


**FIG. 1.** Boxplot showing the mean time from onset to surgery subgrouped according to whether patients experienced an improvement in MRC grade. Figure is available in color online only.

most of whom had either MRC grade 2 or 3 preoperatively, thus requiring the least recovery of function. Patients with MRC grades 0 and 1 had the highest mean change in recovery, but as this was a mean change of only +1.8 and +1.3, respectively, they did not experience resolution of foot drop. Additionally, patients with MRC grades 0–2 all had a median improvement of +1, while patients with MRC grade 3 had a median improvement of 0, further confirming this trend.

Oosterbos et al.[23] have reported that while 32% of the specialists who responded to their survey considered the MRC grade for ankle dorsiflexion to be the most important outcome in the treatment of foot drop, 36% (the largest option) prioritized gait improvement and 20% prioritized patient-reported outcomes. Thus, simply looking at the change in MRC grade might not give a holistic view of outcomes. Of the preoperative grades, 35% of patients with an MRC grade of 3 experienced resolution of foot drop compared with 15% of patients with MRC grade 0 and 14% with MRC grade 1. Thus, prioritizing absolute MRC grade increase when most patients with grades 0 or 1 leveled out at either grade 1 or 2 might not truly reflect which cohort stands to benefit the most from intervention.[23] Multiple studies have reviewed the effect of lower limb MRC grading on gait and gait speed.[24,25] While we have not found any that specify an MRC grade cutoff for abnormal gait, several studies have found a significant trend between muscle grade and gait, and some have specified ankle dorsiflexion and plantarflexion specifically as the best predictors of normal gait.[24]

Several studies have attempted to analyze the effect of time from admission and symptom onset on the recovery rate.[12,17,21,22,26,27] One reported cutoff for adverse outcomes is 6 weeks,[17,28] and, while in our study there was no specific

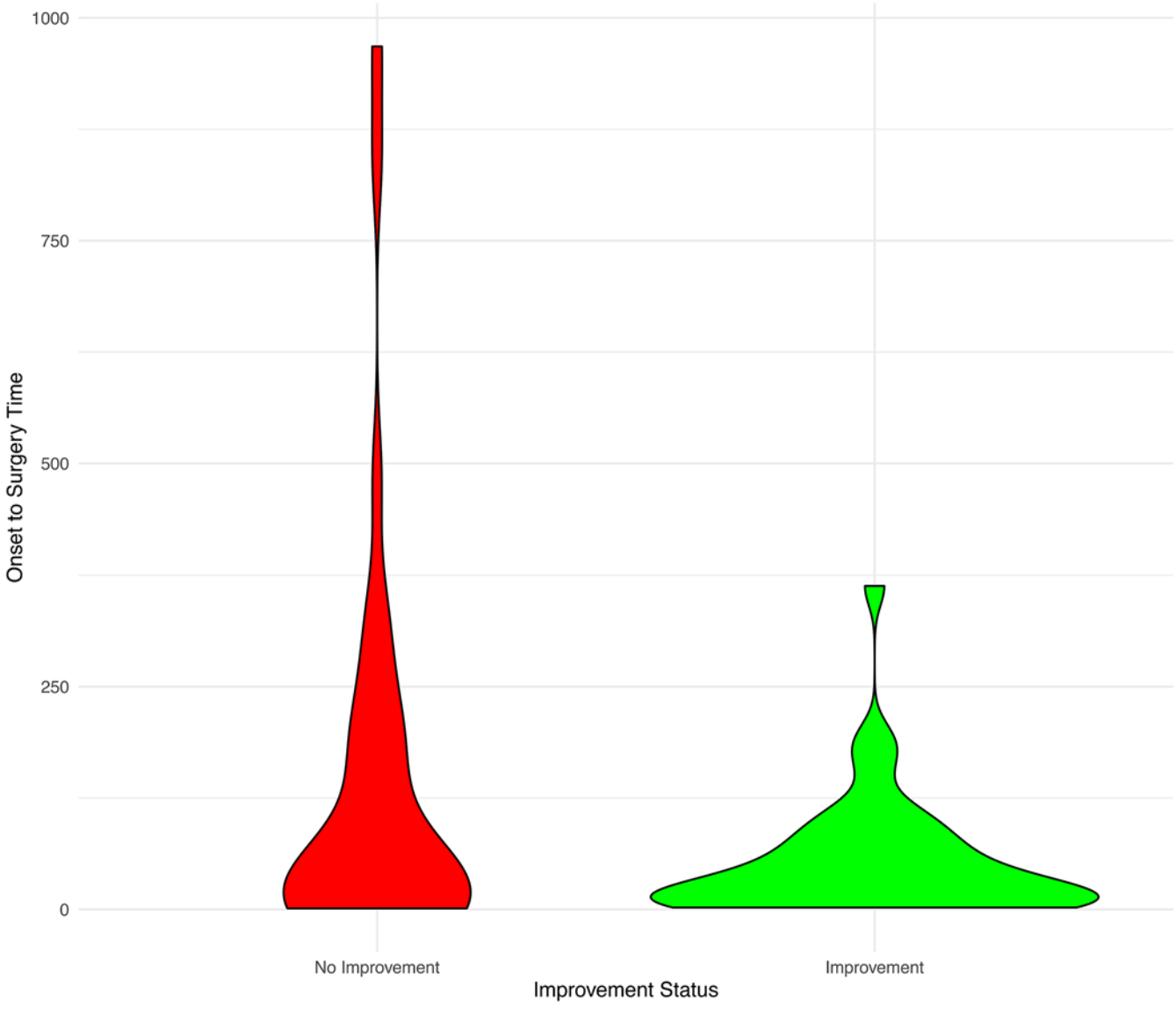


**FIG. 2.** Violin plot showing the individual times from onset to surgery subgrouped according to whether patients experienced an improvement in MRC grade. Figure is available in color online only.

significant cutoff found, we did find a trend with both t-testing and binomial logistic regression showing the time from onset to surgery to be a significant predictor of improvement in function ($p = 0.03$). In our cohort, for every day from symptom onset, there was a 0.2% reduction in the likelihood of improvement. However, as we noted in *Results*, when the log transformation was applied or the longest outliers were removed, this relationship disappeared, suggesting that these data could have significant skewness.

One possible explanation presented by the literature is that when foot drop can be explained by nerve compression secondary to disc herniation or even spinal stenosis, recovery is more likely when there is immediate decompression of the inflamed tissues in comparison to delayed compression, which allows time for scar formation and permanent damage even if the disc or stenosis has spontaneously improved.[17,28] Tanaka et al.[26] have also noted that the disappearance of radicular leg pain might lead to decreased recovery rates. The authors hypothesized that as axonal flow is obstructed by compression of the nerve root,[29] pain mediators are unable to release and build up in the axons until the mechanical pressure irreversibly changes the dorsal root ganglion cells, which undergo cell death.[30] Whether this phenomenon is a proxy for time or if this specific change also inhibits the recovery rate will need to be validated in future studies, as our study included only patients with painful foot drop because there is less controversy in the literature regarding whether surgery is required in such cases.[31]

Age has also been reported previously as a prognostic variable[9,21,27,28] and was a significant variable in our cohort as well. While others have not found age to be significant,[17,18,22,26] this may be explained by the finding that clinical frailty, measured using the Rockwood scale, was

**TABLE 3. Demographics and subgroup analysis based on resolution of foot drop**

| | Total | Resolution | No Resolution | p Value |
|---|---|---|---|---|
| No. of pts | 75 | 17 | 58 | |
| Age, yrs | 49.03 ± 13.35 | 45.3 ± 14.4 | 50.1 ± 13.0 | 0.225 |
| Sex | | | | 0.788 |
| M | 37 | 9 | 28 | |
| F | 38 | 8 | 30 | |
| BMI | 28.47 ± 5.44 | 29.8 ± 7.35 | 28.1 ± 4.75 | 0.359 |
| Time from FD onset to op, days | 91.36 ± 166.67 | 63.6 ± 94.9 | 99.5 ± 182 | 0.285 |
| Time from admission to op, days | 49.21 ± 95.93 | 40.0 ± 92.6 | 51.9 ± 97.5 | 0.649 |
| Rockwood Frailty Scale score | 1.89 ± 1.16 | 1.76 ± 1.05 | 1.93 ± 1.21 | 0.592 |
| Length of stay, days | 5.09 ± 7.00 | 4.12 ± 2.71 | 5.38 ± 7.82 | 0.304 |
| Time from onset to op | | | | |
| <24 hrs | 1 | 0 | 1 | >0.99 |
| 24–48 hrs | 2 | 1 | 1 | 0.404 |
| 49–72 hrs | 3 | 0 | 3 | >0.99 |
| 73 hrs to 7 days | 12 | 5 | 7 | 0.128 |
| 8–14 days | 11 | 2 | 9 | >0.99 |
| 15–42 days | 15 | 2 | 13 | 0.496 |
| 43–180 days | 19 | 6 | 13 | 0.344 |
| >180 days | 12 | 1 | 11 | 0.276 |
| Preop MRC grade | | | | |
| 0 | 13 | 2 | 11 | Control |
| 1 | 22 | 3 | 19 | >0.99 |
| 2 | 20 | 5 | 15 | 0.676 |
| 3 | 20 | 7 | 13 | 0.263 |
| Postop improvement in sciatica | 59 | 16 | 43 | 0.099 |

Values are presented as the number of patients or mean ± SD, except where indicated otherwise.

a significant predictor of recovery. Age and clinical frailty are highly correlated,[32] and some older patients with lower frailty scores could be more resilient in this sense. Both in terms of any improvement and complete recovery, patients with lower frailty scores had superior outcomes, although this was only significant among the improvement cohort.

Future larger prospective studies can validate our findings, and with more patients. Additionally, the large standard deviation in the time from onset to surgery can be addressed to find a statistically significant time frame. Multivariable prediction models using patient age, clinical frailty score, and history of symptoms can be used to determine whether surgery is likely to be successful.

## Conservative Treatment

Our study focused on the surgical treatment of foot

**TABLE 4. Demographics and subgroup analysis based on resolution of sciatic pain**

| | Total | Resolution | No Resolution | p Value |
|---|---|---|---|---|
| No. of pts | 75 | 59 | 16 | |
| Age, yrs | 49.03 ± 13.35 | 48.3 ± 13.5 | 51.9 ± 12.8 | 0.331 |
| Sex | | | | 0.270 |
| M | 37 | 27 | 10 | |
| F | 38 | 32 | 6 | |
| BMI | 28.47 ± 5.44 | 28.3 ± 5.88 | 28.9 ± 3.45 | 0.615 |
| Time from FD onset to op, days | 91.36 ± 166.67 | 77.2 ± 140 | 144 ± 239 | 0.301 |
| Time from admission to op, days | 49.21 ± 95.93 | 43.0 ± 91.7 | 72.2 ± 110 | 0.341 |
| Rockwood Frailty Scale score | 1.89 ± 1.16 | 1.98 ± 1.06 | 1.56 ± 1.46 | 0.294 |
| Length of stay, days | 5.09 ± 7.00 | 4.39 ± 2.86 | 7.69 ± 14.2 | 0.369 |

Values are presented as the number of patients or mean ± SD, except where indicated otherwise.

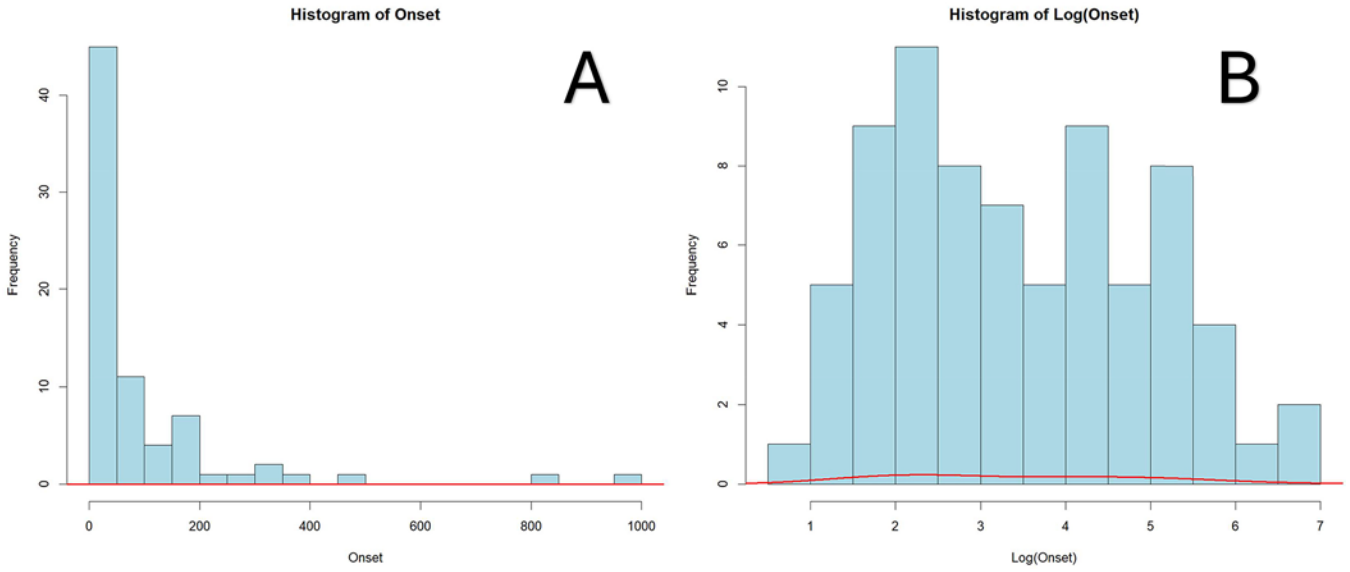


**FIG. 3. A:** Histogram showing the large skew in data of 3.51. **B:** Histogram after a log transformation was applied, with the skew reduced to 0.289. Figure is available in color online only.

drop, yet many patients are treated with conservative therapy.[33] Conservative treatment for LDH-causing foot drop typically involves a multifaceted approach aimed at reducing pain, improving function, and potentially promoting nerve recovery.[23,33–35] The primary goal is to alleviate pressure on the affected nerve root, usually L4, L5, or S1, which is responsible for foot dorsiflexion.[18,26,36] Initial management often includes a period of relative rest to reduce inflammation, followed by a gradual return to activities.[37] Physical therapy plays a crucial role, focusing on exercises to strengthen core and lower extremity muscles, improve flexibility, and correct posture.[38] Nonsteroidal anti-inflammatory drugs can be prescribed to manage pain and reduce inflammation. In some cases, epidural steroid injections can be administered to provide more targeted anti-inflammatory effects.[39] Ankle-foot orthoses are commonly used to support the foot and improve gait mechanics, preventing tripping and falls.[37,40] Additionally, lifestyle modifications, such as weight management and ergonomic adjustments, can be recommended to reduce stress on the lumbar spine.[36] While conservative treatment can be effective, it is important to note that severe or progressive neurological deficits could necessitate surgical intervention.[18]

## Limitations

This study focuses on a small subset of an already rare pathology.[36] While this does mean it can contribute meaningfully to the literature, it means that the cohort sizes are naturally small and while it is the largest in the literature we have found, pooled analysis will be needed to validate many of our findings. Additionally, as this was a multicenter retrospective study, there could be differences in diagnosis, treatment, and follow-up between centers, making comparisons more difficult. However, this might help generalize it to the wider population and reduce the chance of overfitting. We recognize the chance of selection bias inherent to all retrospective studies and have attempted to standardize our approach and limit exclusion criteria as much as possible.

This study's relatively small sample size, heterogeneous outcomes, and inclusion of multiple treating centers introduce variability that limits the ability to detect strong reliable signals amid potential statistical noise. These factors inherently reduce the precision of our estimates and could contribute to the observed variability in effect sizes.

The wide confidence intervals for some findings, such as the OR for patients with preoperative MRC grade 3 weakness (OR 0.18, 95% CI 0.03–0.81), reflect the uncertainty introduced by the sample size and variability in outcomes. While the point estimate suggests an association, the range of plausible values underscores the need for caution in interpreting these results.

The data suggest that patients with weakness indicated by a preoperative MRC grade of 3 have reduced odds of experiencing improvement, but the nearly 30-fold range of the confidence interval highlights significant uncertainty. This variability likely stems from the small sample size and heterogeneity in pathology, treatment protocols, and follow-up durations across multiple centers.

These findings should be viewed as hypothesis-generating rather than confirmatory. Larger multicenter studies or pooled analyses are required to validate these associations and provide more precise estimates.

Future research could benefit from methods such as Bayesian modeling or penalized regression, which are better suited to handle variability in small datasets and provide more reliable effect estimates.

Finally, radiological data were not analyzed as radiological findings were outside the scope of this study, with clinically or radiologically confirmed cauda equina syndrome being an exclusion criterion. Combined analysis of radiological severity combined with the time of compression might better help explain why the importance of timing has been difficult to ascertain in foot drop secondary to LDH.

## Conclusions

Prompt surgical intervention for patients with foot drop improved outcomes, especially in those who were younger and less frail. While a specific time cutoff was not found in our study, for every day of symptoms, there was a 0.2% decrease in positive recovery. Patients with lower MRC grades were more likely to experience any improvement in MRC grade, but unlikely to experience resolution of foot drop. Patients with higher MRC grades were less likely to experience improvement but more likely to experience functional recovery (MRC grade > 3). Most patients experienced improvement in preoperative sciatic pain, independent of the time from onset to surgery or any other factors.

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## Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this article.

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Conception and design: Baig Mirza, Bull, Sadek, Grahovac. Acquisition of data: Vastani, El Sheikh, Rowland, Trindade, Toescu, Murphy, Jindal, Reischer, Corr, Nolan, Sims-Williams, Read, Goonewardena, Johani, Pandit, Khoja, Bull, Hassan, Okasha, Sadek, Grahovac. Analysis and interpretation of data: Baig Mirza, Fayez, Suvarna, El Sheikh, Velicu, Toescu, Murphy, Khoja, Hassan, Sadek. Drafting the article: Baig Mirza, Vastani, Fayez, Suvarna, El Sheikh, Sharma, Velicu, Toescu, Goonewardena, Sadek. Critically revising the article: Baig Mirza, Vastani, Fayez, El Sheikh, Sharma, Rowland, Toescu, Reischer, Syrris, Rashed, Khoja, Matloob, Bull, Montgomery, Moran, Okasha, Nader-Sepahi, Grahovac. Reviewed submitted version of manuscript: Baig Mirza, Fayez, Suvarna, El Sheikh, Trindade, Toescu, Murphy, Jindal, Reischer, Goonewardena, Syrris, Pandit, Rashed, Khoja, Matloob, Bull, Montgomery, Sayal, Hassan, Nader-Sepahi, Malik, Grahovac. Approved the final version of the manuscript on behalf of all authors: Baig Mirza. Statistical analysis: Fayez, Suvarna, Velicu, Toescu, Rashed. Administrative/technical/material support: El Sheikh, Trindade, Toescu, Corr, Syrris. Study supervision: Matloob, Bull, Sayal, Arvin, Sadek, Grahovac.

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