Abstract

Introduction
Myelography is a radiological examination method that has been used for the diagnosis of spinal canal pathologies for a long time. More than 90 years of experience has been improved by the development of increasingly less toxic contrast agents. Nowadays, although there are many advanced diagnostic tools, lumbar myelography is a direct imaging technique and so it is a powerful diagnostic method for patients whose treatment has not been decided. The aim of our study is to evaluate the effect of lumbar myelography as a diagnostic method and its contribution to treatment.

Materials and methods
Between January 2016 and April 2018, 63 patients who were admitted to our neurosurgery clinic due to lumbar degenerative disorders and underwent myelography were included in our study. Patients over 30 years of age with lumbar disc disease, narrow spinal canal, and spinal instability, but for whom a surgical decision could not be made, were included in this study.

Results
After lumbar myelography, 55 of 63 patients underwent a surgical procedure and 8 were directed to non-surgical treatment options. The results of the patients were evaluated by Roland-Morris Low Back Pain and Disability Questionnaire (RMQ). Results showed that the contribution of selected treatment protocols to the recovery after myelography was statistically significant.

Conclusion
Nowadays, myelography is not the first choice for the diagnosis of lumbar degenerative disorders. However, according to the results of our study, lumbar myelography is an effective diagnostic tool for specific purposes.
tomography (CT) and magnetic resonance imaging (MRI). Pomerantz defines myelography as a modern technique and lists its indications as follows: (a) spinal stenosis, (b) cervical nerve root avulsion in brachial plexus injury, (c) radiation therapy treatment planning, and (d) cerebrospinal fluid (CSF) leak [2].

In the evaluation of lumbar degenerative disorders, myelography is a good helper for indications in complicated spine surgery, which is now considered to be inadequate in planning the diagnosis and treatment strategy of frequently used MRI and CT imaging.

In their article in 2011, where they described the myelography technique in detail, Harreld et al. emphasized the following in the conclusion section: although MRI is more often performed to evaluate back pain, a well-performed myelogram can provide essential diagnostic information when MRI is not possible or practical, such as in patients for whom MRI is contraindicated or when dynamic imaging is desired [3]. In our article, the contribution of lumbar myelography to the diagnosis and treatment decision in patients who could not be decided by direct radiography, CT and MRI methods were examined.

**Brief history**

In 1890, Quincke described the lumbar puncture procedure. After Roentgen developed the X-ray tube in 1895 and Dandy described pneumoencephalography in 1919, in 1921 two Scandinavian doctors attempted to obtain images by injecting air into the subarachnoid space: Jacobaeus from Sweden and Sofus Widere from Norway [4-7]. In 1922, Jean-Athanese Sicard, a French doctor, and his student Jacques Forestier reported using Lipiodol, an ionized poppy seed oil, in the diagnosis of spinal masses [8-10]. After myelography became widespread as an imaging technique, studies focused on reducing the side effects of contrast agents. Early-term contrast agents could cause hypersensitivity reactions, meningitis, and arachnoiditis. In the 1940s, iophendylate was introduced. In the 1960s, ionic water-soluble contrast agents Meglumineiothalamate and Meglumine iocarmate followed [11-13]. In the 1970s, metrizamide, the first non-ionic water-soluble contrast agent, came into use [14]. In the next decade, iohexol and iopamidol were developed [15,16]. Although the contrast agents used today are not completely risk-free, they have much lighter side effects than the previous ones [17,18].

**Materials And Methods**

A total of 63 patients who applied to our neurosurgery clinic between January 2016 and April 2018 with complaints of low back and/or leg pain and underwent myelography were included in our study. The study included 38 females and 25 males. The mean age of the patients was 57.62±10.78. The age range was between 36 and 79. The study included patients older than 30 years, and who had the lumbar degenerative disorder. Prediagnosis of these patients were lumbar disc herniation, spinal stenosis, spinal instability, and failure of instrumentation. Patients under the age of 30, who had a history of allergy, severe psychiatric disease, suspected pregnancy, or intracranial pressure were excluded from the study. In the history of the patients, 10 patients had undergone surgery for lumbar disc herniation and 17 patients were decompressed for lumbar stenosis. Stabilization and fusion were applied to six patients and epidural injection was applied to one patient. Twenty-nine patients had not been operated on before (Table 1).

| Sex (n=63) | Median age |
|-----------|------------|
| F (38 (60.32%)) | 57.6±10.8 |
| M (25 (39.68%)) | |

**Complaints**

Patients (n=63)

| Complaints | |
|------------|---|
| Waist and right leg pain | 17 (26.98%) |
| Waist and left leg pain | 20 (31.74%) |
| Pain in the waist and both legs | 18 (28.58%) |
| Low back pain and short walking distance | 8 (12.70%) |

**Previous surgery**

| Lumbar discectomy | Lumbar laminectomy | Lumbar stabilization | Epidural injection | No surgery |
|-------------------|--------------------|---------------------|-------------------|------------|
| 10                | 17                 | 6                   | 1                 | 29         |

**TABLE 1: Demographic characteristics, complaints of patients, and history.**
Technique

After the patient and his relatives were given detailed information about the procedure, the patients were taken to the operating table in the lateral decubitus or sitting position. A lumbar puncture was performed at the L3-S1 level with the help of a spinal catheter in the operating room. Then, iohexol, a non-ionic, water-soluble contrast agent, was applied to the intrathecal space. The recommended dose of iohexol for lumbar myelography is 15-17 mL, 180 mg/100 mL; 240 mg/100 mL bottles are also recommended to view a wider area [19,20]. Immediately after iohexol administration, images of the patient in anterior, lateral, flexion, extension, and flexion positions were obtained by fluoroscopy. In addition, the fluoroscopic examination was performed in lateral bending and axial loading positions. Especially, these last two positions gave a remarkable privilege to the application of fluoroscopy in the diagnosis of the disease. CT myelography was then performed. This whole process was carried out under the supervision and approval of a radiologist.

Figures 1 and 2 demonstrate examples of positive myelography images selected from our patient population. In the first of them, the MRI could not be performed due to the orthopedic plaque in the tibial bone. In the patient who had a complaint of lower back and left leg pain, the root compression at the left L4-L5 level was observed in myelography (Figure 1). In the latter case, the patient had previously undergone a stabilization surgery and now had both leg pain. Myelography and CT myelography after MRI revealed dural sac compression at the L3-L4 level (Figure 2).

**FIGURE 1:** The patient who had a complaint of low back and left leg pain.

Root compression at the left L4-L5 level was observed in myelography and CT myelogram. MRI could not be performed due to orthopedic plaque in the tibial bone.
FIGURE 2: The patient had previously undergone a stabilization surgery.

On the new admission of the patient, there was a complaint of pain in both legs. Myelogram and CT myelogram after MRI revealed dural sac compression at the L3-L4 level.

Results

Discectomy surgery was performed in 13 of 63 patients after myelography. The stabilization of 12 patients were revised and lumbar decompression was applied to 10 patients. Epidural injection and facet denervation were performed in 15 patients. Lumbar stabilization and fusion surgery was performed in five patients. It was decided that eight patients did not require surgical treatment (Table 2). Patient satisfaction before and after surgical treatment was evaluated with the Roland-Morris Low Back Pain and Disability Questionnaire (RMQ; Table 3) [21,22].
| Treatment                                           | (n=63)          |
|----------------------------------------------------|----------------|
| Epidural injection, facet denervation               | 15 (23.81%)    |
| Lumbar discectomy                                   | 13 (20.63%)    |
| Stabilization revision                              | 12 (19.05%)    |
| Lumbar decompression without instrumentation        | 10 (15.87%)    |
| Lumbar surgery with stabilization and fusion        | 5 (7.94%)      |
| No surgery (medication and/or physiotherapy)        | 8 (12.70%)     |

### TABLE 2: Surgical decisions after lumbar myelography.

| Patient no. | Sex | Age | Treatment                  | RMQ (before treatment) | RMQ (after treatment) |
|-------------|-----|-----|----------------------------|-------------------------|------------------------|
| 1           | M   | 62  | Stabilization revision     | 18                      | 10                     |
| 2           | F   | 68  | Lumbar decompression       | 20                      | 12                     |
| 3           | F   | 48  | Lumbar decompression       | 21                      | 10                     |
| 4           | F   | 47  | Epidural injection         | 20                      | 10                     |
| 5           | M   | 53  | Epidural injection         | 14                      | 7                      |
| 6           | F   | 45  | Lumbar discectomy          | 20                      | 14                     |
| 7           | M   | 50  | Lumbar discectomy          | 18                      | 10                     |
| 8           | F   | 64  | Epidural injection         | 20                      | 10                     |
| 9           | F   | 43  | Lumbar discectomy          | 16                      | 9                      |
| 10          | F   | 36  | Medication and/or physiotherapy | 20                  | 12                     |
| 11          | F   | 68  | Lumbar decompression       | 16                      | 8                      |
| 12          | F   | 52  | Epidural injection         | 18                      | 16                     |
| 13          | F   | 41  | Epidural injection         | 20                      | 10                     |
| 14          | M   | 57  | Medication and/or physiotherapy | 18                  | 9                      |
| 15          | F   | 69  | Lumbar discectomy          | 16                      | 10                     |
| 16          | F   | 55  | Lumbar discectomy          | 20                      | 12                     |
| 17          | M   | 69  | Stabilization revision     | 22                      | 13                     |
| 18          | M   | 62  | Stabilization and fusion   | 22                      | 15                     |
| 19          | M   | 69  | Stabilization revision     | 18                      | 15                     |
| 20          | M   | 61  | Lumbar discectomy          | 20                      | 14                     |
| 21          | M   | 54  | Lumbar discectomy          | 18                      | 9                      |
| 22          | M   | 63  | Epidural injection         | 16                      | 8                      |
| 23          | M   | 50  | Epidural injection         | 20                      | 10                     |
| 24          | M   | 70  | Lumbar decompression       | 22                      | 11                     |
| 25          | M   | 71  | Medication and/or physiotherapy | 14                  | 6                      |
| 26          | M   | 76  | Facet denervation          | 18                      | 8                      |
| 27          | F   | 63  | Stabilization and fusion   | 20                      | 12                     |
|   |   |   |   |
|---|---|---|---|
| 28 | F | 60 | Lumbar discectomy |
| 29 | F | 49 | Lumbar discectomy |
| 30 | M | 71 | Lumbar discectomy |
| 31 | F | 64 | Stabilization revision |
| 32 | F | 52 | Epidural injection |
| 33 | F | 50 | Lumbar discectomy |
| 34 | F | 61 | Stabilization revision |
| 35 | M | 45 | Lumbar discectomy |
| 36 | M | 32 | Epidural injection |
| 37 | F | 56 | Lumbar decompression |
| 38 | F | 42 | Stabilization revision |
| 39 | F | 66 | Medication and/or physiotherapy |
| 40 | M | 47 | Medication and/or physiotherapy |
| 41 | M | 60 | Stabilization and fusion |
| 42 | F | 57 | Stabilization revision |
| 43 | F | 62 | Stabilization revision |
| 44 | F | 52 | Stabilization revision |
| 45 | F | 59 | Stabilization revision |
| 46 | F | 59 | Epidural injection |
| 47 | F | 65 | Stabilization and fusion |
| 48 | F | 67 | Lumbar decompression |
| 49 | F | 75 | Medication and/or physiotherapy |
| 50 | F | 38 | Epidural injection |
| 51 | F | 62 | Lumbar decompression |
| 52 | F | 70 | Epidural injection |
| 53 | M | 79 | Medication and/or physiotherapy |
| 54 | M | 60 | Medication and/or physiotherapy |
| 55 | F | 71 | Lumbar decompression |
| 56 | F | 60 | Lumbar decompression |
| 57 | F | 50 | Lumbar discectomy |
| 58 | M | 42 | Stabilization and fusion |
| 59 | F | 73 | Stabilization revision |
| 60 | M | 60 | Stabilization revision |
| 61 | M | 36 | Epidural injection |
| 62 | M | 59 | Lumbar decompression |
| 63 | F | 53 | Epidural injection |

**TABLE 3:** This table shows the treatment options chosen after myelography.

In addition, RMQ results were added for each patient before and after treatment.

RMQ: Roland-Morris Low Back Pain and Disability Questionnaire.
When all treatment methods were taken into account, mean RMQ values before and after treatment were calculated as 18.76 and 10.56. We also calculated the rate of change after the treatments for each intervention. Accordingly, the rates of change were determined as 48.2% in percutaneous procedures, 46.7% in lumbar decompressions, 41.04% in lumbar discectomies, 39.39% in instrumented stabilizations, and 37.84% in stabilization revision surgery. Additionally, this change was 46.62% for patients who received only medication and physical therapy (Table 4 and Figure 3).

| Treatment modality                     | Pre-treatment RMQ | Post-Treatment RMQ | Proportional change (%) |
|----------------------------------------|-------------------|-------------------|-------------------------|
| Epidural injection or facet denervation| 18.47             | 9.60              | 48.02                   |
| Lumbar decompression                   | 19                | 10.2              | 46.32                   |
| Lumbar discectomy                      | 18.77             | 11.08             | 41.04                   |
| Stabilization and fusion                | 19.8              | 12                | 39.39                   |
| Stabilization revision                 | 19.17             | 11.92             | 37.84                   |
| Medication and/or physiotherapy        | 17.75             | 9                 | 46.62                   |

TABLE 4: Change rates in RMQ for each intervention after the treatment applied.
RMQ: Roland-Morris Low Back Pain and Disability Questionnaire.

FIGURE 3: X line: treatment modalities enumerated in Table 4. Y line: The proportional rates of change in the RMQ.
RMQ: Roland-Morris Low Back Pain and Disability Questionnaire.

The overall results were analyzed using paired samples T-test in Social Survey Processing environment (SSPE) statistical program. The P-value of the difference between the results was found to be lower than 0.001 (Table 5). This showed that the patients’ recovery rates after treatment were statistically significant.
### Statistical Comparison

|                  | Preoperative         | Postoperative        |
|------------------|----------------------|----------------------|
| RMQ average values | 18.76 2.02 (SD)      | 10.56 2.34 (SD)      |

**TABLE 5: Preoperative and postoperative average results of RMQ for 63 patients.**

RMQ: Roland-Morris Low Back Pain and Disability Questionnaire.

---

**Post-myelography complaints**

Headache was observed in three patients after myelography. No fever, nausea, and vomiting were detected in the patients who were followed up. The headache complaints of the patients gradually resolved within a maximum of four days.

**Discussion**

The most controversial points about the myelography imaging method can be listed as follows: (a) myelography is an invasive radiological examination; (b) there is a risk of complications from the use of contrast agents; (d) the patient is exposed to ionizing radiation; (c) it is an old and inadequate imaging method [1,2,23,24].

Patients who are decided to undergo lumbar myelography in our clinic can be classified as follows: (a) patients with radicular pain in lumbar MRI examinations but without significant pathology in MRI; (b) patients who have previously undergone surgery, have new complaints, and are in the process of decision for surgery indication; (c) MRI images due to spinal instrumentation in the lumbar region patients with intense artifacts; (d) patients whose MRI is not performed due to foreign bodies in their body.

Sasaki et al. state in their article that MRI is not sufficient in the diagnosis of dynamic changes in the dural sac and myelography should be considered in such cases [25].

In the discussion part of their study on imaging of roots in patients with lumbar radiculopathy, Lee et al. also emphasize that post-myelographic computed tomography can be a useful tool for diagnosis when the exact cause of radicular pain needs to be determined [26].

Kitya et al. reported similar results for selected treatment outcomes after myelography. According to what they state in their article, following surgery, 75.8% of patients who presented with extremity pain noted clinical improvement, 56.3% patients with extremity weakness noted improvement, and all patients presenting with numbness noted clinical improvement [27].

In addition, we evaluated the results of RMQ according to the different treatment methods we applied. We saw that the biggest change was in percutaneous treatment options (EI, FD) (48.02%). Besides, the RMQ score change rate was also quite high in non-surgical treatment options (46.62%). Selection of minimally invasive intervention techniques and non-surgical treatment methods as results of myelographic examinations showed high efficiency in the improvement of patient complaints. One of the results of our study is that myelography can help the surgeon turn to options other than major surgery to improve patient complaints.

Although the presented study appears to have an indirect link in terms of improvement after treatments, myelography has been the decisive diagnostic method for these patients at the decision-making stage. In this regard, since myelography is an effective factor in the choice of treatment in our opinion, the statistical link analysis between this imaging method and the treatment outcome is an accurate method of analysis.

**Limitation of the study**

This study does not include long-term results after treatments. This is because our primary goal is not to examine the effectiveness of treatments but to examine the contribution of myelographic examination to diagnosis. The point we want to discuss is whether lumbar myelography application, which is not widely used today, will contribute to diagnosis and treatment in selected cases.

**Conclusions**

In our opinion, due to other advanced examination techniques, myelography is not the first choice for diagnosis. However, it is still a very useful method in complicated and where many problems intertwined cases. As a matter of fact, the results of our study showed that lumbar myelography is an effective contribution to determining the treatment method and improving the quality of life of the patients.
Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. Ethics Committee of Bakırköy Prof. Dr. Mazhar Osman Training and Research Hospital for Psychiatric Neurological Diseases issued approval 04.07.2017/56. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Shah LM, Kranz PG, Anzai Y, et al.: Critical assessment of myelography practices: a call for rational guideline revision. AJNR Am J Neuroradiol. 2018, 39:2378-84. 10.1002/ajnr.25467
2. Pomerantz SA: Myelography: modern technique and indications. Handb Clin Neurol. 2016, 155:195-208. 10.1016/B978-0-444-53485-9.00010-6
3. Harrell JD, McMenamy JM, Toomay SM, Chason DP: Myelography: a primer. Curr Probl Diagn Radiol. 2011, 40:149-57. 10.1067/cpradiol.2010.06.005
4. Dewing SB: Modern Radiology in Historical Perspective. Charles CT (ed): Springfield, Illinois; 1962.
5. Hoefnner EG, Mukherji SK, Srinivasan A, Quiet DJ: Neuroradiology back to the future: head and neck imaging. AJNR Am J Neuroradiol. 2012, 33:2826-32. 10.3174/ajnr.A5565
6. Dandy WE: Rontgenography of the brain after the injection of air into the spinal canal. Ann Surg. 1919, 70:397-405. 10.1097/00000638-191901000-00004
7. Jacobaeus HC: On insufflation of air into the spinal canal for diagnostic purposes in cases of tumors of the spinal canal. Acta Med Scand. 1921, 55:555-64. 10.1111/j.1600-0463.1921.tb15225.x
8. Peterson HO: The hazards of myelography. Radiology. 1975, 115:237-9. 10.1148/115.1.237
9. Bonnemaison B: L’huile iodée (lipiodol) en radiologie. Les premières années d’expérience: 1921-1931. Revue d’Histoire de la Pharmacie. 2000, 328:495-508.
10. Bede P, Fineman E, Hardiman O: From pneumomyelography to cord tractography: historical perspectives on spinal imaging. Future Neurol. 2017, 12:121-4. 10.2217/fnl-2017-0018
11. Centeno RS, Sovak M, Hackney DB, Garfin SR: Brain changes on computed tomography following metrizamide myelography. Significance and therapeutic implications. Spine (Phila Pa 1976). 1986, 11:509-12. 10.1097/00000658-198607000-00001
12. Campbell RL, Campbell JA, Heimberger RF, Kalsbeck JE, Mealey J Jr: Ventriculography and myelography with absorbable radiopaque medium. Radiology, 1964, 82:286-9. 10.1148/82.2.286
13. Gonsette R: An experimental and clinical assessment of water-soluble contrast medium in neuroradiology a new medium: Dimer X. Clin Radiol. 1971, 22:44-56. 10.1016/s0009-9260(71)80009-0
14. Skalpe IO, Amundsen P: Lumbar radiculography with metrizamide. A nonionic water-soluble contrast medium. Radiology, 1975, 115:91-5. 10.1148/115.1.91
15. Eldevik OP, Natstad P, Kendall BE, Hindmarsh T: Iohexol in lumbar myelography; preliminary results of an open, noncomparative multicenter study. AJNR Am J Neuroradiol. 1985, 4:299-301.
16. Witwer G, Cataycorin ED, Bernstein AD, Hubballah MY, Yuan HA, Kieffer SA: Iopamidol and metrizamide for myelography: prospective double-blind clinical trial. AJR Am J Roentgenol. 1984, 145:869-73. 10.2214/ajr.145.4.869
17. Aftschuler EM, Segal R: Generalized seizures following myelography with iohexol. J Spinal Disord. 1990, 3:59-61.
18. Stevens JM: Imaging of the spinal cord. J Neurol Neurosurg Psychiatry. 1995, 58:403-16. 10.1136/jnnp.58.4.403
19. Simon JH, Ekholm SE, Kido DK, Utz R, Erickson J: High-dose iohexol myelography. Radiology. 1987, 163:455-9. 10.1148/radiology.163.2.5628286
20. Burrows EH: Myelography with iohexol (Omnipaque): review of 300 cases. AJR May/June. 1985, 6:349-51.
21. Roland M, Morris R: A study of the natural history of back pain. Part I: development of a reliable and sensitive measure of disability in low-back pain. Spine (Phila Pa 1976). 1983, 8:141-4. 10.1097/00000662-198305000-00004
22. Stratford PW, Binkley J, Solomon P, Finch E, Gill C, Moreland J: Defining the minimum level of detectable change for the Roland-Morris questionnaire. Phys Ther. 1996, 76:359-65; discussion 366-8. 10.1093/ptj/76.4.359
23. Sather MD, Gibson MD, Treves JS: Spinal subarachnoid hematoma resulting from lumbar myelography. AJNR Am J Neuroradiol. 2007, 28:220-1.
24. Sandow BA, Donnal JF: Myelography complications and current practice patterns. AJR Am J Roentgenol. 2005, 185:768-71. 10.2214/ajr.185.3.1850768
25. Sasaki K, Hasegawa K, Shimoda H, Keiji I, Homma T: Can recumbent magnetic resonance imaging replace myelography or computed tomography myelography for detecting lumbar spinal stenosis?. Eur J Orthop Surg Traumatol. 2013, 23 Suppl 1:S77-83. 10.1007/s00590-013-1299-y
26. Park CK, Lee HI, Ryu KS: Comparison of root images between post-myelographic computed tomography and magnetic resonance imaging in patients with lumbar radiculopathy. J Korean Neurosurg Soc. 2017, 60:540-9. 10.3340/jkns.2016.0809.008
27. Kitya D, Punchak M, Bajuniwe F: Role of conventional myelography in diagnosis and treatment of degenerative spine disease in low-income communities: prospective study. World Neurosurg. 2017, 104:161-
6. 10.1016/j.wneu.2017.04.121