Needle-Guided Suture Technique for Lumbar Annular Fiber Closure in Microendoscopic Discectomy: A Technical Note and Case Series

Kefeng Luo*
Kaiwen Cai*
Guoqiang Jiang
Bin Lu
Bing Yue
Jiye Lu
Kai Zhang

* Kefeng Luo and Kaiwen Cai contributed to the work equally to the first author

**Corresponding Author:**
Guoqiang Jiang, e-mail: jiangguoqiang@nbu.edu.cn

**Source of support:**
Departmental sources

**Background:**
Annular fiber closure techniques have been proven effective in reducing short-term recurrence after discectomy. However, annular fiber closure devices are expensive and still fail at a low rate. We present a novel suture method, needle-guided annular closure suture (NGACS) that does not require a special device and can be performed for annular fiber closure following microendoscopic discectomy.

**Material/Methods:**
Twenty-five patients who underwent treatment with NGACS were reviewed by analysis of the medical records. The clinical outcomes were assessed and compared preoperatively and immediately, 1, 6, and 12 months postoperatively. The parameters included the Visual Analog Scale (VAS)-back and VAS-leg scores and the Oswestry Disability Index (ODI). Midsagittal T2WI images were obtained to evaluate lumbar disc degeneration using the Pfirrmann grade. Additional adverse events were also recorded and tracked.

**Results:**
The VAS-back and VAS-leg scores and the ODI were significantly different at each follow-up time point \( (P<0.001) \), and improvements in pain and disability were maintained well during the follow-up period. Lumbar disc reherniation or other serious adverse events were not observed in this series. There was no significant difference between the initial and final Pfirrmann grades \((Z=-1.414, \ P=0.157)\). The preoperative average disc height was \(9.94\pm1.97\ \text{mm} \), and the disc height at 12 months after surgery was \(9.14\pm1.88\ \text{mm} \). The average decrease in disc height was \(8.11\pm3.36\%\).

**Conclusions:**
This study demonstrates the feasibility and superior clinical outcomes of the NGACS technique. This method can be a good substitution when annular fiber closure devices are not available. Moreover, this technique can be easily popularized due to its low cost and few restrictions.

**MeSH Keywords:**
Diskectomy • Endoscopes • Suture Techniques • Wound Closure Techniques

**Full-text PDF:**
https://www.medscimonit.com/abstract/index/idArt/918619
Background

The microendoscopic discectomy (MED) technique for the treatment of lumbar disc herniation was first reported by Foley and Smith [1]. An increasing number of studies have shown that it can achieve satisfactory clinical outcomes [2–4]. However, the recurrence rate after MED is occasionally reported to be higher than that after conventional discectomy, at 1.6% to 10.8% for the former [3–6] and 1% to 15% for the latter [7–10]. A number of studies have indicated that annular fiber (AF) defects might be an important risk factor for potential reherniation [11–13]. Therefore, the AF closure technique has been widely accepted and emphasized by most orthopedists. This procedure can restore the mechanical integrity of the AF and significantly increase the failure strength of the disc [14,15]. Moreover, it can significantly delay the process of disc degeneration after surgery [14,16].

To achieve AF closure in a narrow incision space, special instrumentation is usually needed. Currently, there are various annular fiber closure devices (ACDs) for intraoperative AF repair, such as the Barricaid® (Intrinsic Therapeutics, Inc., Woburn, MA, USA) [16–19] and Xclose® Tissue Repair System (Anulex Technologies, Minnetonka, MN, USA) [20]. All of these devices have shown superior clinical outcomes in reducing the short-term reherniation rate. However, the ACDs aforementioned are implantable devices that require preparation of the implantation environment. In some cases, when the environment does not meet the requirements, these ACDs are not suitable. Furthermore, ACDs still have a small probability of failure, such as invalid implantation [19], bone resorption/loosening [21,22], infection [16,21], and instrumentation fracture. Thus, revision surgery is necessary for these conditions. The high price of ACDs can also be an additional financial burden for patients without insurance coverage. Therefore, it is urgent to find an alternative to ACDs for AF closure when ACDs fail or are unavailable.

Here, we present a novel technique called needle-guided annular closure suture (NGACS), which can be performed in a narrow incision space using common surgical instruments in the operating room. We also established a case series to show the clinical outcomes.

Material and Methods

This study received approval from the Institutional Review Board of The Affiliated Hospital of Medical School of Ningbo University.

Patient enrollment

This was a retrospective study of medical records between January 2016 and January 2017. The inclusion criteria included the following: 1) patients with progressive neurological deficit symptoms confirmed by imaging; 2) patients with intractable lower back pain (meaning that the symptoms could not be relieved by 12 weeks of conservative treatment); 3) patients who underwent MED surgery with AF repair; and 4) a follow-up period of at least 1 year. The exclusion criteria included the following: 1) patients with severe AF ossification; 2) use of any other ACDs; 3) patients with pedicle screw fixation or spinal fusion.

Surgical technique and NGACS management

All operations were performed by the same surgical team. Patients were placed in a prone position under general anesthesia. After a 20 mm paramedian incision was made and correct placement of the 22 G location needle was confirmed, the guide wire was inserted. The initial dilator was inserted through the guide wire, and then the wire was removed. Sequential dilators were inserted until the tubular retractor could be placed. Fluoroscopy was used to reconfirm the trajectory of the tubular retractor, and it was docked. To separate the soft tissue and expose the lamina, laminotomy, and flavectomy were performed routinely using a high-speed drill and laminectomy rongeur. The nerve root and dural sac were identified and separated carefully, then, the nerve root was retracted gently using a retractor to expose the herniated disc. Annulotomy was performed in a linear or cruciate manner (easy for suturing), and the nucleus pulposus was removed using grasping forceps.

After discectomy, we started the procedures for NGACS, as follows: 1) we prepared 2 long 22 G needles (0.7×180 mm) for suture line guiding and 2 long 4-0 suture lines (Coated, Braided Silk, Jiangsu, China) for each suture process. 2) Each suture line passes through the guide wire, and then the wire was removed. 2 ends of each line were exposed. This process could be easily accomplished with the help of vacuum suction. The key point was that the suture line needed to be kept wet; otherwise, the excessive friction between the suture line and needle inhibited the suture line from passing through the needle. 3) We inserted the line needle into one edge of the AF incision to embed one end of the suture line into the disc. Then, we clamped this end outside of the incision using grasping forceps. Although this procedure might be time consuming, it is much easier to find the line by following the tip of the needle. 4) This procedure was repeated at the other edge of the AF incision. 5) Now, 2 ends of each line are available through the AF incision. The inner ends of both lines are knotted together; then, the outer ends of both lines are pulled outward to embed the inner knot.
into the disc. Attention should be paid to avoid high temperature and cutting effects caused by drawing the suture line too fast. 6) The outer ends of both lines are knotted together using a knot pusher, ensuring that there is some strain in the knot to obtain a better closure effect. 7) Steps 1–6 are all the procedures of a single suture operation, which can be repeated if necessary (Figure 1).

**Data collection**

We collected the demographic data, clinical data, and radiological data preoperatively and immediately, 1, 6, and 12 months postoperatively. The clinical outcome parameters included the Visual Analog Scale (VAS) score [23] of the low back (VAS-back), the VAS score of the lower limbs (VAS-leg), and the Oswestry Disability Index (ODI) [24]. Magnetic resonance imaging (MRI) data for each patient were collected preoperatively and 12 months postoperatively and evaluated independently by a radiologist. Radiological data were acquired from midsagittal T2WI images, including the degree of disc degeneration (using the Pfirrmann grading system [25]) and the average disc height (ADH). The ADH was defined as the mean value of the anterior disc height, posterior disc height and central disc height (Figure 2). All adverse events, such as reherniation, infection, and neural lesions, were also documented.

**Statistical analysis**

SPSS version 22.0 (IBM Co., Armonk, NY, USA) was used for statistical analysis. Repeated measures ANOVA and the least significant difference (LSD)-t test were used for comparing measurement data with a normal distribution. The Wilcoxon
matched-pairs signed-rank test was used for comparing ranked data. Significance was defined as a \( P \)-value <0.05.

**Results**

**Patient characteristics**

There were 11 female patients and 14 male patients enrolled in this study. All patients were diagnosed with single-level lumbar disc herniation and treated by MED with the NGACS technique. The follow-up period was at least 1 year. The mean age was 45.6 ± 10.9 years, and the mean body mass index (BMI) was 23.1±2.6 kg/m\(^2\). The discs involved in this study were L3–L4 (1 case), L4–L5 (13 cases), and L5–S1 (11 cases). The disc degeneration degree, lumbar disc herniation type and AF incision shape are described in Table 1.

**Clinical outcomes**

The average VAS-back and VAS-leg scores preoperatively and immediately, 1 month, 6 months, and 12 months postoperatively were 4.56±1.26, 3.04±0.94, 1.88±0.73, 1.72±0.94, and 1.32±0.56, respectively. The difference in the VAS-back score over the entire period was statistically significant (F=51.778, \( P \)<0.001), corresponding to the difference in the VAS-leg score (F=427.027, \( P \)<0.001). The ODI preoperatively and 1 month, 6 months, and 12 months postoperatively was 61.33±6.32%, 22.49±5.22%, 17.96±3.26%, and 15.20±3.83%, respectively. The overall difference was significant (F=617.584, \( P \)<0.001), and significant differences were also found between each follow-up time point (\( P \)<0.05) (Figure 3). Improvements in pain and disability were maintained well during the follow-up period.

| No. | Sex   | Age | BMI  | LDH level | Pfirrmann grading | LDH type | AF incision shape |
|-----|-------|-----|------|-----------|-------------------|----------|-------------------|
| 1   | Female | 52  | 24.7 | L4–L5     | IV                | Extrusion| Linear            |
| 2   | Male   | 37  | 22.2 | L4–L5     | III               | Protrusion| Cruciate          |
| 3   | Female | 40  | 22.8 | L5–S1     | III               | Protrusion| Cruciate          |
| 4   | Female | 63  | 25   | L4–L5     | IV                | Extrusion| Linear            |
| 5   | Male   | 46  | 24.2 | L5–S1     | III               | Protrusion| Cruciate          |
| 6   | Male   | 28  | 24.6 | L5–S1     | III               | Protrusion| Cruciate          |
| 7   | Male   | 51  | 20.1 | L5–S1     | III               | Protrusion| Box defect        |
| 8   | Female | 55  | 22.4 | L4–L5     | IV                | Extrusion| Linear            |
| 9   | Female | 52  | 25.6 | L5–S1     | III               | Protrusion| Linear            |
| 10  | Female | 46  | 22.2 | L5–S1     | III               | Extrusion| Cruciate          |
| 11  | Male   | 42  | 25.7 | L4–L5     | IV                | Extrusion| Linear            |
| 12  | Male   | 49  | 19.9 | L4–L5     | IV                | Protrusion| Box defect        |
| 13  | Female | 36  | 21.5 | L4–L5     | III               | Protrusion| Linear            |
| 14  | Male   | 36  | 20.4 | L4–L5     | III               | Protrusion| Linear            |
| 15  | Male   | 45  | 27.2 | L5–S1     | III               | Extrusion| Linear            |
| 16  | Male   | 38  | 26.7 | L5–S1     | III               | Protrusion| Cruciate          |
| 17  | Female | 56  | 25.1 | L3–L4     | III               | Protrusion| Linear            |
| 18  | Male   | 63  | 20.7 | L5–S1     | V                 | Extrusion| Box defect        |
| 19  | Female | 60  | 19.3 | L4–L5     | IV                | Protrusion| Cruciate          |
| 20  | Female | 44  | 21.1 | L5–S1     | III               | Extrusion| Cruciate          |
| 21  | Male   | 31  | 20   | L4–L5     | III               | Protrusion| Cruciate          |
| 22  | Female | 58  | 26.5 | L4–L5     | IV                | Extrusion| Linear            |
| 23  | Male   | 26  | 19.4 | L4–L5     | III               | Protrusion| Cruciate          |
| 24  | Male   | 55  | 23.4 | L5–S1     | IV                | Extrusion| Linear            |
| 25  | Male   | 45  | 26.3 | L4–L5     | III               | Protrusion| Cruciate          |

BMI – body mass index; LDH – lumbar disc herniation; AF – annular fiber.
Figure 3. The Visual Analog Scale (VAS)-back, VAS-leg score and Oswestry Disability Index (ODI) in each period.

Table 2. Radiological Outcomes (Pfirrmann Grading and ADH).

| No. | Pfirrmann grading | Preoperative | 12 months | Average disc height | Height decrease (%) |
|-----|-------------------|--------------|-----------|---------------------|---------------------|
|     |                   | Preop        | 1 month   | 6 months            | 12 months           |
| 1   | IV                | 8.41         | 11.47     | 7.92                | 9.01                |
| 2   | III               | 11.25        | 10.66     | 10.44               | 5.21                |
| 3   | III               | 8.17         | 10.10     | 7.46                | 8.69                |
| 4   | IV                | 11.73        |           | 10.76               | 8.24                |
| 5   | III               | 11.12        |           | 9.25                | 16.76               |
| 6   | IV                | 8.37         |           | 7.68                | 8.28                |
| 7   | III               | 10.15        |           | 9.70                | 4.46                |
| 8   | IV                | 9.70         |           | 9.09                | 6.26                |
| 9   | III               | 8.67         |           | 8.22                | 5.15                |
| 10  | IV                | 6.38         |           | 5.95                | 6.79                |
| 11  | III               | 9.81         |           | 9.07                | 7.57                |
| 12  | III               | 11.13        |           | 9.97                | 10.04               |
| 13  | III               | 11.74        |           | 10.42               | 11.16               |
| 14  | III               | 12.60        |           | 11.72               | 7.04                |
| 15  | III               | 10.37        |           | 9.50                | 8.36                |
| 16  | IV                | 11.31        |           | 9.07                | 17.30               |
| 17  | III               | 8.13         |           | 7.53                | 7.42                |
| 18  | V                 | 4.62         |           | 3.82                | 17.30               |
| 19  | IV                | 8.13         |           | 7.53                | 7.42                |
| 20  | III               | 10.79        |           | 9.78                | 9.36                |
| 21  | III               | 12.46        |           | 12.06               | 3.21                |
| 22  | IV                | 8.14         |           | 7.32                | 10.07               |
| 23  | III               | 11.25        |           | 10.69               | 4.98                |
| 24  | IV                | 9.55         |           | 8.77                | 8.17                |
| 25  | III               | 12.47        |           | 11.40               | 8.58                |
Radiological outcomes

The Pfirrmann grade and the ADH at each time point are presented in Table 2. The signed-rank test showed no significant difference between the initial and final grade ($Z=-1.414, P=0.157$). The preoperative ADH was 9.94±1.97 mm, and the ADH at 12 months postoperatively was 9.14±1.88 mm, resulting in a decrease in ADH of 8.11±3.36%.

Adverse events

During the entire follow-up period, we confirmed that no cases of reherniation occurred at the surgical segment based on the judgment of symptoms and MRI findings. In addition, no cases of surgical infection were observed. The only adverse event was one case of hyperesthesia of the lower limb on the affected side, while myodynamia remained normal. This may have been caused by traction of the nerve root during the operation. This patient’s symptoms were relieved during the 6th week after neurotrophic treatment and rest.

Discussion

Adequate evidence indicates that AF closure after discectomy can improve clinical outcomes. The major advantages of AF closure are improved postoperative symptoms, early postoperative rehabilitation and a reduced short-term recurrence rate [16–20].

Currently, several kinds of AF closure methods that do not require ACDs have been reported, each of which has its own indications and limitations. Suh et al. [26] reported a method for AF closure using 2 sewn threads and an anchor fixed to cortical bone. This technique requires an AF incision close to the vertebral body and produces high longitudinal tension in the suture area. Li et al. [27] reported the application of a kind of pistol-shaped, disposable fibrous ring stitching instrument. This device allows automatic puncture and easy knotting, but it also has high requirements for incision shape; incisions over 3 mm in width cannot be processed by this device. Compared with the limitations of existing methods, the NGACS method we suggest in this study allows the suturing of AF incisions unrestricted by shape. The contraindications to NGACS are severe AF ossification and a complete defect in the incisal edge.

In our study, MED combined with the NGACS technique showed good maintenance of symptomatic improvement, and no short-term reherniation cases were observed. For the majority of cases in our study, in which a linear or cruciate AF incision was used, the NGACS technique achieved sealed closure of the AFs and prevented the nucleus pulposus from extruding through the breach. For those cases with an AF defect, NGACS may not be able to completely close the AFs, but it can reduce the cross-sectional area of the AF defect. More importantly, repeated suturing can form a net barrier for the nucleus pulposus. Examination of the case data revealed that in the 2 box-defect cases in our study, the patients had severe ADH loss. This type of patient is prone to having wide basal AF folds at the posterior aspect of the disc; thus, thorough decompression tends to remove more AFs. We suggest that AFs should be resected to a limited extent on the premise of ensuring the decompression effect in such patients. Although there was no recurrence in either of the 2 box-defect cases, we suggest that this kind of AF incision should be avoided as much as possible. Studies have shown that the box-defect incision is associated with a higher recurrence rate [28], and even after repair, the strength will be only 40–50% of that resulting from a linear or cruciate incision during the early healing process [29].

For the prevention of disc degeneration, NGACS also showed good maintenance of the disc signal on imaging and the ADH. The preoperative and 12-month Pfirrmann grades were similar, and maintenance of the disc height was superior to the results of previous studies, in which discectomy was performed without AF repair [28,30,31]. Regarding surgical complications, the only case of hyperesthesia may have been associated with severe nerve root compression and traction. There was no evidence that NGACS increases the likelihood of other complications in our limited case study. Suturing under endoscopy can be visualized and controlled well to ensure the lowest risk of nerve injury.

There are still some limitations to this study. This was a retrospective non-controlled study, and the conclusions might be biased. The sample size of this study was small, and the follow-up period was short. To verify the reliability of the NGACS technique, further biomechanical studies and large sample-size case-control studies are needed.

NGACS also has some shortcomings. Compared with the use of the automatic disposable suture device, the NGACS procedure is more cumbersome. A well-trained surgeon usually needs to spend an extra 10 to 15 minutes for suturing. Moreover, there are 2 knots in each NGACS suture, which makes it theoretically more probabilistic for the knots to loosen. As a complement, when NGACS is contraindicated or fails, other AF suture technique or an ACD can still be considered. Therefore, we believe that the NGACS technique is an ideal and widely adaptable suture method that can complement the existing AF closure technology as a low-cost alternative when ACDs or disposable suture devices are not available or have failed.
Conclusions

This present study demonstrates the feasibility and superior outcomes of a method for AF closure that does not require a special device. We suggest that the NGACS technique can serve as a back-up or low-cost alternative technique for AF closure.

Acknowledgements

The authors thank Guoqiang Jiang, MD for his creativity in this suture technology and policy support during the whole research process.

References:

1. Foley KT, Smith MM: Microendoscopic discectomy. Techniques in Neurosurgery Vol 3, No 4, Lippincott-Raven Publishers: Philadelphia, 1997; 301–7
2. Wu X, Zhuang S, Mao Z, Chen H: Microendoscopic discectomy for lumbar disc herniation: Surgical technique and outcome in 873 consecutive cases. Spine, 2006; 31(23): 2689–94
3. Kulkarni A, Bassi A, Dhruv A: Microendoscopic lumbar discectomy: Technique and results of 188 cases. Indian J Orthop, 2014; 48(1): 81–87
4. Casal-Moro R, Castro-Menéndez M, Hernández-Blanco M et al: Long-term outcome after microendoscopic discectomy for lumbar disk herniation: A prospective clinical study with a 5-year follow-up. Neurosurgery, 2011; 68(6): 1568–75
5. Matsumoto M, Watanabe K, Hosogane N et al: Recurrence of lumbar disc herniation after microendoscopic discectomy. J Neurol Surg A Cent Eur Neurosurg, 2013; 74(06): 222–27
6. Teli M, Lovi A, Brayda-Bruno M et al: Higher risk of dural tears and recurrent herniation with lumbar micro-endoscopic discectomy. Eur Spine J, 2010; 19(3): 443–50
7. Yorimitsu E, Chiba K, Toyama Y, Hirabayashi K: Long-term outcomes of standard discectomy for lumbar disc herniation: A follow-up study of more than 10 years. Spine, 2001; 26(6): 652–57
8. Kim MS, Park KW, Hwang C et al: Recurrence rate of lumbar disc herniation after open discectomy in active young men. Spine, 2009; 34(1): 24–29
9. Migói M, Garcezmambossi G, Datou G et al: Recurrent disc herniation and long-term back pain after primary lumbar disc herniation: Review of outcomes reported for limited or aggressive disc removal. Neurosurgery, 2009; 64(2): 338–44; discussion 344–45
10. Hakkinen A, Kiviranta I, Neva MH et al: Reoperations after first lumbar disc herniation surgery: A special interest on residues during a 5-year follow-up. BMC Musculoskelet Disord, 2007; 8: 2
11. Aizawa T, Ozawa H, Kusakabe T et al: Reoperation for recurrent lumbar disc herniation: A study over a 20-year period in a Japanese population. J Orthop Sci, 2012; 17(2): 107–13
12. Berjano P, Pejrona M, Damlano M: Microdiscectomy for recurrent L5–S1 disc herniation. Eur Spine J, 2013; 22(12): 2915–17
13. Lebow RL, Adogwa O, Parker SL et al: Same-level recurrent disc herniation after microdiscectomy: Results of a prospective cohort study with 2-year serial imaging. Spine J, 2010; 10(9): 565
14. Chiang CI, Cheng CK, Sun IS et al: The effect of a new anular repair after discectomy in intervertebral disc degeneration: An experimental study using a porcine spine model. Spine, 2011; 36(10): 761–69
15. Yang CH, Chiang YF, Chen CH et al: The effect of annular repair on the failure strength of the porcine lumbar disc after needle puncture and punch injury. Eur Spine J, 2016; 25(3): 906–12
16. Parker SL, Grahovac G, Vukas D et al: Effect of an annular closure device (barricaid) on same-level recurrent disc herniation and disk height loss after primary lumbar discectomy: Two-year results of a multicenter prospective cohort study. Clin Spine Surg, 2016; 29(10): 454–60
17. Vukas D, Ledić D, Grahovac G et al: Clinical outcomes in patients after lumbar disk surgery with annular reinforcement device: Two-year follow up. Acta Clinica Croatica, 2013; 52(1): 87–91
18. Klassen PD, Bernstein DT, Köhler HP et al: Bone-anchored annular closure following lumbar discectomy reduces risk of complications and reoperations within 90 days of discharge. J Pain Res, 2017; 10: 2739–40
19. Bouma GI, Barth M, Ledić D, Vilendecic M: The high-risk discectomy patient: Prevention of re herniation in patients with large annular defects using an annular closure device. Eur Spine J, 2013; 22(5): 1030–36
20. Bailey A, Araghi A, Blumenthal S, Huffman GV: Anular repair clinical study group: prospective, multicenter, randomized, controlled study of anular repair in lumbar discectomy: Two-year follow-up. Spine 2013; 38(14): 1161–69
21. Lange N, Meyer B, Shibani E: Symptomatic annulus-repair-device loosening due to a low-grade infection. Acta Neurochir (Wien), 2018; 160(1): 199–203
22. Krufo AV, Daykov EV, Sadovo MA: Reoperation after microdiscectomy of lumbar herniation: case report. Int J Surg Case Rep, 2016; 24: 119–23
23. Atkin RC: Measurement of feelings using visual analogue scales. Proc R Soc Med, 1969; 62(10): 989–93
24. Fairbank J: The Oswestry low back pain disability questionnaire. Physiotherapy, 1980; 66(8): 271–73
25. Pfirrmann CW, Metzdorf A, Zanetti M et al: Magnetic resonance classification of lumbar intervertebral disc degeneration. Spine, 2001; 26(17): 1873–78
26. Suh BG, Uh JH, Park SH, Lee GW: Repair using conventional implant for ruptured annulus fibrosus after lumbar discectomy: Surgical technique and case series. Asian Spine J, 2013; 9(1): 14–21
27. Li C, Ma Y M, Li Z H et al: [Comparison of results between fenestration discectomy and standard discectomy]. J Spinal Disord Tech, 2015; 28(6): 338–44; discussion 344–45
28. Rosendahl K, Mathiesen J, Blix P et al: Annular repair device for recurrent lumbar herniation: A prospective cohort study. Acta Spine, 2016; 29(10): 1161–69
29. Krufo AV, Daykov EV, Sadovo MA: Reoperation after microdiscectomy of lumbar herniation: case report. Int J Surg Case Rep, 2016; 24: 119–23
30. Barth M, Weiss C, Thomé C: Two-year outcome after lumbar microdiscectomy associated with annulus repair and fenestration discectomy for lumbar disc herniation: Surgical technique and outcome in 873 consecutive cases. Acta Spine, 2015; 44(5): 428–34