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Research Article

Therapeutic effects of full endoscopic spine surgery via transforaminal approach in elderly patients with lumbar spinal stenosis: A retrospective clinical study

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ABSTRACT

Objective: This study aimed to investigate the therapeutic effects of full endoscopic spine surgery on clinical and radiological outcomes in elderly patients over 70 years with lumbar spinal stenosis, without any obvious segmental instability.

Methods: A total of 47 patients (27 males, 20 females; the mean age=74.23±5.16) above 70 years who underwent a transforaminal percutaneous endoscopic decompression with the diagnosis of lumbar spinal stenosis, were included in this retrospective study. The mean follow-up was 26±2.97 months. The clinical efficacy of the surgical procedure was assessed by the Oswestry disability index (ODI) and the visual analog scale (VAS) of the leg and lower back at 1 week, 3 months, and 1 year postoperatively, and at the final follow-up examination. Modified MacNab criteria was also performed to assess the clinical efficiency of surgery at the final follow-up.

Results: An excellent outcome as per modified MacNab criteria was obtained in 9 patients (19.1%), a good outcome in 33 patients (70.2%), a fair outcome in 3 patients (6.4%), and poor results in 2 patients (4.3%). The mean ODI score significantly improved from 71.29±5.69 preoperatively to 32.05±10.71 at postoperative 1 week, 30.27±9.89 at 3 months, 27.23±8.47 at 1 year, and 23.11±9.97 at the final follow-up ($p<0.05$ for each evaluation point). The mean VAS score of the leg and lower back significantly decreased from 6.10±0.96 and 5.71±1.13 preoperatively to 1.69±0.96, 2.24±1.01 at postoperative 1 week, 1.69±0.84, 2.45±0.87 at 3 months, 1.71±0.81, 2.38±0.79 at 1 year, and 1.71±0.92, 2.48±0.67 at the final follow-up, respectively ($p<0.05$ for each evaluation term). Postoperative computed tomography or magnetic resonance imaging showed adequate decompression of the central or lateral recess and removal of combined herniated discs.

Conclusion: The results of our preliminary study have demonstrated that full endoscopic spine surgery is a safe and efficient technique for the therapy of neurogenic claudication and radiculopathy in elderly patients with lumbar spinal stenosis.

Level of Evidence: Level IV, Therapeutic Study

Introduction

Degenerative lumbar spinal disease has become an increasingly frequent spinal ailment in the elderly, often leading to neurogenic claudication and radiculopathy (1). When symptomatic patients do not respond to conservative treatments, including medication, injections, and physical therapy, surgical treatment is then indicated. Regarding surgery on elderly patients, multiple comorbidities should initially be considered, as they may affect the efficacy of the spinal surgery (2). Owing to physical disability and comorbid disease, surgical intervention becomes a challenging task (3).

Numerous studies have been documented presenting the advantages of percutaneous endoscopic lumbar discectomy (PELD) for lumbar disc herniation (4, 5). On the contrary, lumbar spinal stenosis (LSS) was once considered as a contraindication for this method (6). For the past few years, the spectrum of indications has remarkably broadened to include degenerative lumbar stenosis, benefiting from technical evolution, including operative approaches, optics design and surgical apparatus (7).

Although percutaneous endoscopic spinal surgery utilization for decompression of lateral recess stenosis has received considerable attention in the literature (8, 9), few studies have focused on surgery of LSS in elderly patients. We undertook this retrospective study of patients over 70 years of age, who presented with radicular, paindominant, degenerative lumbar stenosis (DLS), without any obvious segmental instability. Surgical interventions were performed on the patients in the form of percutaneous endoscopic spine surgery. The therapeutic and radiological follow-up, as well as their quality of living, were assessed in order to determine the role of endoscopic spine surgery in elderly patients.

Materials and Methods

From June 2016 to January 2018, a total of 51 patients above 70 years old, diagnosed with LSS, were collected for this retrospective analysis. Institutional review approval was obtained from the committee of medical ethics of the hospital (No. 2020-01). Imaging procedures, including X-ray, computed tomography (CT), and magnetic resonance imaging (MRI) were performed on all patients to confirm the diagnosis and to preclude other pathologies.

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The clinical efficacy was documented to assess the therapeutic effect by using the Oswestry disability index (ODI) and the visual analog scale (VAS) of the leg and lower back at 1 week, 3 months, and 1 year post surgery, as well as at a final follow-up (over 2 years) visit. Modified MacNab criteria were also applied in order to evaluate the clinical efficiency of the surgery according to the last follow-up visit. All procedures were performed by two associate chief physicians, each of whom has performed over above 300 PELD operations.

The inclusion criteria consisted of the following: (i) intermittent neurologic claudication or radiculopathy; (ii) LSS without instability as demonstrated on imaging; (iii) failure of regular conservative treatment >3 months; and (iv) elderly patients (≥70 years old) with potential hazards for general anesthesia due to severe comorbidities, including coronary heart disease, hypertension, diabetes mellitus, and/or respiratory dysfunction.

The exclusion criteria included: (i) lumbar spine pathologic conditions, including trauma, tumor, or infection; (ii) ossification of the posterior longitudinal ligament; and (iii) prior history of lumbar surgery.

Surgical procedure

Transforaminal percutaneous endoscopic decompression (PED)

The patient was placed in the prone position, then basal anesthesia along with local anesthesia were administered. An entry point was determined by the intersection of the horizontal line and the oblique caudal directional line tangent with the tip of the superior articular process (SAP). The approximate distance from the midline to entry point was 6 to 8 cm for L3/4 or L4/5, and 8 to 12 cm for L5/S1. A spinal needle was used in the piercing process, and the puncture trajectory was slightly toward the SAP rather than the intervertebral foramen, in order to avoid potential iatrogenic injury to the ventral dural sac. Under monitored anesthesia care, 10 mL of 0.5% lidocaine was applied along the puncture trajectory and the anterior aspect of the SAP. After the stylet of the spinal needle was replaced by a guide wire, the needle cannula was removed. A stab skin incision of approximately 7 mm in length was made, focused on the guide wire. Along with the guide wire, multilevel blunt guide rods were inserted step by step. Then, the inner guide rod was replaced by a Kirschner wire, 1.5 mm in diameter, which was anchored onto the SAP (Figure 1a). The protective cannula was introduced along the outer guide rod and pressed against the ventral surface of the SAP. Then, the guide rods were retrieved, and a trephine was inserted into the cannula to perform the foraminoplasty. Under fluoroscopic guidance, the trephine was pressed downward, nearly horizontally and cranially to remove more bone fragments of the ventral aspect of the SAP (Figure 1b). If the foraminoplasty could not fully achieve decompression, the above steps were repeated, beginning with the puncture of the Kirschner wire (Figure 1. c, d). Next, the working cannula and endoscope were inserted into the incision (Figure 2. a-c). Following removal of the disk protrusion, ventral facet of the SAP, and ligamentum flavum, the traversing nerve root and dural sac were exposed with adequate mobility and good pulse, indicating complete decompression. It was necessary to eliminate residua along the entire traversing nerve root up to the lateral recess. Annuloplasty was performed to prevent relapse of the herniation.

Statistical analysis

All data were analyzed with the Statistical Package for Social Sciences 11.0 software (SPSS Inc., Chicago, IL, USA). Significant difference was accepted at $p<0.05$. Normality of the data was tested by the Shapiro-Wilk test. Parametric data were presented as mean±standard deviation. Non-parametric data were expressed as medians (range). Categorical variables were presented as frequencies (%). Comparison of parametric data was analyzed by a paired t-test.

Results

Demographic characteristics and outcomes

The patient demographic characteristics are summarized in Table 1. Fifty-one patients with LSS underwent surgery, and we achieved a mean follow-up of 26 months for 47 of these patients. Reasons for losing follow-up included loss of contact with 3 patients and natural death of 1 patient. Follow-up data were summarized from the 47 cases. A total of 27 males and 20 females were included in this study. Their mean age was 74.23±5.16 years. The body mass index in the cohort was 22.29 (21.13–28.04). The incidence of comorbidities was as follows: hypertension (21, 44.7%); diabetes mellitus (11, 23.4%); coronary artery disease (5, 10.6%); respiratory diseases (3, 6.6%); lung cancer or mastocarcinoma (2, 4.3%); and renal disease (4, 8.5%). A total of 47 patients underwent lumbar decompression via a transforaminal approach. A total of 52 spinal levels were treated, with 3 patients at the L3/4 (5.7%) level, 29 at L4/5 (55.8 %), and 20 at L5/S1 (38.5%). A total of 5 patients received surgery at two levels, whereas the others underwent surgery at only a single level. All surgical procedures were performed successfully; the mean operative time was 61.15±33.04 minutes for a single level.

Clinical outcomes

Modified MacNab criteria were implemented for the therapeutic

Table 1. Patients demographic characteristics (n=47)

Characteristics	Value
Age (years, mean±SD)	74.23±5.16
Gender (female)	20(42.6%)
Levels (n=52)	
L3/4	3 (5.7%)
L4/5	29 (55.8 %)
L5/S1	20 (38.5%)
Incidence of comorbidities	
Hypertension	21, (44.7%)
Diabetes mellitus	11 (23.4%)
Coronary artery disease	5 (10.6%)
Respiratory diseases	3 (6.6%)
Renal disease	4 (8.5%)
Lung cancer or mastocarcinoma	2 (4.3%)
follow up (months)	26.00±2.97
Body mass index (kg/m²)	22.29 (21.13 28.04)

Normally distributed variables are presented as the means±SD; non-normal continuous variables are presented as the medians (range); categorical variables are presented as frequencies (%)

HIGHLIGHTS

- Analysis of the therapeutic efficiency of full endoscopic spine surgery in patients over the age of 70 years with segmental LSS.
- In the research, the double or multiple foraminoplasties technology, guided by Kirschner wire, has been proven safe and effective in surgery of lateral stenosis.
- Optimal enlargement of the lateral recess is an essential step for successful surgery.
- In terms of determining the proper segment for multilevel DLS with similar clinical manifestations, it is necessary to use selective nerve root block to confirm the causal location.

Table 2. Comparisons of clinical data at each follow-up time point

Score	Preoperative	1 week Postoperative	3 Months postoperative	1 year postoperative	final follow up
VAS of low back pain	5.71±1.13	2.24±1.01*	2.45±0.87*	2.38±0.79*	2.48±0.67*
VAS of sciatica	6.10±0.96	1.69±0.96*	1.69±0.84*	1.71±0.81*	1.71±0.92*
ODI	71.29±5.69	32.05±10.71*	30.27±9.89*	27.23±8.47*	23.11±9.97*

Values were presented as mean±standard deviation
*Paired t-test. p<0.05, statistically significant differences

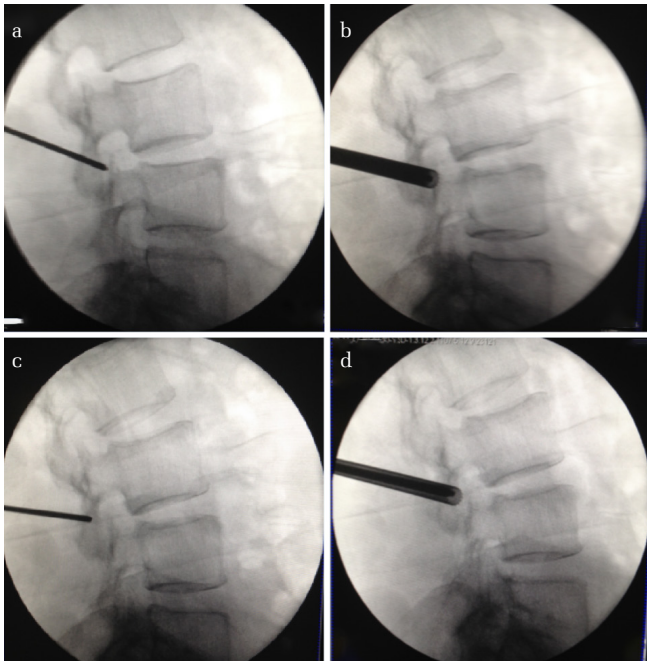

Figure 1. a-d. a. Lateral X-ray showing placement of a Kirschner wire during the first foraminoplasty. The tip of the Kirschner wire is fixed on the joint space of facet joints, the middle part of the SAP in the lateral fluoroscopic view. b. Lateral X-ray showing insertion of a trephine to complete first foraminoplasty. c. Lateral X-ray showing placement of a Kirschner wire during the second foraminoplasty. The tip of the Kirschner wire is shifted backward toward the inferior articular process of upper segment. d. Lateral X-ray showing insertion of a trephine in the second foraminoplasty, in order to decompress the dorsal nerve root

assessment in the present study. An excellent outcome on modified MacNab criteria was obtained for 9 patients (19.1%), a good outcome for 33 patients (70.2%), a fair outcome for 3 patients (6.4%), and poor results for 2 patients (4.3%). Of the 2 patients with poor results, 1 converted to opendecompression revision surgery after 3 weeks of observation, and the other refused further treatment.

The mean preoperative ODI score was 71.29±5.69, and the VAS scores of the leg and lower back were 6.10±0.96 and 5.71±1.13, respectively. Improved outcomes were documented by patients postoperatively (32.05±10.71, 1.69±0.96, 2.24±1.01 at 1 week; 30.27±9.89, 1.69±0.84, 2.45±0.87 at 3 months; 27.23±8.47, 1.71±0.81, 2.38±0.79 at 1 year; and 23.11±9.97, 1.71±0.92, 2.48±0.67 at the final follow-up (Table 2). Significant improvement in the ODI and VAS scores for the leg or lower back was noted at 1 week, 3 months, 1 year, and at the final follow-up (Figure 3-5).

Radiological outcomes

Postoperative CT or MRI images demonstrated adequate decompression of the central canal or lateral recess, and the removal of combined herniated discs in patients undergoing these endoscopic procedures (Figure 6).

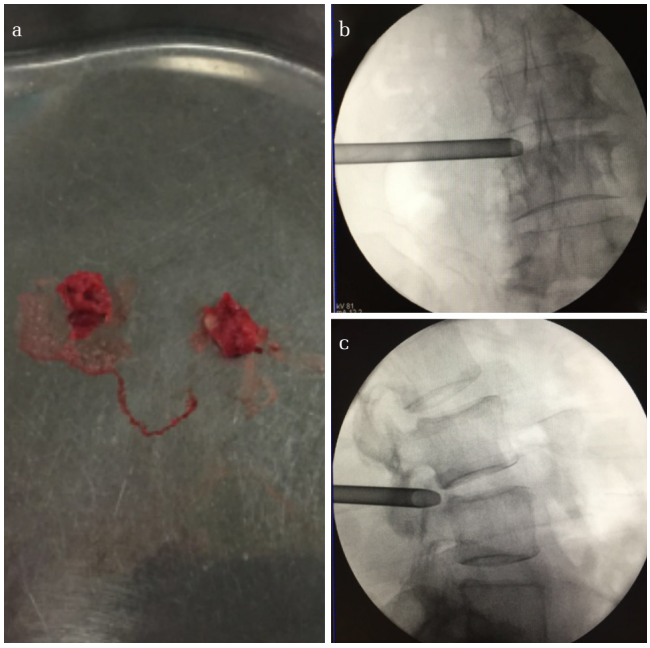

Figure 2. a-c. a. The two segments of bone are removed by two foraminoplasty procedures. b. Posterior-anterior (AP) X-ray, showing placement of the working sheath (transforaminal approach). c. Lateral X-ray showing placement of the working sheath (transforaminal approach). The bevel of the working sheath is located in the intraspinal canals completely in the lateral fluoroscopic view

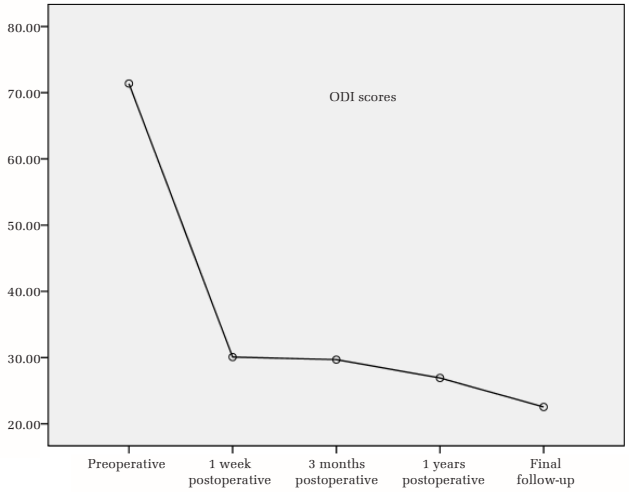

Figure 3. Graphs showing changes in the Oswestry disability index before operation and at each time point postoperation

Complications and recurrence

No dysfunctional nerve root injury, dural tear, intestinal injury, iatrogenic segmental instability, or intervertebral disc infection was detected in any patient.

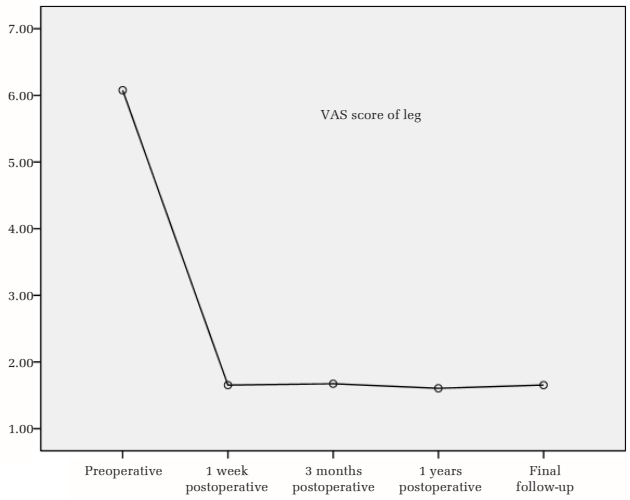

Figure 4. Graphs showing changes in the visual analog scale of leg before operation and at each time point postoperation

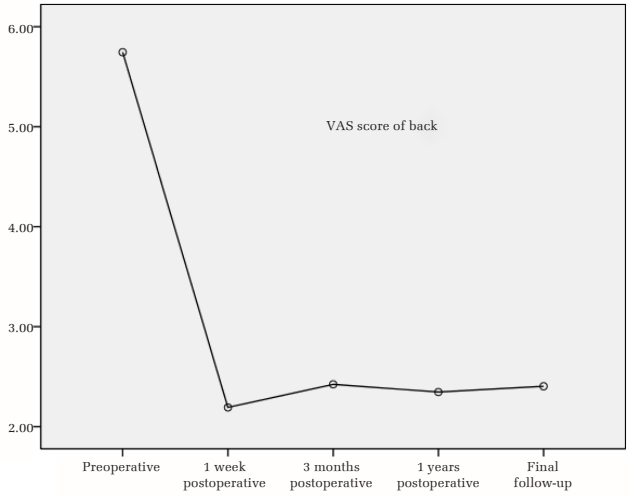

Figure 5. Graphs showing changes in the visual analog scale of back before operation and at each time point postoperation

Discussion

LSS is classified into two anatomical categories: central stenosis and lateral stenosis (10). Over the past decade, although spinal surgery has experienced rapid developments, surgery for LSS on the elderly, especially those over 70 years of age, remains a daunting issue. As the age of the patient increases, so do the accompanying comorbidities (11, 12). In this study, the incidence of accompanying comorbidities could be as high as 80%, which provides a challenge for the administration of general anesthesia, and may lead to serious consequences. All 47 patients received transforaminal PED surgery. The risk of these consequences may be mitigated through the use of local anesthesia and mild sedation, rather than general anesthesia.

Concerns involving perioperative complications can also be reduced by the technological progress made regarding minimally invasive spinal surgery (13). In this series, we expanded the surgical indications for PED to include virtually all varieties of LSS. For the elder patients, it was important to preserve their posterior elements as much as possible, allowing more functional daily activities, while avoiding

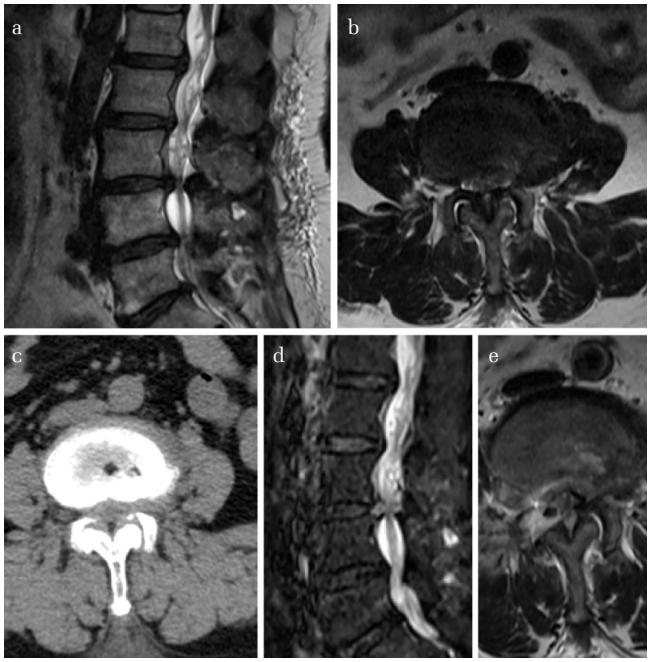

Figure 6. a-e. a. Sagittal T2 magnetic resonance imaging showing lateral recess stenosis of L3-S1 due to ligamentum flavum hypertrophy and disk degeneration. b. Axial T2 magnetic resonance imaging showing lateral foraminal stenosis and nerve compression prior to surgery, at the L3/4 segment (transforaminal approach). There is high intensity fluid in both hypertrophied facet joints indicative of joint inflammation. c. Scans showing severe lateral foraminal stenosis caused by hypertrophy of facet and disk degeneration. d. Postoperative sagittal T2-weighted MRI demonstrating the absence of the hypertrophied ligamentum flavum and herniated disc, as compared with the preoperative MRI view. The diameter of the intraspinal canal has been clearly widened (transforaminal approach). e. Postoperative axial MRI results indicating complete decompression of the right lateral recess and an enlarged spinal canal volume (transforaminal approach)

relevant fusion complications. We did not find any absolute surgical contraindications to PED in DLS, with the obvious exception of spondylolisthesis. The functional activity assessment, such as the VAS of legs/back or ODI, demonstrated remarkable and persistent results at the follow-up 2 years post surgery.

The techniques for endoscopic spinal surgery vary, based on the disease pathology, approach, operative level, skill degree of the surgeon and the characteristics of the endoscopic instruments (14). Up until now, the following types of endoscopic decompression methods have been fully studied and well utilized in the process of development: percutaneous endoscopic lumbar discectomy (PELD), PED for lumbar stenosis, and percutaneous endoscopic cervical discectomy.

Hypertrophy of the SAP was considered the main typical pathology in LSS, which could lead to compression of the traversing nerve root and the exiting nerve root (14). The double or multiple foraminoplasty technology, guided by Kirschner wires, which we performed in our patient cohort, has been proven safe and effective in the surgical treatment of lateral stenosis without the need for additional equipment. If the results of the first foraminoplasty was not satisfactory, the Kirschner wire could be easily shifted to another position and direction, in order to perform a second or even further foraminoplasties, until optimal enlargement of the lateral recess has been achieved.

In terms of determining the proper segment for multilevel DLS with similar clinical manifestations, we tend to use selective nerve root

block to confirm the causal location. The level was positively identified when a local anesthetic nerve root block provided at least 50% pain alleviation as the reference standard (15, 16). Although evidence for the accuracy of selective nerve root injections is limited as a diagnostic procedure for multilevel DLS, it may still remain a feasible technique until such time as a more optimal method is developed.

There were some limitations to our study. First, the research was not a randomized controlled trial, and the overall number of patients in this study is not adequate, which could lead to bias. Further randomized controlled trials with larger cohorts are required in order to confirm the findings. Second, the two surgeons who performed all of the operations may have differing skill levels, and limitations in generalization might still exist. Third, the disease severity and type of DLS were not taken into account, and a long-term follow-up study is necessary to identify the curative effect.

In conclusion, providing long-term perfect treatments for degenerative lumbar spinal disease is a frustrating task, especially patients over 70 years of age. The results of our preliminary study demonstrate that full endoscopic spinal surgery is a safe and efficient technique for the treatment of neurogenic claudication and radiculopathy in elderly patients with LSS involved with DLS. The imaging data demonstrated that the transforaminal approach had positive effects on spinal canal decompression as well as symptom alleviation. For appropriate indication, selection, and successful endoscopic decompression, the surgeon should memorize the technical characteristics as compared with demographical and radiological conditions of each patient.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of 923nd Hospital of People's Liberation Army (No.2020-01).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Author Contributions: Concept - G.Y., B.H.; Design - G.Y.; Supervision - B.H.; Materials - C.W.; Data Collection and/or Processing - C.W., S-q.L.; Analysis and/or Interpretation - G.Y., B.H.; Literature Review - G.Y.; Writing - G.Y.; Critical Review - G.Y., B.H.

Conflict of Interest: The authors have no conflicts of interest to declare.

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