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Original Research

Significance of preoperative planning software for puncture and channel establishment in percutaneous endoscopic lumbar DISCECTOMY: A study of 40 cases

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HIGHLIGHTS

- Surgical planning software is effective for puncture and channel establishment in PELD.
- PELD was applied in treating 40 cases of LDH and achieved satisfactory results.
- The fluoroscopic times, channel establishing and operative time reduce notably after planning.

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ABSTRACT

Background: Preoperative planning software has been widely used in many other minimally invasive surgeries, but there is a lack of information describing the clinical benefits of existing software applied in percutaneous endoscopic lumbar discectomy (PELD). This study aimed to compare the clinical efficacy of preoperative planning software in puncture and channel establishment of PELD with routine methods in treating lumbar disc herniation (LDH).

Material and methods: From June 2016 to October 2016, 40 patients who had single L4/5 or L5/S1 disc herniation were divided into two groups. Group A adopted planning software for preoperative puncture simulation while Group B took routine cases discussion for making puncture plans. The channel establishment time, operative time, fluoroscopic times and complications were compared between the two groups. The surgical efficacy was evaluated according to the Visual Analogue Scale (VAS), Oswestry Disability Index (ODI) and modified Macnab's criteria.

Results: The mean channel establishment time was 25.1 ± 4.2 min and 34.6 ± 5.4 min in Group A and B, respectively ($P < 0.05$). The mean operative time was 80.8 ± 8.4 min and 92.1 ± 7.3 min in Group A and B, respectively ($P < 0.05$). The fluoroscopic times were 21.5 ± 5.2 in Group A and 29.3 ± 5.5 in Group B ($P < 0.05$). There were no significant differences in VAS and ODI scorings between the two groups either preoperatively or postoperatively ($P > 0.05$). The findings of modified Macnab's criteria at each follow-up also showed no significant differences ($P > 0.05$).

Conclusion: The application of preoperative planning software in puncture and cannula insertion planning in PELD was easy and reliable, and could reduce the channel establishment time, operative time and fluoroscopic times of PELD significantly.

1. Introduction

In order to respect as much as possible the anatomy of lumbar spine and further improve the clinical efficacy, many percutaneous endoscopic procedures were introduced in lumbar discetomy surgeries [1]. As a new surgical technique, percutaneous endoscopic

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lumbar discectomy (PELD) was utilized for the decompression of lumbar disc space and the removal of herniated disc on the basis of fluoroscopy localization and visible operation under a microscope [2]. Endoscopic techniques took developments from the Yeung endoscopic spine system [3] to transforaminal endoscopic spine system (TESSYS) [4] and the interlaminar approach [5] in the past decade or so. Compared with the open microdiscectomy technique, PELD has many advantages such as preserved spinal stability, spared tissue, lower blood loss, fewer complications, as well as faster rehabilitation and earlier return to daily activities [2,5–7]. Despite its versatility, problems such as puncture accuracy, cannula insertion and radiation exposure are still tricky and remain to be resolved.

Establishing an appropriate working channel is the prerequisite procedure for the success of PELD. Routine puncture and location procedures rely heavily on repeated fluoroscopy, which may increase the risk of tissue injury and postoperative complications of patients [8]. Radiation exposure caused by fluoroscopy has placed spinal surgeons at risk of radiation-induced complications and serious diseases [9,10].

Novel techniques and devices were introduced to improve puncture and cannula insertion accuracy such as the "floating retraction" technique [11], trajectory-assisted locators [12] and XMR-assisted suite [13]. However, these designs were either cumbersome, time-consuming or expensive. Therefore, we adopted a software for easy preoperative puncture and cannula insertion planning based on computed tomography (CT) and three-dimensional reconstruction.

2. Material and methods

2.1. General information

This study was approved by the Ethical Committee of Shanghai East Hospital. Informed consents were obtained from patients before the study began. The study has been also reported in line with the SCARE and the PROCESS criteria [14,15]. From June 2nd 2016 to October 20th 2016, 40 patients who underwent PELD by the same senior surgeon (LJL)were included in this study. The basic information of patients was listed in Table 1. The inclusion criteria were as follows: (1) patients age >18 years old; (2) single L4/L5 or L5/S1 lumbar disc herniation (LDH) with a failure of formal conservative therapy and confirmed by CT and/or MRI examination. The exclusion criteria were as follows: (1) other segments or multilevel LDHs; (2) highly free herniated disc; (3) lumbar spondylolisthesis, instability, or malformation; (4) other severe mental and physical diseases, active infection and pregnancy. The included patients were divided into two groups, those with odd numbers were assigned to the experimental group (Group A) and those with odd numbers were assigned to the control group (Group B).

2.2. Simulative puncture and channel establishment

The preoperative lumbar CT scan of patients in Group A was performed using a 64-detector spiral CT scanner (SOMATOM Definition Flash; Siemens Medical Solutions Inc., Forchheim, Germany). The parameters of scanning were: tube current = 250 mA, tube voltage = 120 kV, scanning slice thickness = 1.0 mm, and reconstruction slice thickness = 1.0 mm. Then the CT data (DICOM format) were transferred into the Boholo software (Fengsuan Inc., Shanghai, China). This software enables the surgeon to navigate the virtual cannula into a proper position in the three-dimensional space based on the CT data. On the multi-planar reformation mode, the herniated disc fragment was specified and the compressed nerve root was marked by adjusting control lines on coronal, sagittal and axial planes (Fig. 1A). The virtual cannula is available in diameters ranging from 1 to 10.0 mm in 1 mm increment. On the simulation mode, the virtual cannula was adjusted to a satisfactory position while avoiding the marked nerve root (Fig. 1B). After the insertion, the whole procedure of puncture and insertion from skin to the targeted foramen were replanned. During this procedure, focal tissues and abdominal viscera around the cannula were carefully observed under multiple windows. The parameters including the depth of puncture approach, the distance of incision to the median line, puncture angle values in dorsal, lateral and axial view and the minimal distance to the compressed nerve root were displayed in real time (Fig. 1C). Observational virtual x-ray and body-surface reconstructed modes were available for mimicking surgery scenes and further confirming the position of virtual cannula (Fig. 2). After the simulation, the results were exported as preoperative data for each case (Table 2). To reduce operator error, each case was planned for three times and the mean value was adopted.

2.3. Surgical procedure and efficacy evaluation

The operation was performed using the TESSYS technique under local anesthesia [1]. For patients in Group A, the operation was performed with the patient lying on a prone position and parallel to the long axis of a radiolucent table. The entrance point was determined with a metal rod based on the preoperative planned data (Fig. 3). After the channel was established, the subsequent procedures were the same as it was done in the conventional method. For patients in Group B, the puncture of guiding wire and the

Table 1
General information of patients in two groups.

	Group A(n = 20)	Group B(n = 20)	*P* value
Age	41.6 ± 10.4	43.3 ± 12.2	0.638
Gender (male/female)	14/6	12/8	0.507
BMI	23.4 ± 6.5	24.1 ± 5.4	0.713
Types of herniated disc (central/lateral/foraminal)	5/10/5	4/12/6	*
Operative level			0.736
L4/L5	13	14	NA
L5/S1	7	6	NA
Channel establishing time	25.1 ± 4.2 (min)	34.6 ± 5.4 (min)	<0.001
Operative time	80.8 ± 8.4 (min)	92.1 ± 7.3 (min)	<0.001
Fluoroscopic times	21.5 ± 5.2	29.3 ± 5.5	<0.001
Complications			
postoperative dysesthesia	1	0	NA
residual disc fragments	0	1	NA
neuropathic pain	0	1	NA

**P* value of all three types > 0.05; BMI: body mass index; NA: not applicable.