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The Trans-Superior Articular Process Approach Utilizing Visual Trephine: A More Time-Saving and Effective Percutaneous Endoscopic Transforaminal Lumbar Discectomy for Migrated Lumbar Disc Herniation

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ABSTRACT

AIM: To introduce, and to evaluate the efficacy of the trans-superior articular process (trans-SAP) approach utilizing visual trephine in percutaneous endoscopic transforaminal lumbar discectomy (PETLD) for migrated lumbar disc herniation.

MATERIAL and METHODS: This study included 98 patients, 50 patients were in trans-SAP PETLD group and 48 patients were in conventional PETLD group. Visual analogue scale (VAS), Oswestry disability index (ODI), gender, age, blood loss, operation time, the frequency of X-ray fluoroscopy and the percentage of highly migrated herniation were evaluated and compared between the trans-SAP PETLD and conventional PETLD group.

RESULTS: In both trans-SAP PETLD and conventional PETLD group, VAS and ODI were decreased at postoperative 1 day and 3 months compared with preoperative ($p<0.001$). What's more, the VAS and ODI of postoperative 3 months were lower than postoperative 1 day ($p<0.001$). There was no difference in gender, age, blood loss after the operation, and VAS during operation between trans-SAP group and conventional group ($p>0.05$). The blood loss during the operation of trans-SAP group was higher ($p<0.05$), but the operation time and frequency of X-ray fluoroscopy were lower than conventional group ($p<0.001$). Last, trans-SAP group had a higher percentage of highly migrated herniation ($p<0.001$).

CONCLUSION: Both the conventional way and trans-SAP approach can achieve excellent surgical results. But, in trans-SAP group, the operation time is shorter, and X-ray fluoroscopy is less. PETLD with visual trephine has more advantages in highly migrated herniation and maybe easier to be mastered by young surgeons.

KEYWORDS: Percutaneous endoscopic transforaminal lumbar discectomy, Trans-superior articular process, Visual trephine, Migrated lumbar disc herniation

ABBREVIATIONS: PETLD: Percutaneous endoscopic transforaminal lumbar discectomy, **trans-SAP:** Trans-superior articular process, **VAS:** Visual analog scale, **ODI:** Oswestry Disability Index

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INTRODUCTION

Percutaneous endoscopic transforaminal lumbar discectomy (PETLD) has undergone significant development since it was introduced in 1987 (9). Compared with traditional open surgery, PETLD has the advantages of minimally invasive, visual decompression, and faster recovery. It has been widely used in the clinical treatment of lumbar spine diseases (7,17,22). But, conventional PETLD still has its weakness, such as the increase of the radiation exposure time for location. And the small operation channel is difficult to fully take out migrated lumbar disc herniation and decompress the dura mate and nerve roots that lead to the postoperative dissatisfaction (1,13). If the degree of migration is greater than the height of the posterior marginal disc space at the T2-weighted sagittal magnetic resonance image (MRI), it is described as highly migrated degree, according to the classification proposed by Lee et al. (10,14). And, PETLD is considered to be not suitable for the treatment of distant migrated lumbar disc herniation (15). Then, we describe the trans-superior articular process (SAP) approach that utilizes visual trephine in PETLD for migrated lumbar disc herniation. And, for the question whether the trans-superior articular process (trans-SAP) with visual trephine has more advantages compared with conventional PETLD? Controlled trials have been barely reported.

MATERIAL and METHODS

Participants

Patients with migrated lumbar disc herniation who received trans-SAP PETLD from September 2018 to October 2019 and conventional PETLD from June 2017 to August 2018 were reviewed retrospectively in this study. The criteria for inclusion are as follows: 1) Unilateral lower limb radiating pain, numbness, or other symptoms caused by single nerve root compression; 2) The symptoms should be consistent with preoperative imaging and migrated lumbar disc herniation should be confirmed by magnetic resonance imaging (MRI); 3) Symptoms were not significantly relieved after 8 weeks of conventional conservative treatment. The exclusion criteria are as follows: 1) Lumbar spinal infection, tumor, spinal deformity; 2) Lumbar responsibility segment instability; 3) Incomplete date or uncooperative rehabilitation exercise. The criteria were based on clinical experience and refer to Wang et al. (21).

Trans-SAP PETLD Group Surgical Procedure and A Case Report.

A 70 years old patient suffered from low back pain accompanied by right lower limb pain for 2 years and worsened for 2 days. As shown in Figure A-D, the prominent nucleus pulposus of L4/5 highly migrated downward, and located behind the L5 vertebral body and inside the L5 left pedicle. The patient was placed on the radiolucent operating table, with continuous and slow intravenous injection of dexmedetomidine through a micropump. The skin markings of the pedicle were marked by X-ray fluoroscopy. The distance between the left and right pedicle was defined as 1L, and the puncture point was chosen away from the spinous process 2L (about 8-12 cm), as shown in Figure E. For patients with a high iliac crest or L5/S1 level, the insertion point should be moderately upward sloped. The skin and subcutaneous tissues of the puncture site were used for local anesthesia with 0.75% lidocaine. 18G needle was used for puncturing, and anesthetics was injected into the deep tissues while puncturing. The puncture needle was removed, a transverse incision about 1cm in length was made at the puncture point, and subcutaneous and fascial layers of the skin were cut. Then, a blunt guide rod 3 mm in diameter was inserted. Last, the guide rod was performed on SAP's outer edge, as shown in Figure F, G. Visual trephine was placed in and adjusted to attach SAP. Trans-SAP approach is a novel approach that utilizes a safe surgical corridor via SAP to access lateral recess pathology (6). Under endoscopic monitoring, the visual trephine was slowly and forcefully rotated clockwise to perform foraminoplasty. The ventral SAP was excised by visual trephine, as shown in Figure H, and the free bones were cleaned. The yellow ligament was removed with microscopic pulposus rongeur, and the walking root of the nerve was exposed. The nucleus pulposus forceps was extended to the L5 vertebral body back, as is shown in Figure I, J, and the herniated disc was thoroughly excised. After hemostasis by radiofrequency coagulation, the nerve root would be seen throbbing free. Finally, the drainage tube was placed in the wound. The tubular retractor was removed, and the wound was closed in layers. A visual trephine and removed nucleus pulposus tissue are shown in Figure K, L. The foraminoplasty of this patient is shown in Figure M, N, and the red arrow signs the bone tunnel that is shaped by visual trephine. The postoperative MR after trans-SAP PETLD is shown in Figure O, P. Some edema signs are still shown in postoperative MR, but they are totally absorbed at postoperative 3 months in Figure Q, R. The migrated lumbar disc herniation was removed thoroughly, and the pain of this patient was completely relieved.

Postoperative Management

Neurotrophic drugs and antiedematous drugs were given routinely after the operation. 4-6 hours after the operation, the patient can exercise straight leg elevation on the bed and get out of the bed with the help of a brace. The drainage tube was removed within 12~24 hours after the operation.

Outcome Measurement

1) Demographic data included gender, and age; 2) Clinical data included blood loss during and after the operation, operation time, fluoroscopy frequency and complications, visual analogue scale (VAS) of the lower back pain and lower extremities radicular pain before and after surgery, Oswestry disability index (ODI) of functional status before and after surgery.

Statistical Analysis

ANOVA was applied to analyze VAS, ODI, age, blood loss, operation time, and the frequency of X-ray fluoroscopy. And a chi-square test was performed to determine gender. All data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 22 (IBM, USA). When p value is less than 0.05, the results are considered to be significant.

RESULTS

This study included 98 patients, with 50 patients in trans-SAP PETLD group and 48 patients in conventional PETLD. All patients were followed-up at least 12 months after the operation. No patients had blood vessel or nerve injury and no reoperation was performed during the follow-up period.

The VAS of trans-SAP group was 7.62 (± 0.85), 2.08 (± 0.67), and 1.24 (± 0.52) at preoperative, postoperative 1 day, and 3 months. And, the VAS of conventional group was 7.10 (± 1.06), 2.56 (± 0.87) and 1.46 (± 0.54) at preoperative, postoperative 1 day and 3 months. The ODI of the trans-SAP group were 74.44 (± 5.83), 21.84 (± 7.09), and 18.80 (± 5.47) at preoperative, postoperative 1 day and 3 months. And the ODI of conventional group was 75.00 (± 7.16), 23.75 (± 6.38), and 15.83 (± 5.68) at preoperative, postoperative 1 day, and 3 months. In both trans-SAP and conventional groups, the VAS of pain and ODI of functional status decreased at postoperative 1 day and 3 months compared to preoperative ($p<0.001$, Table I). What's more, the VAS and ODI of postoperative 3 months were lower than the postoperative 1 day ($p<0.001$, Table I).

The male gender was 52.00% (26/50) in trans-SAP group and 62.50% (30/48) in conventional group. The mean age was 51.56 (± 14.97) years old in trans-SAP group and 57.83 (± 17.53) years old in conventional group. During operation and after operation, blood loss was 50.20 ± 6.85ml and 45.72 ± 20.32 ml in trans-SAP group. The blood loss during operation and after the operation was 42.50 ± 11.85 ml and 46.85 ± 17.67 ml in conventional group. There was no difference in gender, age, and the blood loss after operation between the trans-SAP and the conventional group ($p>0.05$, Table II). But, the blood loss during the operation of trans-SAP group (50.20 ± 6.85 ml) was higher than conventional group (42.50 ± 11.85 ml) ($p<0.05$, Table II). The VAS during operation made no difference between trans-SAP (7.66 ± 0.96) and conventional group (7.40 ± 0.98) ($p>0.05$, Table II). But the operation time of trans-SAP group (63.20 ± 11.28 minutes) was lower than conventional group (78.44 ± 18.25 minutes) ($p<0.001$, Table II). Similarly, the frequency of X-ray fluoroscopy of trans-SAP group (4.10 ± 1.28) was less than that of conventional group (7.04 ± 1.41) ($p<0.001$, Table II). Last, trans-SAP group (58.00%, 29/50, had a higher percentage of highly migrated herniation than conventional group (22.92%,11/48, ($p<0.001$, Table II).

DISCUSSION

PETLD has become the primary method to solve their pain due to less invasiveness and faster recovery (7,17). But it

Table I: The VAS and ODI of Trans-SAP and Conventional PETLD Group at Preoperative, Postoperative 1st Day and 3rd Months

		Preoperative	Postoperative 1st day	postoperative 3rd months	p
VAS	Trans-SAP group	7.62 (± 0.85)	2.08 (± 0.67)	1.24 (± 0.52)	**<0.001**
	Conventional group	7.10 (± 1.06)	2.56 (± 0.87)	1.46 (± 0.54)	**<0.001**
ODI	Trans-SAP group	74.44 (± 5.83)	21.84 (± 7.09)	18.80 (± 5.47)	**<0.001**
	Conventional group	75.00 (± 7.16)	23.75 (± 6.38)	15.83 (± 5.68)	**<0.001**

VAS: *Visual analogue scale;* ***ODI:*** *Oswestry disability index.;* ***trans-SAP:*** *trans-superior articular process;* ***PETLD:*** *percutaneous endoscopic transforaminal lumbar discectomy.*
The VAS and ODI were significantly different at preoperative, postoperative 1st day and 3rd months.

Table II: The Data Compared Between Trans-SAP and Conventional PETLD Group

	Trans-SAP group	Conventional group	p
Gender (male)	52.00% (26/50)	62.50% (30/48)	>0.05
Age (years)	51.56 (± 14.97)	57.83 (± 17.53)	>0.05
Operative blood loss (ml)	50.20 (± 6.85)	42.50 (± 11.85)	**<0.001**
Blood loss after operation (ml)	45.72 (± 20.32)	46.85 (± 17.67)	>0.05
VAS during operation	7.66 (± 0.96)	7.40 (± 0.98)	>0.05
Operation time (minutes)	63.20 (± 11.28)	78.44 (± 18.25)	**<0.001**
Frequency of X-ray fluoroscopy	4.10 (± 1.28)	7.04 (± 1.41)	**<0.001**
Highly migrated disc herniation	58.00% (29/50)	22.92% (11/48)	**<0.001**

VAS: *Visual analogue scale;* ***trans-SAP:*** *trans-superior articular process;* ***PETLD:*** *percutaneous endoscopic transforaminal lumbar discectomy.*
There were no difference in gender, age, blood loss after the operation.
There were significant differences in blood loss during operation, operation time, frequency of X-ray fluoroscopy, and highly migrated disc herniation.

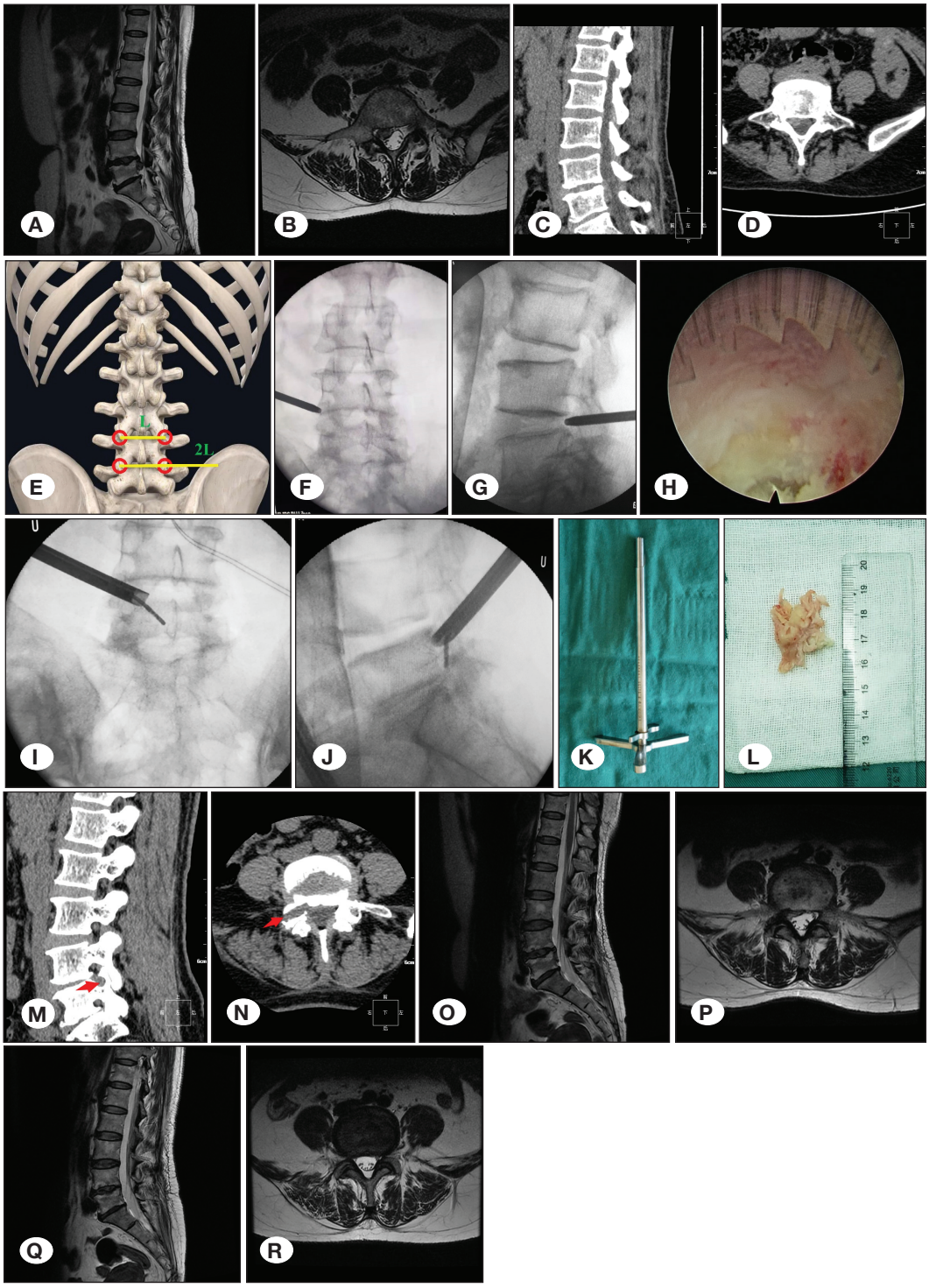

Figure: A, B) The preoperative lumbar magnetic resonance imaging (MRI) of the patient, the herniation was described as highly migrated because the extent of the migration was larger than the measured height of the posterior marginal disc space. **C, D)** The preoperative lumbar CT (C: sagittal, D: axial) of this patient. **E)** The mode pattern of lumbar and the distance between the left and right pedicle was defined as 1L. The puncture point was chosen away from spinous process 2L. **F, G)** The guide rod was performed on the outer edge of superior articular process. **H)** The ventral superior articular process was excised by visual trephine. **I, J)** Nucleus pulposus forceps was extended to L5 vertebral body back. **K)** Visual trephine in cannula. **L)** The removed nucleus pulposus tissue. **M, N)** The superior articular process was formed. And the bone tunnel shaped by visual trephine was signed by the red arrow. **O, P)** The postoperative lumbar MR of this patient, some edema signs were still shown in it. **Q, R)** The postoperative 3 months lumbar MR of this patient, the edema signs were totally absorbed.

is sometimes hard for Asians to use the endoscope access because of their relatively smaller intervertebral foramen (4). And it is also relatively difficult to adopt this approach for migrated lumbar disc herniation especially in patients with the wider transverse process or high iliac crest (5,19). Then, it has become another development direction of PETLD, including how to improve the safety and satisfaction, reduce the radiation exposure of doctors and patients during surgery, simplify the operation steps and shorten the operation time as much as possible. Therefore, the foraminoplasty and visualized percutaneous endoscopic lumbar discectomy have been widely emphasized among some surgeons (12,18). So, we demonstrated the trans-SAP approach utilizing visual trephine, and compared the healing effects between trans-SAP way and conventional PETLD way.

In this study, we found that patients in both trans-SAP and conventional PETLD groups obtain excellent surgical treatment and follow-up effects (Table I). Then, the data are compared between trans-SAP group and conventional group. Although the intraoperative blood loss of trans-SAP group is more than that of conventional group, the blood loss after operation makes no differences between the two groups (Table II). What's more, the small amount of blood loss of endoscopic surgery does not affect human body (20). The VAS score during the operation of the two groups is not different (Table II). Moreover, the pain can be tolerated with local anesthesia and intravenous injection of dexmedetomidine.

The results showed that the operation time is shorter, and the frequency of X-ray fluoroscopy of trans-SAP group is less than that of conventional group (Table II). In trans-SAP group, after the successful puncture, the process of foraminoplasty is conducted under the monitoring of spinal endoscopy. A lack of repeated fluoroscopy by X-ray significantly reduces the number of intraoperative radiation exposure for doctors and patients. We can identify the tip and root of SAP under the endoscope during the procedure of visual foraminoplasty. The bevel of the cannula was made close to the ventral facet of the SAP, and the foraminoplasty is formed almost by once. The operation procedure is simplified, the operation time is shortened, and the efficiency of foraminoplasty is improved. Therefore, visual foraminoplasty trans-SAP approach is more effective and timesaving. And the shaped SAP doesn't lead to secondary low back pain because of accurate foraminoplasty without the destruction of the articular process's stability. For some patients with high grade inferiorly migrated lumbar disc herniation, these conditions may be contraindicant for conventional PETLD, especially in patients with high iliac crest (2,14). But, the trans-SAP approach utilizing visual trephine should have more advantages and it could relieve their diseases easily instead of traditional open surgery (11,16). So, trans-SAP group has a higher percentage of highly migrated herniation.

In our trans-SAP approach, the puncture point is about 8-12 cm away from the spinous process, which is depended on the operational level. It's shorter than standard TESSYS technology, and it's easier to touch the ventral herniated disc with less bone destruction than conventional PETLD based on TESSYS technology (3). Even though the learning curve of conventional PETLD is still steep (8,23), the procedure of trans-SAP approach is more straightforward for young surgeons. Because, a blunt guide rod is adjusted to attach SAP, which has the sensation of the rod colliding with the lateral slope of the articular process.

This study still has several shortcomings. Firstly, the number of patients enrolled in this study was relatively small. Secondly, the follow-up time was short. The mean follow-up period was 16.1 months, and the long-term follow-up data were deficient. Thirdly, this study was not a random study, and there may be some selection bias between the two groups.

CONCLUSION

Generally, both conventional PETLD and trans-SAP PETLD can achieve very excellent surgical results. But the trans-SAP approach is easier to be mastered by young surgeons. Secondly, the operation time is shorter, and X-ray fluoroscopy is less. Finally, in some patients, the herniated nucleus pulposus were huge and high grade upward or downward migrated, and the trans-SAP PETLD utilizing visual trephine may be the best choice.

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AUTHORSHIP CONTRIBUTION

Study conception and design: JYL

Data collection: LQ

Analysis and interpretation of results: LQ, XBT

Draft manuscript preparation: LQ, HTL

Critical revision of the article: DW, ZQZ

Other (study supervision, fundings, materials, etc...): YQW

All authors (LQ, JYL, XBT, HTL, DW, ZQZ, YQW) reviewed the results and approved the final version of the manuscript.

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