Clinical Outcomes of TESSYS and TESSYS-ISEE Approach on Treatment of Lateral Recess Stenosis: A Comparison Study

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Research article

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Abstract

Background: Lateral recess stenosis (LRS) is a common degenerative disease in the elderly. Since the rise of comorbidity is associated with the increasing age, the percutaneous endoscopic lumbar decompression is advocated. The objective of this study was to compare the clinical outcomes of percutaneous endoscopic lumbar decompression in LRS via TESSYS or TESSYS-ISEE approach.

Methods: A total of 45 and 42 consecutive patients with limp or radiculopathy symptoms underwent percutaneous endoscopic lumbar decompression using transforaminal endoscopic spine system (TESSYS) and TESSYS-ISEE, respectively. The radiation exposure and operation time, time to return to work, and complications were compared between two groups. Their clinical outcomes were evaluated with visual analogue scale (VAS) leg pain score, VAS back pain score, Oswestry Disability Index (ODI) and Modified MacNab's criteria.

Results: The average values of radiation exposure and operative time in TESSYS group were significantly higher than those in TESSYS-ISEE group ($P<0.05$). The postoperative VAS and ODI scores in both groups were significantly improved compared with before the operation ($P<0.05$). In addition, the VAS score of the leg and ODI score in the TESSYS-ISEE group were significantly lower than those in TESSYS group at 1 week follow-up ($P<0.05$). The good-to-excellent rates of the TESSYS and TESSYS-ISEE group were 88.89 and 90.48%, respectively, whereas the complication occurrence rates were 6.67 and 4.76% in TESSYS and TESSYS-ISEE groups, respectively.

Conclusions: TESSYS-ISEE can be applied to treat LRS safely and effectively with short radiation exposure and operation time. This approach was comparable to the TESSYS approach with improved VAS leg pain and ODI score in short period after operation. However, potential complications and risks still needs to be considered.

Introduction

Lumbar spinal stenosis (LSS) is a common degenerative disease in the elderly. LSS can be categorized into central stenosis, lateral recess stenosis (LRS) and foraminal stenosis [1, 2]. Surgery is indicated for patients with neurogenic claudication and radicular symptoms when conservative treatment has failed [3–5]. The pathogenesis of LRS is responsible for the compression of nerve roots caused by hypertrophic ligamentum flavum (LF) and facet joint with/without herniated intervertebral disc (IVD). The main purpose of surgical treatment is to decompress the spinal canal and relieve symptoms [6]. Compared with traditional open surgery, minimally invasive spine surgery (MISS) is associated with less postoperative complications, such as scarring, infection and restricted mobility etc [7]. Therefore, MISS is considered for patients with LSS if dynamic spinal instability wasn't observed preoperatively [8, 9].

Percutaneous endoscopic lumbar discectomy (PELD) is one of the most applied MISS operations, and it is becoming increasingly popular in treating spinal degenerative disease. PELD appears to be a cost-

effective procedure due to short hospital stay, low postoperative costs of care and rapid rehabilitation with comparable clinical outcomes [10]. PELD was originally designed for the IVD discectomy. Hoogland et al. have reported that PELD under the transforaminal endoscopic spine system (TESSYS) was effective in treating IVD herniation with a success rate of 90% [11]. With the improvement of specialized instrument such as drill or reamer system, the indication of this technique has expanded from lumbar disc herniation (LDH) to LRS. By using different instruments, the foraminal window can be widened to improve operative access and intracanal visualization. Shin et al. have reported that adequate decompression of the LRS can be achieved by using TESSYS with the aid of endoscopic drill system [12].

Besides endoscopic drill system, endoscopic reamer system was also designed and developed. PELD under TESSYS-ISEE (TESSYS-ISEE) technique was developed from TESSYS technique for the treatment of LRS [13]. The posterior wall of lateral recess can be directly opened by the bony-plasty using this newly developed endoscopic reamer system. In this study, TESSYS-ISEE and TESSYS technique with the endoscopic drill system were compared for the treatment of patients with LRS to analyze the safety and efficiency of TESSYS-ISEE approach.

Material And Methods

Patient population

Between January 2016 and May 2018, 87 patients (51 males and 36 females), ranging from 43 to 80 years old (average 58.53 years), were enrolled in this study. The patients were categorized into two groups: TESSYS-ISEE group or TESSYS group. The surgery was performed by two different senior surgeons in both groups. All the procedures of this study were approved by the Ethics Committee of General Hospital of Central Theater Command and were in accordance with the Helsinki Declaration. Written informed consent was obtained from every participant.

Inclusion and exclusion criteria

The following inclusion criteria were used to select the patients: i) All participants complained of neurogenic claudication or radiculopathy symptoms; ii) Degenerative LRS localized at one segment was diagnosed on Computed Tomography (CT) scanning and Magnetic Resonance Imaging (MRI), ventral compression was caused by disc herniation and osteophytes, dorsal compression was due to hypertrophic LF and facet, or both [12] (anteroposterior diameter of the lateral recess was<4mm) [14] ;In addition, the Bartynski Grading System was applied in our study [15]. iii) Neurological symptoms were consistent with CT scanning and MRI findings; iv) Conservative treatments failed to reduce the symptoms over a period of 6 weeks; The following exclusion criteria were applied: i) Dynamic spinal instability was observed; ii) central stenosis was combined with contralateral lateral recess stenosis at the same level; iii) Highly migrated discs; iv)Prior surgery at the same segment; v) Participants with severe systemic diseases who were unable to tolerate surgery. In the present study, all patients were informed objectively about the surgical procedure, benefits and potential risks, and each patient was able to freely select the surgical option.

Surgical procedures

TESSYS. Surgery was performed using a transforaminal endoscopic spine system (Joimax®, Karlsruhe, Germany). Each patient underwent surgery in the prone position. The IVD space at the stenosis level was located using C-arm fluoroscopy. The distance between entry point was lateral to the midline was 12-16cm. The entry point and approach angle was determined by preoperative imaging and intraoperative fluoroscopy. The procedure was performed as follows: 1) After local anesthesia, an 18-gauge needle was inserted into spinal canal at the entry point, and the guide wire was inserted after the core needle was removed; 2) A skin incision was made at the entry site for guide wire, and the dilator was passed over the guide wire until it reached the lateral border of superior articular process; 3)The foraminal window was widened by 4 graded reamer in sequence; 4) The final working cannula was introduced over the dilator and positioned properly; 5) An endoscope system was assembled by two irrigation channels and an eccentrically placed 2.7-mm working channel; 6) The foramen was widened vertically by using the high-speed drill under the endoscopy; 7) The posterior wall of lateral recess was undercut by high-speed drill, and then the hypertrophic LF was resected with Kerrison rongeur; 8) The herniated disc can be dissected by moving the working cannula to the disc if ventral neural compression was accompanied by dorsal neural compression; 9) Hemostasis was checked, and the endoscope was removed after the decompression.

TESSYS-ISEE. Surgery was performed using a transforaminal endoscopic spine system-ISEE (Joimax®, Karlsruhe, Germany). The instrumentation was shown in Fig. 1. All participants were in the prone position. The IVD space at the stenosis level was located using C-arm fluoroscopy. The distance between entry point was lateral to the midline was 10-14cm. The entry point and approach angle was determined by preoperative imaging and intraoperative fluoroscopy. The procedure was performed as follows: 1) After local anesthesia, an 18-gauge needle was inserted through the skin into the ventral portion of the superior articular process (SAP), and the skin incision was made at the entry site of guide wire; 2) The guide wire was introduced through the core needle, and the needle was removed; 3) Sequential dilator was inserted through the guide wire aiming at SAP; 4) Remove the dilator, and secondary guide rod and special designed eccentric guide rod were inserted through the guide wire step by step, and base on the fiuoroscopy views of guide wire, rotating the eccentric guide rod around the secondary guide rod to ideal starting point. 5) A half-serrated working cannula was passed over the eccentric guide rod to the SAP, and positioned properly; 6) A special designed reamer and endoscope were introduced through the half-serrated working cannula; 7) The bony-plasty at the posterior wall of lateral recess was performed by the reamer and the “bone-column” was removed (Fig2); 8) Then the hypertrophic LF was resected with Kerrison rongeur; 9) The half-serrated working cannula was replaced by a sharp, bevel-ended working cannula aiming at disc if ventral neural compression was present; 10) Under the endoscopy, the disc discectomy was performed until the nerve roots were decompressed. 11) Hemostasis was checked after the decompression. The Surgical procedure was shown in Fig 3.

Clinical assessment

The preoperative demographic data, including age, sex, body mass index (BMI), rate of diabetes and low extremity atherosclerosis disease, duration of symptoms, operative level, combined herniated disc, bartynski grade, follow-up time were collected. We also recorded radiation exposure time, operative time, time to return to work, complication rate and recurrences. We evaluated each participants with visual analogue scale (VAS) for back and leg pain and Oswestry disability index (ODI) questionnaires, preoperatively and at each follow-ups (1-week, 3-months and the latest follow-up). The VAS and ODI scores were recorded in the questionnaires at each follow-ups in our outpatient clinic. Postoperative Modified MacNab Criteria [16] was also evaluated for clinical global outcome assessment at the latest follow-up. Sometimes, follow-ups were obtained by email or telephone communication.

Statistical analysis

Statistical analysis was performed using the SPSS 17.0 software (SPSS Inc, Chicago, USA). Measurement data were expressed as mean±standard deviation, was analyzed by Student t-test. Enumeration data was analyzed by $\chi 2$ tests. $P<0.05$ was considered to indicate a statistically significant difference.

Results

Comparison of basic demographic characteristics.

87 participants (TESSYS, 45 cases; TESSYS-ISEE, 42 cases) who met the inclusion criteria were assessed in our study. The basic demographic characteristics (age, sex, BMI, comorbidities, duration of symptoms, operative level , combined herniated disc and follow-up) were compared and presented in Table I. There were no significant differences observed regarding to the basic demographic characteristics between the two groups.

Comparison of surgery-related indicators between the two groups

The intraoperative data has shown that the average values of operative time (75.51±15.63 minutes) and radiation exposure time (28.11±7.13 s) in TESSYS group were significantly higher than those (66.07±11.23 minutes; 15.48±5.01 s) in TESSYS-ISEE group ($P<0.05$). However, there was no significant difference with regarding to the time to return to work between TESSYS group (12.02±3.50 days) and TESSYS-ISEE group (10.95±2.52 days) (Table II).

Comparison of clinical and functional outcomes

There was no significant difference between two groups for the average VAS scores of back/leg pains and ODI scores at preoperation ($P > 0.05$); The average VAS scores of back/leg pains following surgery improved in both TESSYS group and TESSYS-ISEE group ($P<0.05$). The average VAS scores of the leg pain was reduced from 7.36±1.11 to 1.42±0.71 in TESSYS group, and from 7.14±1.03 to 1.48±0.83 in TESSYS-ISEE group ;The average VAS scores of the back pain was reduced from 5.27±1.12 to 1.47±0.66 in TESSYS group, and from 5.05±1.23 to 1.51±0.57 in TESSYS-ISEE group .In addition, the average ODI

scores following operation also improved. The average ODI scores were reduced from 66.36±9.87 to 21.02±4.58 in TESSYS group, and from 69.52±9.22 to 20.11±5.49 in TESSYS-ISEE group (Table III).

There was also no significant difference between the two groups for the average VAS score of the back pain ($P > 0.05$, Fig. 4A). Remarkably, the average VAS score of the leg pain in TESSYS-ISEE group was significantly reduced as compared with TESSYS group at the 1-week follow-up; however, there was no significant difference between the two groups at both the 3-month and latest follow-up ($P<0.05$, Fig. 4B). Similarly, the ODI score in TESSYS-ISEE group was significantly reduced as compared with TESSYS group at the 1-week follow-up; however, there was no significant difference between the two groups at the 3-month and the latest follow-ups ($P<0.05$, Fig. 4C).

Modified MacNab Criteria was applied. Good-to-excellent rate in TESSYS group was 88.89%, and good-to-excellent rate in TESSYS-ISEE group was 90.48%. There was no significant difference of good-to-excellent rate between TESSYS group and TESSYS-ISEE group ($P > 0.05$, Table IV).

Comparison of complications and recurrence

Complications occurred in three participants (6.67%) in TESSYS group and two participants (4.76%) in TESSYS-ISEE group. Two participants in TESSYS group experienced dysesthesia in the area distribution of the ipsilateral neighboring exiting nerve roots. Their symptoms were recovered after physical treatment combined with medication. One participant in TESSYS group complained of severe pain of the affected lower extremity which was caused by the nucleus pulposus omissions close to the traversing nerve roots. His symptoms have vanished after the second surgical removal of nucleus pulposus. Part of the facet joint of one participant in TESSYS-ISEE group was removed by the reamer, however, no spinal instability was observed postoperatively. One participant in TESSYS-ISEE group experienced small sized dural tear and headache which was recovered after medication and bed rest in one week. There were no severe complications such as vascular injury, cauda equina injury, abdominal contents injury and surgical wound infection. There was no significant difference in complication occurrence between two groups ($P > 0.05$).

Only one participant in TESSYS-ISEE group with sciatica suffered from the same symptom as preoperation at the 15-month after the operation. The participant with recurrent sciatica were subjected to transforaminal posterior lumbar interbody fusion (TLIF) when conservative management has failed. The sciatica of this participant had been relieved until the latest follow-up.

Representative cases

Representative cases who underwent endoscopic surgery e using TESSYS-ISEE are presented in Fig. 5.

Discussion

This study retrospectively compared two different minimal techniques (TESSYS and TESSYS-ISEE) on the treatment of LRS. Although most of our participants experienced symptom relief following

procedures, however, complications (5.75%) and recurrence (1.15%) still occurred. TESSYS is emerging as an attractive minimally invasive surgical option in the treatment of LRS[12,17,18], and was routinely applied to treat LRS at our institution. TESSYS-ISEE was newly designed to treat LRS [13]. However, no studies have been performed to compare this technique with previous minimal techniques. Therefore, TESSYS served as a reference to evaluate the efficiency and safety of this technique. This preliminary results demonstrated that TESSYS-ISEE system is a feasible and safe way to treat LRS.

The PELD techniques can be selectively applied according to the different types of LSS, including interlaminar approach and transforaminal approach [2,19]. PELD via the posterior interlaminar approach is suitable for the central stenosis and LRS [2]. Rutten et al. have reported that the clinical outcomes of full-endoscopic interlaminar operation were equal to those of open microsurgical decompression surgery [20,21]. PELD via the lateral transforaminal approach is mainly used for the decompression of LRS and foraminal stenosis [2]. This lateral transforaminal approach is technically difficult due to the restricted field of vision and limited working mobility. Therefore, various specialized instruments have been developed to facilitate PLED technique to overcome the anatomic limitations.

Many studies have reported satisfactory results of patients with LRS following TESSYS with endoscopic drill system [12,22]. In order to achieve effective dorsal decompression of LRS , the distance from the midline to the skin entry point is farther than that of a typical transforaminal approach in these studies. This extreme lateral approach makes it possible to obtain good visibility when removing the LF. However, potential risks of abdominal and vascular injury still should be cautioned by using this approach. Although such complication wasn’t observed in our study, identification of appropriate trajectory before operation is important for the prevention of this complication. And besides, though the high-speed drill can also be applied to shape and sculpture the edges of articular osteophyte and expand the foramina precisely, it is time-consuming to acquire adequate space for the surgical manipulation. Additionally, the high-speed drill may lead to exit nerve root injury, which is caused by thermal damage or vibration stimulation [23,24]. TESSYS-ISEE was developed from TESSYS, however, the principle of TESSYS-ISEE approach is different from that of TESSYS. The puncture target of TESSYS-ISEE approach is the posterior element of nerve roots, so the distance from the midline to the skin entry point is shorter comparing with a typical transforaminal approach . The target of the puncture is at the ventral portion of SAP. If the guide wire is not positioned at the target location, we can change the direction of the guide wire by rotating the eccentric guide rod. After part of SAP was removed by endoscopic reamer, and then the “bone-column” was taken out for the exposure of LF. So, there is enough working space left for us to perform the dorsal decompression by resecting hypertrophic LF directly. On ground of the advantage of eccentric guide rod and endoscopic reamer, the radiation exposure time and average operative time in TESSYS-ISEE group was significantly shorter than that in TESSYS group. Besides TESSYS-ISEE, other reamer system has also been employed for the treatment of LRS. Li et al. have reported that LRS with IVD herniation can be treated by PELD using a specially designed reamer [14]. However, the reamer applied in this study was advanced with rotation under fluoroscopic guidance. This operation design is feasible, however, steep learning curve must be overcome and potential risk of nerve roots injury still exists despite such complication wasn’t reported in this study. Although the endoscopic reamer can ensure the safe dorsal

decompression in clear vision, two potential risks should be considered by using TESSYS-ISEE. Firstly, the endoscopic reamer might advance deeper in older osteoporosis patients due to inefficient control of the reamer handle; Secondly, this approach might affect the stability of facet. Although no postoperative spinal instability was observed at the follow-ups until now, potential complications should be monitored during follow-up. TESSYS and TESSYS-ISEE techniques were compared in Fig 6 and Table V.

VAS scores for leg pain was significantly higher in TESSYS group than those in TESSYS-ISEE group at at the 1-week follow-up; however, there was no significant difference of leg pain between two groups at the 3-month and latest follow-ups. These results might be due to the difference of the operation duration. Previous study has shown that a shorter operation duration and quicker rehabilitation are closely related to the reduced postoperative VAS in a short-period [25].There was no significant difference for VAS back pain between two groups. Our participants also experienced lesser VAS back pain relief than VAS leg pain relief during the first week of follow-up. The removal of mechanical barriers, including the epidural fat and ligamentous structures, may exaggerate the tendency toward spinal instability, and spinal instability is an important cause of low back pain [26]. However, with the formation of granulation tissue and bone union, the spinal mechanical stability might be re-established, and symptoms were better relieved at later follow-ups. The ODI score is significantly correlated with VAS [27]. The difference in the VAS back and leg pain might be the explanation for the difference in the ODI. The decrease of 15-points in the ODI is perceived as effective [27], and the average decrease in the ODI at follow-ups was consistent with this criteria.

Dysesthesia is a common complication in patients treated with PELD postoperatively. The incidence of Dysesthesia following PELD is from 2.3 to 5.4% [19,24,28]. The incidence of postoperative dysesthesia (4.44%) in TESSYS group was consistent with previous findings, and there was no postoperative dysesthesia occurred in TESSYS-ISEE group. The possible reason for postoperative dysesthesia in TESSYS group might be due to the stimulation exit nerve root caused by drill or reamer, whereas further large-scale comparison study should be conducted to testify this hypothesis. The positioning target of TESSYS-ISEE system is the posterior element of nerve roots. Compared to the TESSYS system, the working zone of reamer is farther from exiting nerve root , decreasing the risk of exiting nerve root injury [13]. The recurrence occurred in TESSYS-ISEE group might be due to the following reasons: Firstly, the participant was older than 60 years, and the elderly was at high risk for recurrent herniation after MISS operation [29]. Secondly, a non-recommended weight-bearing history was obtained postoperatively.

Previous studies showed that PELD via transforaminal appraoch is an effective MISS procedure for the management of LRS. Li et al. [14] reported good outcomes by application of PELD via transforaminal approach for LRS. 90.6% of the 85 patients were given “excellent” or “good” according to the modified MacNab’s score. Similarly, Chen et al. [30] reported that 25 elderly patients with LRS, were treated using PELD via transforaminal approach, with an excellent and good rate of 87.5%. In our study, a good-to-excellent rate in the TESSYS group was discovered to be 88.89%, whereas a good-to-excellent rate in the TESSYS-ISEE group was revealed to be 90.48%. However, there was no significant difference with

regarding to the good-to-excellent rate between the two groups. These results are similar to previous studies using PELD via transforaminal approach [14,30].

However, there were some limitations exist in the present study. Firstly, this was a retrospective study with small cohort of sample, and the follow-up was not long enough. A randomized, prospective and long-term follow-up study with a larger sample size was needed to testify these findings. Secondly, each surgical procedure was performed by two different surgeons. The different skill level of the two surgeons may also have an impact on the results. Ideally, all patients should be operated by the same surgeon to minimize the impact of personal experience on the results.

In conclusion, The PELD via TESSYS-ISEE system and the TESSYS system are both effective surgical options for the management of LRS. However, the TESSYS-ISEE system is shown to shorten radiation exposure and operation time and relieve the VAS leg pain and ODI during the early period following the operation as compared with the TESSYS approach. TESSYS-ISEE system for LRS can be performed safely and effectively, and it might be regarded as a treatment alternative for LRS.

Abbreviations List

LSS: Lumbar spinal stenosis; LRS: lateral recess stenosis; LDH: lumbar disc herniation; LF: ligamentum flavum; IVD: intervertebral disc; MISS: minimally invasive spine surgery; PELD: percutaneous endoscopic lumbar discectomy; TESSYS: transforaminal endoscopic spine system; TESSYS-ISEE: transforaminal endoscopic spine system-ISEE; CT: Computed tomography; MRI: Magnetic resonance imaging; SAP: superior articular process; VAS: visual analog scale; ODI: Oswestry disability index

Declarations

Ethics approval and consent to participate

This study was according to the Helsinki Declaration and was approved by the General Hospital of Central Theater Command

Consent for publication

Written informed consent for publication was obtained from all participants.

Availability of data and materials

The datasets for this study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

FX and HK have designed the study and performed the operations. BW and CX was involved in drafting the manuscript or revising it critically for important intellectual content. BW, DZ, ZY and YY have collected the data. BW has analyzed the data and made the statistics. All authors read and approved the final version of the manuscript.

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Tables

Table I: Comparison of demographic characteristics in two groups

Characteristics	TESSYS (n = 45)	TESSYS-ISEE(n = 42)	P value
Age (years)	59.18 ± 8.84	57.83 ± 7.54	0.45
Gender: (male) (%)	28 (62.22)	23 (54.76)	0.48
BMI(kg/m^2)	25.10 ± 4.11	24.73 ± 4.18	0.68
Diabetes (%)	7 (15.56)	5 (11.90)	0.62
Low extremity atherosclerosis disease (%)	6 (13.33)	7 (16.67)	0.66
Duration of symptoms (months)	12.58 ± 6.12	14.12 ± 7.11	0.28
Operative level:(L4/5)/(L4/5 + L5/S1) (%)	31 (68.89)	26 (61.90)	0.49
With/without herniated disc	22 (48.89)	27(64.29)	0.15
Bartynski grade: Bartynski grade 3/(Bartynski grade 2 + Bartynski grade 3) (%)	18 (40.00)	14 (33.33)	0.52
Follow-up (months)	23.29 ± 5.36	21.57 ± 5.10	0.13

The Age,BMI,Duration of symptoms, Follow-up were verified by student t-test; The Gender, Diabetes, low extremity atherosclerosis, operative level,combined herniated disc and Bartynski grade were verified by χ^2 test. $P < 0.05$ represented significance.TESSYS, transforaminal endoscopic spine system.

Table II. Comparison of clinical operation effects between the two groups

Items	TESSYS (n = 45)	TESSYS-ISEE (n = 42)	P value
Radiation exposure time(s)	28.11 ± 7.13	15.48 ± 5.01	< 0.05
Operation time (minutes)	75.51 ± 15.63	66.07 ± 11.23	< 0.05
Time to return to work(days)	12.02 ± 3.50	10.95 ± 2.52	0.11

The Radiation exposure time, operation time and time to return to work were verified by student t-test. $P < 0.05$ represented significance.TESSYS, transforaminal endoscopic spine system.

Table III. Comparison of VAS and ODI scores in two groups

Items	TESSYS (n = 45)	TESSYS-ISEE (n = 42)	P value
VAS of Leg			
Preoperation	7.36 ± 1.11	7.14 ± 1.03	0.36
1-week after operation	2.40 ± 0.72	1.95 ± 0.79	< 0.05
3-month after operation	1.93 ± 0.86	1.67 ± 0.72	0.12
The latest follow-up	1.42 ± 0.71	1.48 ± 0.83	0.66
VAS of Back			
Preoperation	5.27 ± 1.12	5.05 ± 1.23	0.39
1-week after operation	2.31 ± 0.85	2.21 ± 0.75	0.58
3-month after operation	2.02 ± 0.81	2.07 ± 0.51	0.97
The latest follow-up	1.47 ± 0.66	1.51 ± 0.57	0.76
ODI			
Preoperation	66.36 ± 9.87	69.52 ± 9.22	0.13
1-week after operation	34.80 ± 7.74	29.67 ± 5.91	< 0.05
3-month after operation	24.49 ± 5.61	22.81 ± 4.70	0.14
The latest follow-up	21.02 ± 4.58	20.11 ± 5.49	0.35

The VAS and ODI scores were compared by using student t-test. $P < 0.05$ represented statistical significance. TESSYS, transforaminal endoscopic spine system; ODI, Oswestry dysfunction indexes; VAS, visual analogue scale.

Table IV. Comparison of MacNab evaluation in two groups (n, %)

Groups	n	Excellent	Good	Fair	Poor
TESSYS	45	19(42.22)	21(46.67)	4(8.89)	1(2.22)
TESSYS-ISEE	42	22(52.38)	16(38.10)	2(4.76)	2(4.76)
P value	0.62				

χ^2 test was used to compare between each group. $P < 0.05$ represented significance. TESSYS, transforaminal endoscopic spine system.

Table V. Comparison between TESSYS and TESSYS-ISEE Technique		
Items	TESSYS	TESSYS-ISEE
Approach	Transforaminal	Transforaminal
Puncture site	Paraspinal muscle 12–16 cm lateral to the midline	Paraspinal muscle 10–14 cm lateral to the midline
Puncture target	Tip of SAP	Ventral portion of SAP
Adjustment instrumentation of puncture	NO	Eccentric guide rod
Requirements for puncture accuracy	High	Low
Instrumentation of foraminoplasty	4 graded reamer	Endoscopic reamer
Instrumentation of bony-plasty	Drill	Endoscopic reamer
Radiation exposure time	Long	Short
Operation time	Longer	Long
Facet disturbance	smaller	small
Lateral recess decompression	More precise	Precise
TESSYS, transforaminal endoscopic spine system.		

Figures

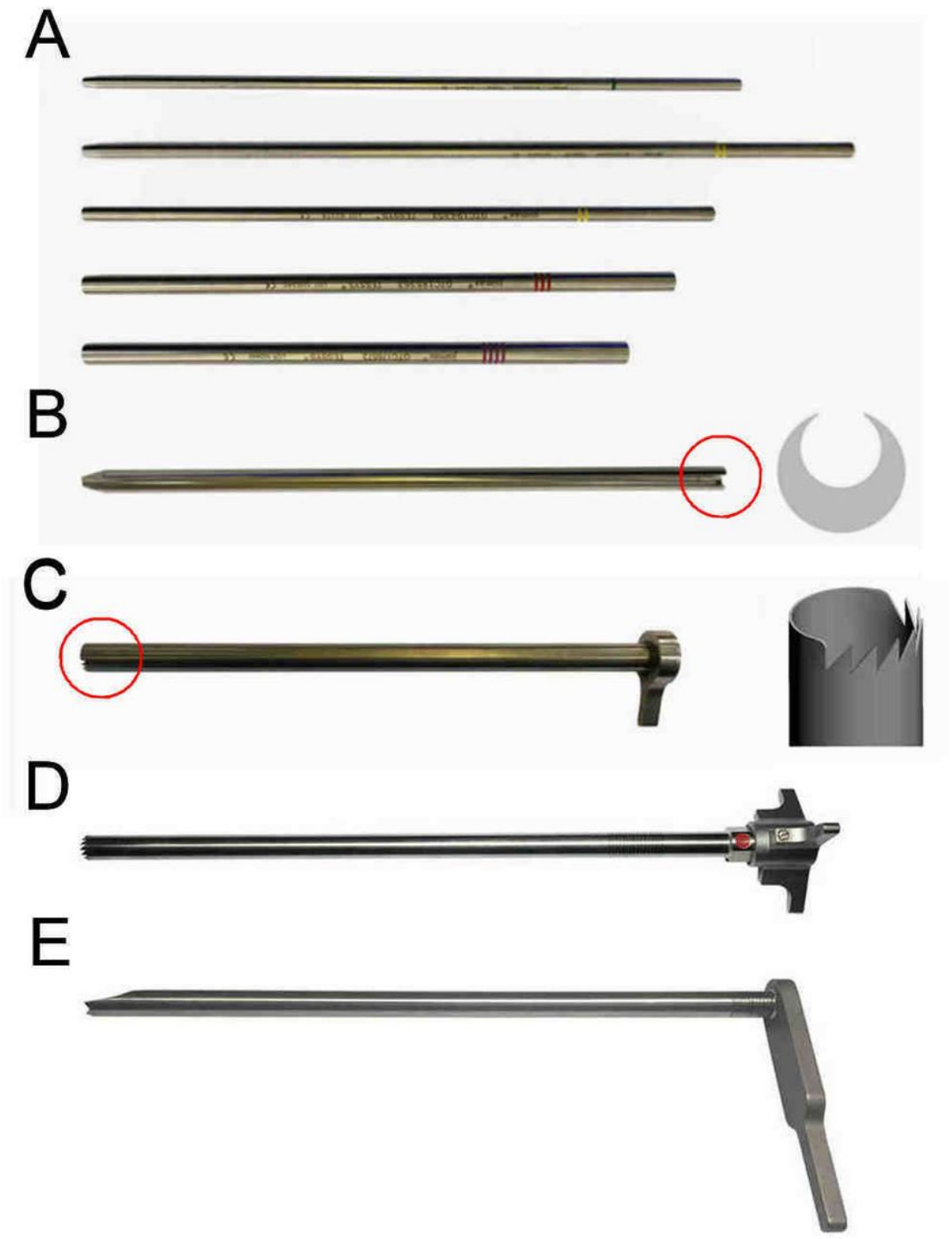

Figure 1

The instrumentation for the TESSYS-ISEE system. A. The sequential dilator and guide rod were applied to establish the portals once the 18-gauge needle was properly inserted. B. The special designed eccentric guide rod were inserted through the guide wire and secondary guide rod if the guide wire is not positioned at the target location, and we can change the direction of the guide wire by rotating the eccentric guide rod. C. A half-serrated working cannula was inserted along the eccentric-shaft obturator for the re-

positioning. D. A special reamer was designed for the resection of osteophyte under the endoscopic system; E. A sharp, bevel-ended working cannula was used for the decompression of the nerve roots.

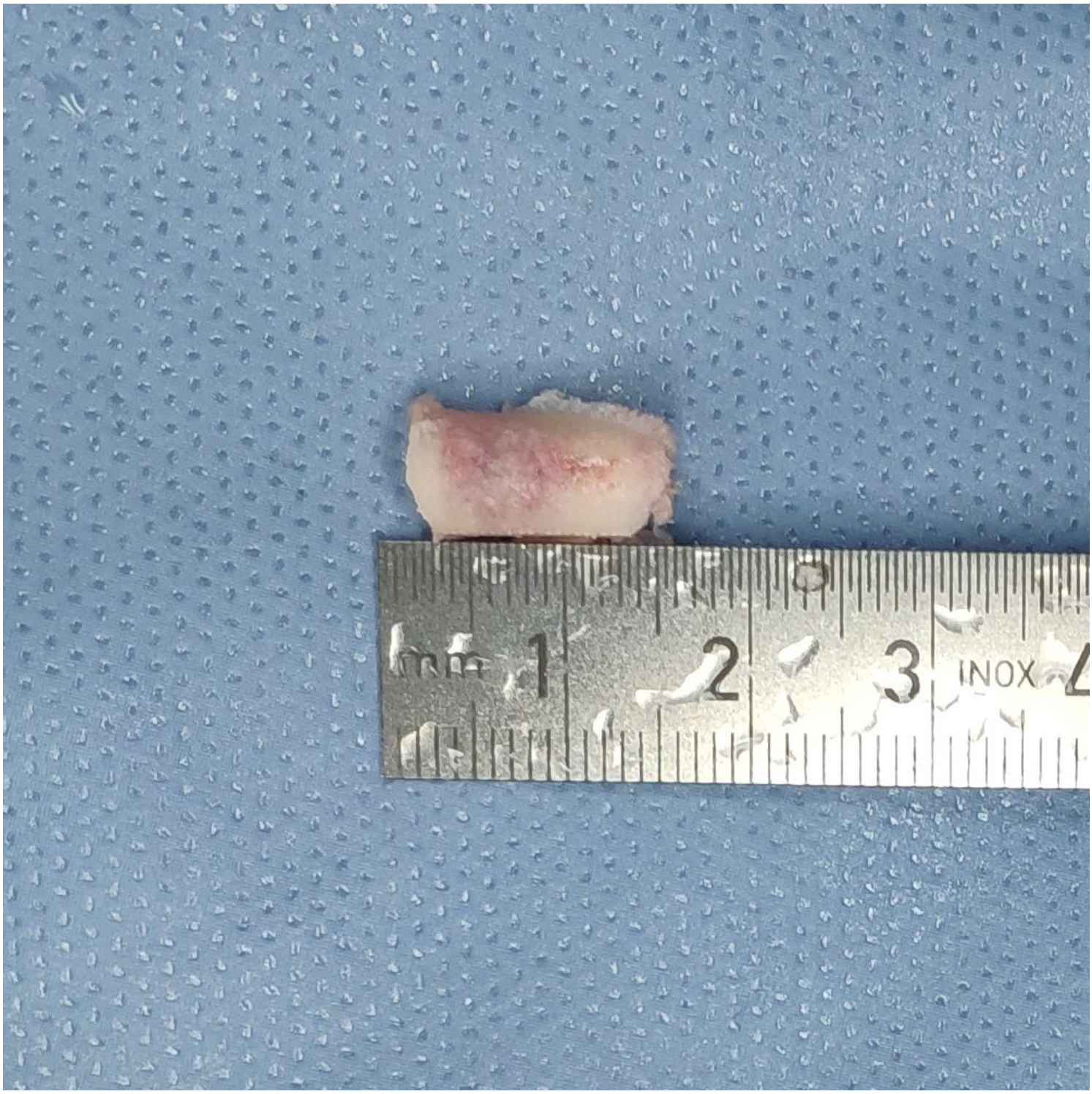

Figure 2

The bony-plasty at the posterior wall of lateral recess was performed by the reamer and the “bone-column” was removed.

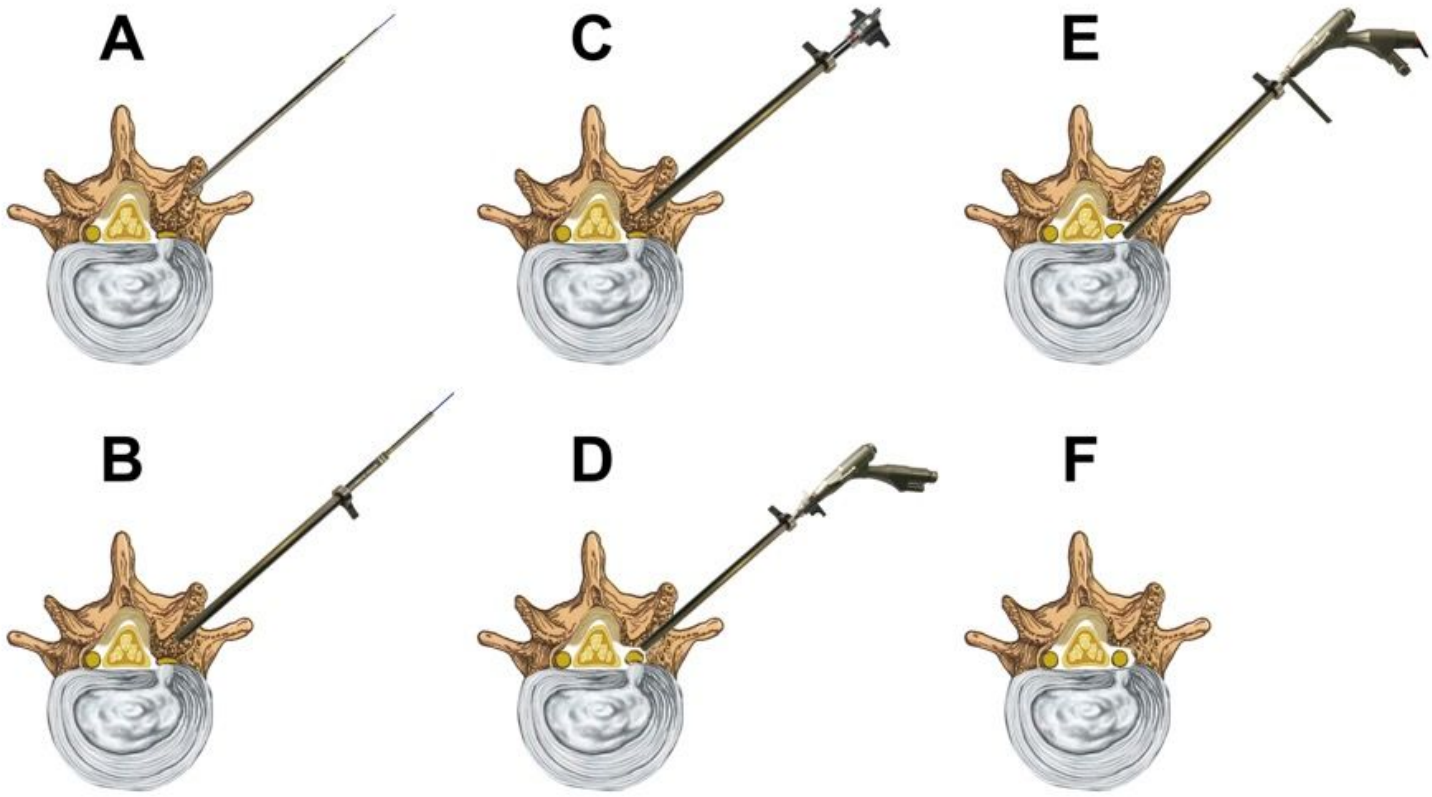

Figure 3

The illustration scheme of the spinal canal decompression. A. The dilator and guide rod were properly positioned. B. The secondary guide rod and special eccentric guide rod were inserted through the guide wire step by step, and the half-serrated working cannula was inserted into the superior articular process along the eccentric guide rod . C. The special designed reamer was applied for the resection of osteophyte under the endoscopic system. D. The dorsal decompression of the nerve roots; E. The ventral decompression of the nerve roots; F. The achievement the spinal canal decompression.

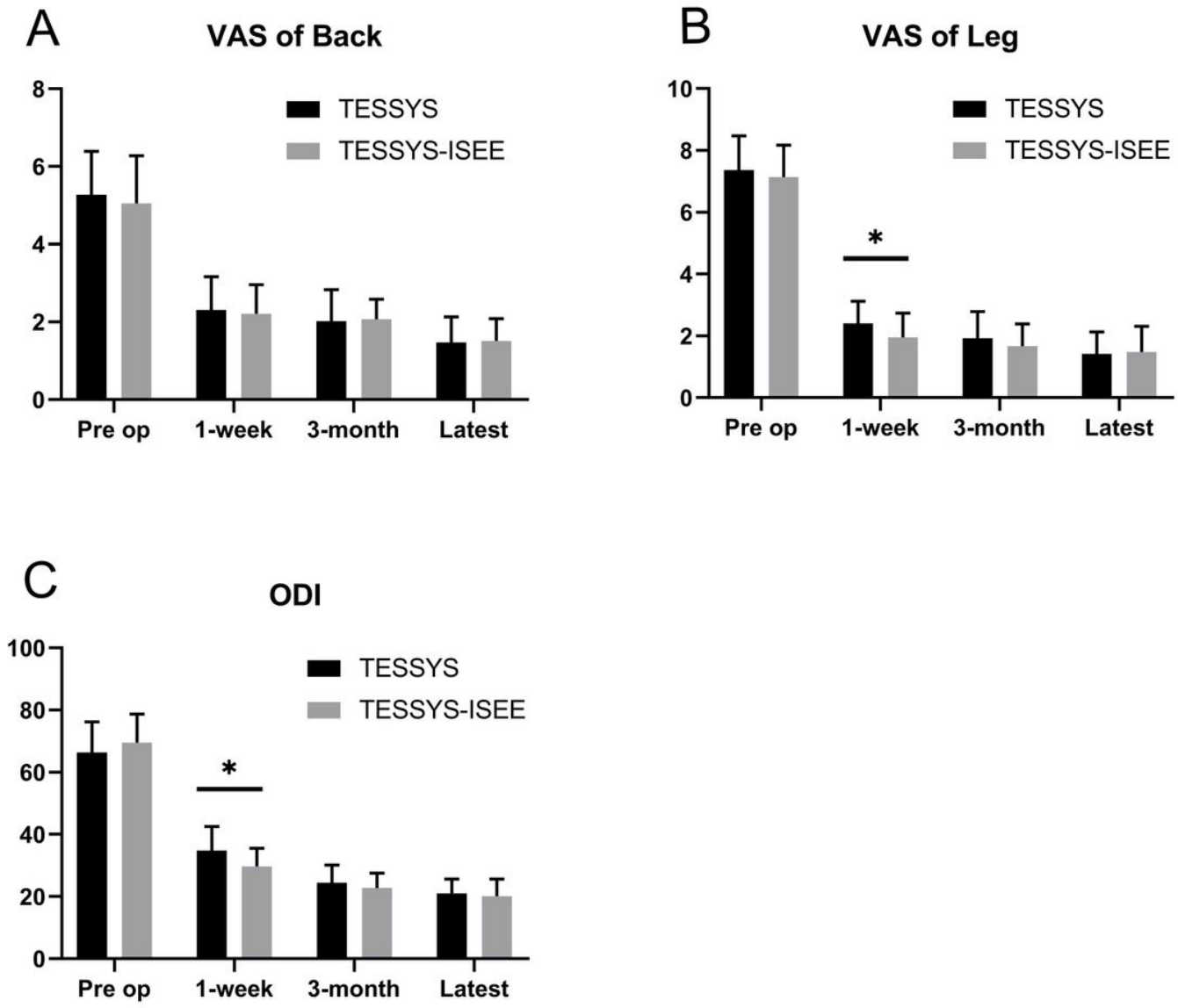

Figure 4

Comparison of VAS score of leg (A), VAS score of back (B) and ODI (C) at different time points. VAS, visual analogue scale; ODI, Oswestry Disability Index; Mon, month. * P < 0.05 TESSYS group vs. TESSYS-ISEE group. Pre-op: Preoperation; 1-week: 1-week after operation; 3-month: 3-month after operation; Latest: The latest follow-up.

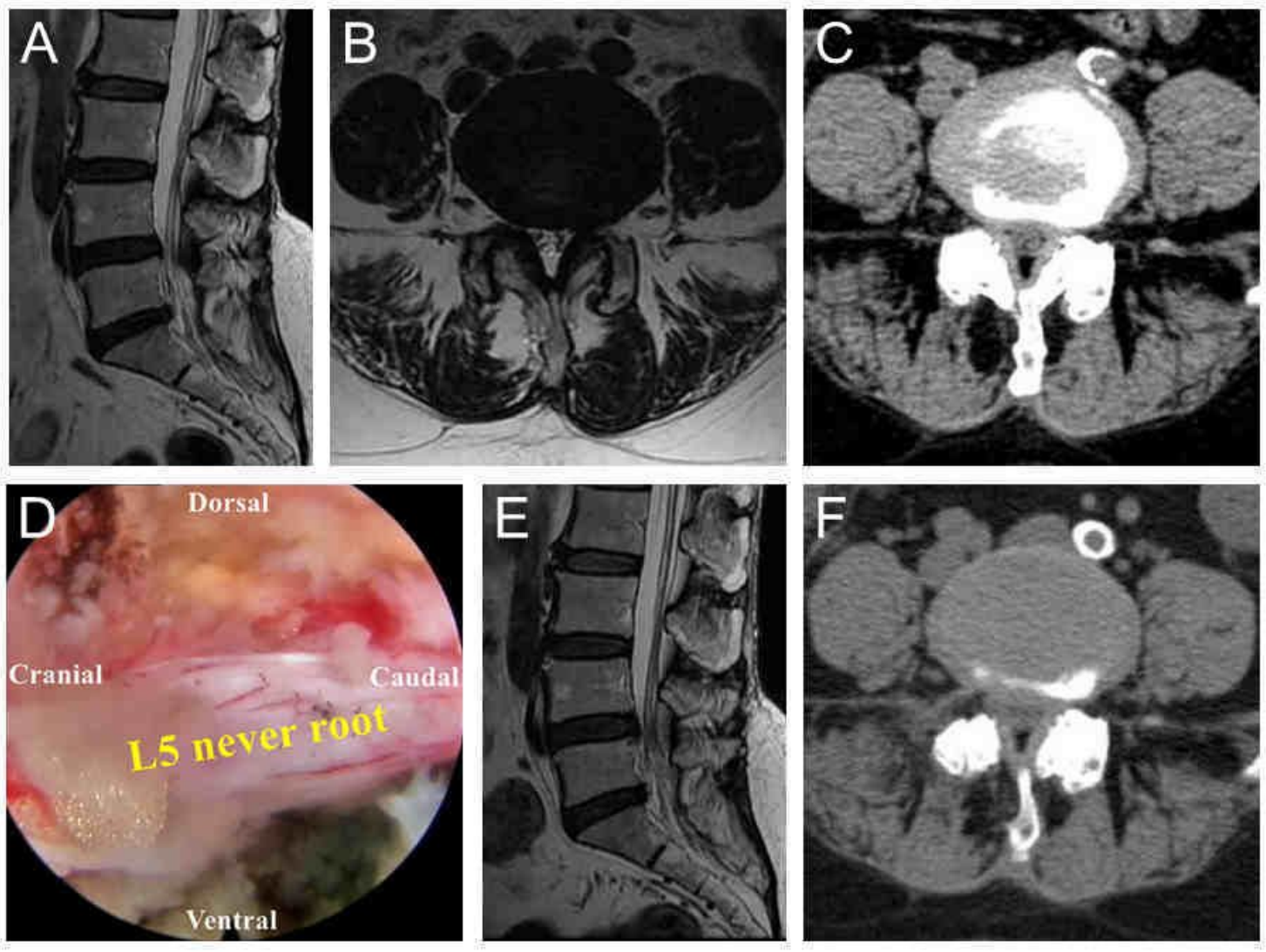

Figure 5

A case with lateral recess stenosis treated by TESSYS-ISEE system. Preoperative MRI (A,B) and CT (C) of a 60-year-old woman with right leg radiating pain showed lateral recess stenosis and disc herniation of L4/5. The L 5 nerve root was fully released after decompression (D).Postoperative MRI and CT showed the lateral recess was enlarged, and dorsal and ventral of L5 nerve root was totally decompressed(E,F).

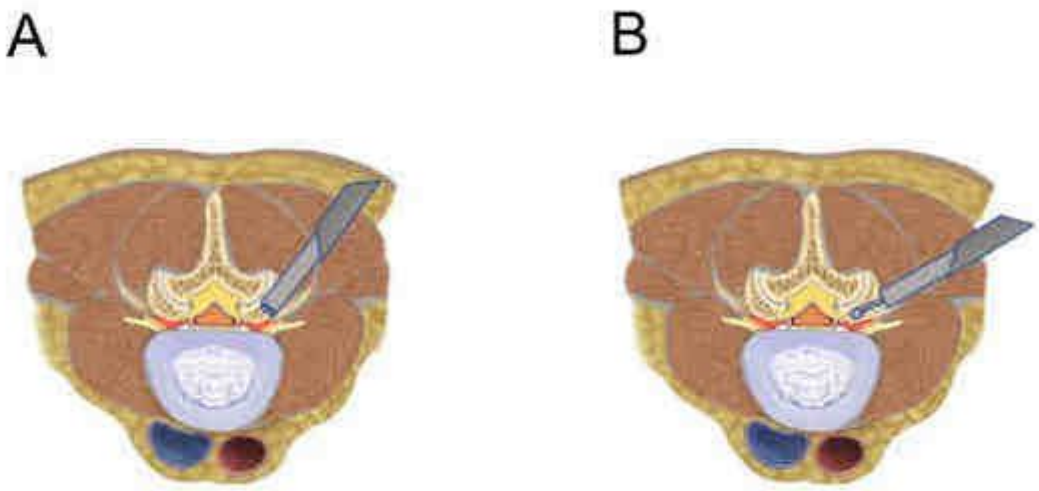

Figure 6

The comparison between TESSYS-ISEE and TESSYS. A. The bony-plasty of the lateral recess by the endoscopic reamer. B. The foraminoplasty by the endoscopic drill.