

Floating Technique for L5-S1 Foraminal Approach by Biportal Endoscopic Spine Surgery

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The foramen of L5-S1 can develop several degenerative diseases such as extraforaminal lumbar disc herniation, foraminal stenosis with disc height collapse, degenerative or spondylolytic spondylolisthesis, and far-out syndrome. The floating technique in biportal endoscopic spine surgery (BESS) keeps a certain distance between instruments and spinal structures.¹⁾ This key point makes the floating technique different from conventional endoscopic surgery, which uses the Kambin's safe triangle as a work zone. The floating view can enable the surgeon to see the structures panoramically, under high magnification: consequently, fine discrimination of their margin and safe manipulation of neural structures can be guaranteed. A certain gap between the floating scope and lesion can permit various instruments, generally used in open spine surgery, to be inserted from the sides with fewer limitations. Extraforaminal or foraminal lesions under the lamina can be reached by avoiding the iliac crest, and total facetectomy, which has the potential of iatrogenic instability, is not required to explore the foraminal structures. However, the floating view can be obstructed by small bleeds from laminectomized bone and/or surrounding vessels. This present article describes the technique and provides tips on how to perform BESS with floating technique safely and successfully for various lesions at the L5-S1 foramen.

Keywords: Stenosis, Lumbar, Spine surgery, Endoscopic, Floating technique

Indications

The following conditions are indications for early surgical interventions within 6 weeks.

- Intolerable radicular pain with progressive motor deficit or a neurologic pain-causing limping gait;
- Uncontrolled buttock and leg pain and/or neurologic claudication for at least 6 weeks with trials of conservative management with nonsteroidal anti-inflammatory drugs, physical therapy and pain-blocking injections;
- Cross-sectional magnetic resonance imaging scan demonstrating nerve root compression with a stenotic foramen and/or herniated disc with concordant symptoms is an indication for surgical interventions;

Foraminal lesions at the L5-S1 level:

- Extra-foraminal or foraminal lumbar disc herniation;
- Foraminal stenosis with the following conditions: disc

height collapse, degenerative spondylolisthesis, spondylolytic spondylolisthesis in senile patients with moderately progressive disc degeneration, and adjacent segment disease including fusion surgery at the level of the L4-5 and/or higher; and

- Far-out syndrome due to a traction spur of the L5 transverse process with L5 root compression symptoms such as sensory disturbance of the L5 dermatome, weakness of the extensor hallucis longus, Kemp sign, and neurologic claudication less than 100 m with a relatively preserved the height of the L5S1 foramen.²⁾

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Contraindications

Surgical intervention may not be recommended for the patients with vascular claudication, sequelae after cerebral disease or peripheral neurologic disorders of the lower extremities. Patients with any medical comorbidity with a higher risk of general anesthesia are not recommended to undergo an operation because the systolic blood pressure is maintained around 100 mmHg or lowered during the procedure. Just senility, age, or controlled diabetes is not an absolute contraindication, but these factors are associated with the risk of postoperative infection; thus, it is beneficial to perform the saline-irrigation procedure and use small inlets in patients with these factors.

Operative Setup

The following instruments and materials are required: a surgical table with a radiolucent chest frame, intraoperative fluoroscopy, endoscopic system, arthroscope with 0° view, shaver, high-speed burr (a cutting blade burr and diamond burr), radiofrequency ablation tools (3-mm and 1.5-mm head), saline for irrigation (several 3000-cc bags), micro-surgical instrument set (Kerrison punch and Cushing pituitary punch), and biportal endoscopic spine surgery (BESS)

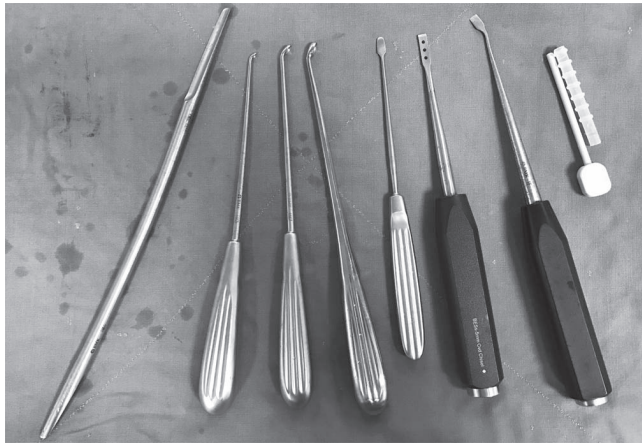


Fig. 1. Biportal endoscopic spine surgery (BESS) instrument set. Some unusual instruments are used when performing the extra-foraminal approach inside the foramen. The following instruments are shown from left to right: muscle detacher; 2mm-headed, 3mm-headed, and 5mm-headed angled curettes; Indian Knife; 5mm-headed osteotome; hockey chisel; and BESS cannula.

instrument set (muscle detacher; 2-mm-headed, 3-mm-headed, and 5-mm-headed angled curette, Indian knife, 5-mm-headed osteotome, hockey chisel, and BESS cannula) (Fig. 1).

Positioning

The patient was placed in the prone position over the radiolucent chest frame of the operating table. The patient's head and the upper back were placed somewhat lower than the back and buttock for sufficient circulation since the systolic blood pressure should be kept at 90~100 mmHg to decrease small bleeds. The hip was flexed naturally at about 70°, and the knee was protected with soft pillows. We assessed the patient's knees by inserting our hand under them if necessary, we make adjustments to ensure that the hip and knee were in a relaxed position. If the knee position was too tight, the patients would complain of pain in the hip and anterior knee for a few days postoperatively. Fluoroscopic confirmation of a certain level of positioning should be made after all positions are set.

Surgical Technique

Step 1: Portal Position

A somewhat proximal incision on the skin is needed to reach the L5-S1 foramen tangentially as much as possible. Two points are generated from three crossing lines; one longitudinal and two transverse guidelines. In the right-side approach, the longitudinal guideline is 2 cm (3 cm for patients with a heavier back muscle or obese patients) from the lateral margin of the L4-L5-S1 pedicles. A transverse, proximal guideline is located halfway between the L4 and L5 transvers process (TP), and a crossing point with the longitudinal guideline is used as a working portal for certain instruments. The other transverse, distal guideline is located at the distal margin of the L5 TP, and the crossing point with the longitudinal point is used as a viewing portal for the scope. In the left-side approach, the longitudinal line is the same as that in the right-side approach. A transverse guideline is located at the middle of the L5 TP, and a crossing point with the longitudinal guideline is used for viewing purposes. A working portal is located at 1 cm distal and 1 cm medial from the viewing portal to avoid the iliac crest. If

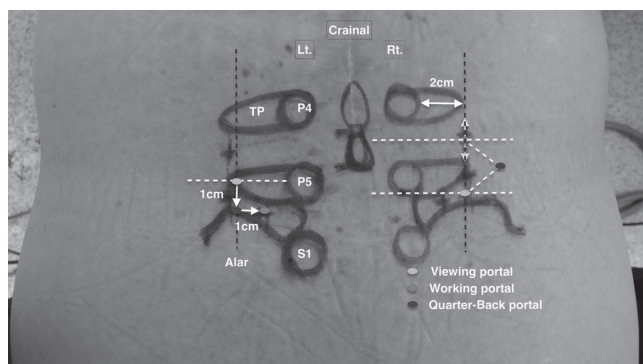


Fig. 2. Portals for the L5-S1 foraminal approach. The right (Rt.) side portals are somewhat different from those of the left (Lt.) side because of left-handed scoping and the position of the alar wing. Lateral distance is located on about 2cm from the lateral margins of the pedicles in a C-arm view. TP, transverse process.

the surgeon is ambidextrous, the right portal positions can be used as the left ones, with the right hand maneuvering the scope and the left hand manipulating the instruments. A triangular point lateral from the two portals, i.e., quarter-back portal, can be prepared for the BESS cannula to maintain fluent saline outflow in patients with thicker back muscles, or to enable the surgeon to reach far inner side (lateral recess) from the outside of the foramen (Fig. 2).

Step 2: Creating Basecamp and Fluent Saline Flow

The skin must be incised about 1 cm from the two portal sites, deeper to the superficial muscle fascia using a mess (#12 blade), and the blade should be turned vertically to cut the fascia crosswise again. The basal muscle is detached from the dorsal surface of the L5 TP and proximal surface of the alar using a muscle detacher; this is absolutely necessary before inserting a scope. The muscle detacher must go straight down and touch the dorsal surface of the TP. Reaching into the foramen first should not be the initial goal. If the scope enters obliquely, it could land on the lamina or hypertrophied facet, causing the surgeon to lose orientation and waste time.

Inserting a scope with a saline infusion lifts up the detached muscles, and debridement of the rugged muscle fibers can be performed using a shaver, which provides good visualization and a free working space among the back muscles. Coagulation of small bleeds from the soft tissue can be achieved using 3 mm-headed radiofrequency ablation, can

provide a clear view, and the basecamp can be made before entering the foramen. If saline outflow is poor, one more incision can be made at the triangular end (quarter-back portal) and a BESS cannula can be inserted to check the rapid flow frequently.

Step 3: View and Orientation

In the right-side approach, the left-handed scoping shows the distal surface of the L5 TP rather than the dorsal side. The distal surface of the dorsal surface of the L5 should be differentiate, and the bony margin can be tracked along the distal surface of the L5 TP that is connected to the base of the L5 pedicle. The bony margin can be located with a 3-mm headed, angled curette to determine the surrounding anatomy. From the upper (L5 TP) through medial side (foramen) to the distal side (Alar), viewing and making clear bony margins by curetting, shaver, coagulation and debridement two or three times. In the left-side approach, the left-handed scoping shows the pulsating radicular artery as well as the upper surface of the Alar. Cleansing the soft tissue in front of the foramen should be performed without injuring the radicular artery. If heavy bleeding occurs from the radicular artery, a 1.5 mm radiofrequency ablation is useful to coagulate the torn sites gently without forceful retrieval motion of the surrounding muscle.

Step 4: Foraminotomy, Flavectomy, Discectomy

Once the basecamp is prepared, the foramen entrance (medially), under-surface of the superior articular process (SAP) (dorsally) and inter-TP ligament (basally) can be seen in the floating view. Outside bony preparation, if needed, should be performed before performing flavectomy and entering the foramen. Resection of the hypertrophied tip of the SAP can be performed using a Kerrison punch (K-punch) and hockey chisel. About 8mm of the tip of the SAP (one and a half width of the head size of the hockey chisel) should be resected into several fragments with a chisel. The fragments can be removed with a pituitary punch and the foramen can be widened using the K-punch. The proximal margin of the foraminal ligament flavum should be detached from the distal surface of the L5 TP; the ligament flavum at the base of the proximal pedicle is easier to be detached first than the one to the distal pedicle. Care should

be taken to avoid the location of the L5 exiting root just beneath the distal margin of the L5 TP.

Discectomy, if needed, is performed after locating the root margin with removal of the foraminal fat and controlling bleeding of the bundles of small vessels overlying the root. The outer layer or the annulus is incised using an Indian knife, and insert a 3 mm-headed, angled curette should be inserted just beneath the outer layer of the annulus to remove ruptured disc fragments, especially those under the root. Foraminal and inside lesions could be resolved during flavectomy of the overlying lateral recess using a 5 mm-headed, angled curette in patients with degenerative or spondylolytic spondylolisthesis with a hypertrophied facet and hypertrophied ligamentum flavum.

After sufficient decompression of the L5 root at the foramen, there should be enough room with the same width of the root at the distal from the root to prevent restenosis by dynamic compression when the patient stands or sits.

Sealing the exposed surface of the cancellous bone with bone wax and radical coagulation of small bleeding are mandatory to prevent from symptomatic hematoma formation.

Complications

The following complications can occur:

- Incorrect spine positioning due to higher lordosis of the lower lumbar spine, a higher buttock position rather than a higher upper back position on the surgical table, or degenerative lumbar scoliosis;
- Back muscle edema due to poor saline-output and patients with thicker back muscle or obesity;
- Incomplete decompression^{2,3)} due to incomplete resection of the hypertrophied tip of the SAP or neglected spur of the inferior surface of the L5 TP;
- Intramuscular hematoma due to insufficient bleeding control of bone or the radicular artery;
- Recurrent disc herniation; and
- Persistent symptoms such as prolonged compression and fibrosis of the surrounding epineural vessels of the exiting root, dysesthesia and/or allodynia before the surgical decompression, and back heaviness in fatty degenerative or atrophic lower back muscles with flat back syndrome.

Pearls and Pitfalls

The spine position should be checked under the intraoperative fluoroscopy two or three times to confirm the correct level. A higher lumbar curvature of the lower lumbar spine or moderately decreased gap between the L5-S1 can cause incorrect positioning. The head of a curette must be located distal to the L5 pedicle under the fluoroscope when the L5-S1 foramen is positioned correctly.

Muscle edema occurs mostly due to a poor output of saline flow in patients with heavier back muscles or moderate to severe obesity. Crosscutting of the superficial muscle fascia under the skin incision can improve outflow. Inserting a BESS cannula through the quarter-back portal can also be helpful when there is poor outflow.

Under higher magnification and an early learning curve, the L5 exiting root can appear free after removing the foraminal and intertransverse ligament. However, when the patient sits and stands the foramen must become narrow dynamically due to compression force. Removing the hypertrophied tip of the SAP enables surgeons to perform sufficient decompression of the root (Fig 3).

Controlling the small bleeds from the vessels and radicular artery is very important when finishing the procedure.

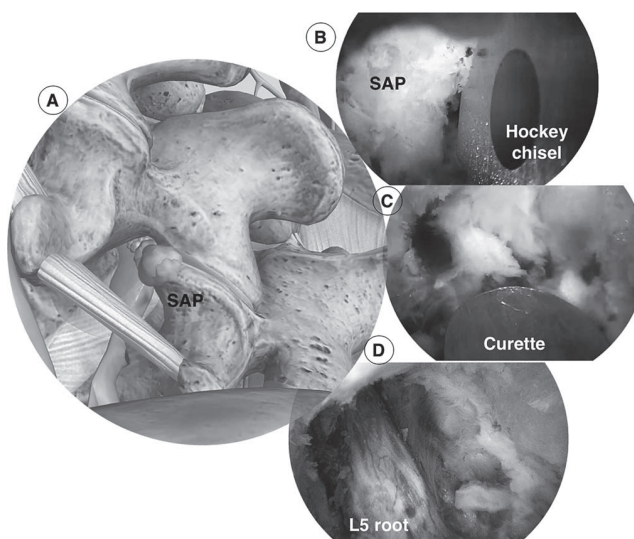


Fig. 3. Procedure of foraminotomy. **(A)** Target lesion of the overgrowing spur of the superior articular process (SAP). **(B)** Partial facetectomy of the SAP using a hockey chisel. **(C)** Foraminal flavectomy is performed using a curette. **(D)** The L5 exiting root is exposed wide enough with distal-free space about the same width of the root.

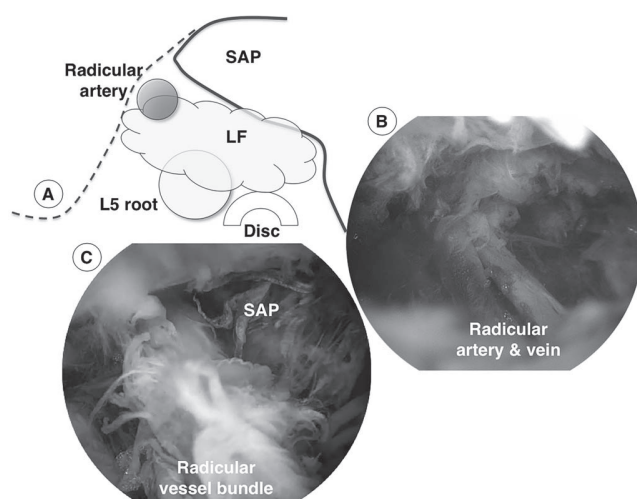


Fig. 4. Anatomic layer of the foraminal structures. **(A)** The radicular artery is located over the foraminal ligament flavum (LF). The L5 root and disc are covered and protected by the LF. **(B)** The radicular artery and vein are running together and looked like a vessel bundle. **(C)** The radicular vessel bundle is running into the just proximal to the superior articular process (SAP).

A blurred surgical field due to small bleedings can interrupt and delay the procedure. Small vascular bleeding can be controlled one at a time using 1.5-mm radiofrequency ablation under the very lowest setting of energy with little retraction of muscle to pull the vessel backward at the time of initial coagulation.

The radicular artery is located at the superior side of the foramen (Fig.4). It is always encountered in the left-side approach with using left proximal scoping. In the right-side approach with left distal scoping, it is hidden under the soft tissue, and only heavy blood flow is shown when its wall is scratched. Surgeons should be careful to avoid injuring an artery far lateral and just proximal to the alar.

In the case of spondylolytic spondylolisthesis, three compressing lesions should be decompressed completely: a spur overlying the L5 exiting root from a defected pedicle base, hypertrophied ligamentum flavum, and loose body at

the isthmic defect of the lamina. The inside approach from the far lateral side of the foramen is feasible to improve instability of the lamina. The foramen appears wider when it is pushed medially by a scope, and the inner side can be reached easily.

If the lesion inside is approached somewhat limitedly from a working portal, using the quarter-back portal as a working portal is preferable to decompressing the inner side of the foramen and even the lateral recess of the spinal canal.

Postoperative Protocol

Patients are permitted to walk about 3 hour after full recovery of general anesthesia. If the pain is tolerable and walking to the restroom is possible, the patient can be discharged home on the day of operation. Walking, sitting on chair and driving with intermittent resting can be permitted within a few days later. Working with gentle bending or twisting within 4 weeks postoperatively, and more activities should be encouraged with the limitation of heavy lifting at around 12 weeks.

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제 5요추-천추간 신경공 접근을 위한 부양 기술을 이용한 양측 투입구 내시경 척추 수술

최대정, 정제태, 김용상, 장한진, 유 방

바른병원 척추센터

제 5요추-천추간 신경공에서는 신경공외 추간판 탈출증, 추체간 협소로 인한 신경공 협착증, 퇴행성 또는 분리성 척추전방 전위증 및 원위 출구 증후군 등의 질환이 발생할 수 있다. 양측 투입구 내시경 척추 수술(BESS)시 수술부위에서 내시경을 띄워 사용하면 척추 구조물과 수술 기구 사이 일정거리를 확보할 수 있다.¹⁾ 이러한 부양 기술은 Kambin씨 안정 삼각지역을 작업 구역으로 사용하는 고식적인 내시경 수술과 차별은 주는 중요한 부분이다. 부양 시각은 술자가 구조물들을 고배율에서 광범위하게 바라볼 수 있도록 해 주고, 결과적으로 구조물의 경계를 정밀히 구분할 수 있으며 신경 구조를 안전하게 조작 하는 것이 확보된다. 띄어진 내시경과 병변 사이 일정한 간격으로 일방적인 개방적 척추 수술 시 사용되는 다양한 기구들의 삽입이 비교적 제한없이 여러 각도에서 삽입이 가능하다. 신경공외측 또는 추궁한 하방의 신경공 병변은 장골익에 방해받지 않고 접근이 가능하고, 이곳을 접근하기 위하여 의인성 불안정성 가능성이 있는 후방관절 전절제도 피할 수 있다. 그러나 내시경의 부양은 추궁판 절제 표면의 뼈나 주위 혈관 등에서 미세 출혈이 발생하면 시야가 방해된다. 이 보고에서는 부양기술을 사용하는 BESS를 제 5요추-천추간 다양한 병변에 안전하고 성공적으로 시행할 수 있는 기술과 조언을 설명하고자 한다.

색인 단어: 협착증, 요추, 척추 수술, 내시경, 부양 기술