# Case Study: Reduction and Stabilization of Grade III L5-S1 Dysplastic Spondylolisthesis in 15-Year-Old Female Using Posterior Approach

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**Background Context:** A female high school student with Grade III-IV L5-S1 dysplastic spondylolisthesis, chronic back pain, left leg pain, and sagittal instability underwent operative reduction, stabilization, decompression and interbody fusion of L5 onto S1. Spondylolisthesis is an anterior displacement of a cephalad vertebra on the adjacent caudal vertebra, most commonly caused by degeneration of the disc and facet joints of the affected motion segment. Other causes include, a fracture of the pars interarticularis bilaterally of the motion segment, commonly called Lytic Spondylolisthesis, and Dysplastic Spondylolisthesis, in children and adolescents, where the pars interarticularis portion of the posterior arch of the motion segment "plastically" deform and elongate in response to trauma rather than fracturing. As the pars deform and elongate slowly over time, the superior endplate of the caudal vertebra assumes a "dome-like" appearance (typically S1) and the involved vertebra translates or slides anteriorly. Generally, the most dramatic slips are seen with lytic and dysplastic spondylolistheses and produce more profound symptoms to the patient. The degree of anterior displacement of the "sliding" cephalad vertebra is divided into 5 grades, where grades 1-4 each represent 25% anterior displacement and grade 5, or spondyloptosis, is when the cephalad vertebra has slid off of the caudal vertebra and is anterior to it. In this patient's case, surgery was necessary to reduce the anterior displacement of L5 so that L5 was back on top of S1, and to decompress and stabilize the motion segment via hardware and an interbody fusion, while minimizing damage to surrounding normal motion segments.

In this application Aesculap Implant System's S$^{4®}$ Spinal System was used for pedicle stabilization. The difficult reduction was performed with the S$^4$ Spondylolisthesis Reduction Instrument (SRI), available for use with the S$^4$ pedicle screw system. A C-Arm was used during reduction to monitor the position of L5 on S1 in real time during the reduction maneuver, utilizing the SRI.

**Conclusions:** Following the surgery and subsequent successful fusion, the patient had near complete relief of back and leg pain; her posture and flexibility improved to normal as a result of the reduction and decompression; and importantly, the adjacent L4-5 segment, remained intact without damage, due to the merits of the S$^4$ SRI.

## Materials and Methods

Aesculap Implant System's S$^4$ Spondylolisthesis Reduction Instrument (SRI) is intended to reduce a spondylolisthesis in a controlled manner, which reverses the anterior slip path of the cephalad vertebra occurring during its anterior translation. The S$^4$ SRI instrumentation facilitates simultaneous correction of translation and slip angle, potentially minimizing excessive exiting nerve root injury during the reduction process. This allows reduction of the deformed motion segment, while sparing the adjacent normal segment. The S$^4$ SRI also reduces the listhetic vertebral body along the same curved displacement route, minimizing interference with anatomical structures and eliminating neurologic deficits that can result from initial over-distraction of an already stretched nerve root. By enabling simultaneous reduction and distraction, the SRI reduces overall procedure time as well as the risk of inadvertent movements through a precise and controlled reduction maneuver.

## History of Present Illness

A 15-year-old, female, high school student initially presented with back and left leg pain and severe hamstring tightness. She reported that the back and leg pain began when she was about 10 or 11 years old. During the next several years, she experienced increasing hamstring tightness and spasm with reduced lumbar flexion. At presentation she was not able to touch her toes, and in fact could barely get her fingertips to her patellae. Interestingly, she was unable to recall any traumatic event in her past that could be responsible for her problem.

On physical examination, the patient presented with a local kyphosis in her low-back and buttock area. She demonstrated significant hamstring tightness and weakness. Patellar and ankle reflexes were 2+ and symmetric. She was unable to lumbar flex below her knees. Bilateral lower extremity muscle strength was 5/5 and symmetric. There were no pathologic reflexes, no hyperreflexia and no clonus. Her main problem was

pain along the posterior aspect of the left thigh, lateral knee, posterior calf and into the dorsolateral foot. If the patient sat for longer than 10 minutes at a right angle of 90 degrees, her left foot went numb and the left leg hurt. She was non-tender over the back, and symptomatically she said that the back accounted for 25% of the pain and the legs 75%. The patient was seen by a chiropractor and was managing pain on Motrin and Tylenol.

## Review of Radiographic Studies

Scoliosis series X-rays showed an S-shaped thoracolumbar scoliosis and spondylolisthesis at L5-S1. The films of the lumbosacral spine, (Fig. 1) and (Fig. 2) showed approximately 75% listhesis of L5 on S1 and disc space narrowing.

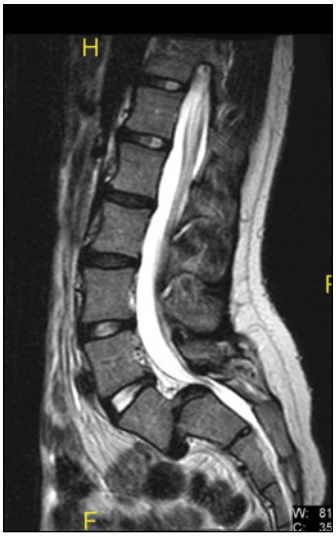

Fig. 1 Pre-op

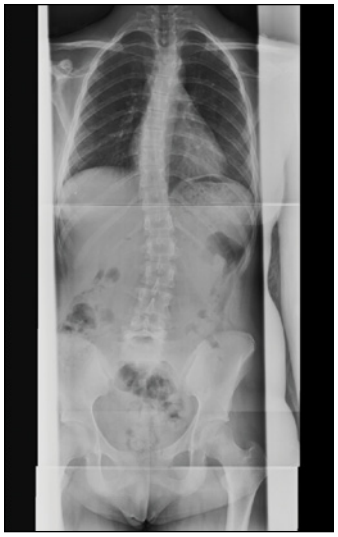
Fig. 2 Pre-op

An MRI without contrast of the lumbar spine revealed approximately 75% listhesis of L5 on S1, and scoliotic curvature apex to the left. Levels were evaluated in the axial planes:

- T-12 – L1 through L3 – L4: No disc bulge, no protrusion, and no central canal or neural foraminal stenosis.
- L4–L5: No disc protrusion. There is some mild narrowing of the neural foramen due to curvature of the lumbar spine but no overt nerve effacement.
- L5–S1: Severe central canal narrowing due to spondylolisthesis and significant narrowing of the neural foramen, left greater than right with impingement of the nerves in the neural foramen

## Diagnoses

1. Grade III + L5-S1 Dysplastic Spondylolisthesis
2. Chronic back pain
3. Left, much greater than right, leg pain
4. Sagittal instability

## Indication for Surgery

The CT and MRI studies clearly demonstrated that the patient had a Grade III L5-S1 dysplastic spondylolisthesis approximately 75% and narrowing of the central canal and neural foramen with L5 exiting nerve roots compression bilaterally. An instrumented L5-S1 interbody fusion with reduction was advised to reduce L5 on S1 while decompressing both exiting L5 nerve roots and the central canal. Biomechanically, she needed an interbody construct to provide support for the anterior column and decrease the stresses on the posterior instrumentation and posterolateral fusion.

## Details of Operation

A Transforaminal Lumbar Interbody Fusion (TLIF) at L5-S1 and a reduction of L5 on S1, by about 90% were completed. This operation was performed one month after last examination and CT and MRI studies.

The patient was placed in a prone position on a Jackson table. Neuro monitoring was used throughout the operation to assess the cauda equina generally and the exiting L5 nerve roots specifically.

An incision was made from L2–S1 and carried through the fatty subcutaneous tissue. The fascia was incised and paraspinous muscles were stripped exposing the posterior arches of L4, L5 and S1. The transverse processes of L4, L5, and the sacral ala were exposed bilaterally. The L5-S1 facet joints were disarticulated bilaterally and the entire posterior arch of L5 was excised, exposing the cauda equina, the L5 and S1 nerve roots bilaterally. It was apparent that the orientation across the spine prior to reduction was almost vertical or perpendicular to the floor. *Decompression of bilateral L5 nerve roots and resection posterior arch of L5.* Complete laminectomy of posterior arch of 5, identification of traversing S1 nerve roots and exiting L5 nerve roots after complete laminectomy of posterior arch of L5, including dysplastic pars bilaterally. *$S^{4®}$ pedicle instrumentation L5–S1, with spondylolisthesis reduction instrument.* Pedicle screws were placed in L5 and in S1. A complete discectomy and end plate preparation was performed at L5-S1, prior to putting the $S^4$ SRI on each side, removing as much

disc as possible to facilitate subsequent distraction and reduction. There was about 75% anterolisthesis of L5 on S1 and the orientation of the disc space was almost cephalo-caudad as opposed to posterior-anterior. The S[4]® SRI was placed bilaterally over the screws and under direct vision of the cauda equina and exiting L5 nerve roots bilaterally along with motor and sensory neuromonitoring, the slip was reduced over about 15 minutes. The L5 nerve roots bilaterally were electrically and visually fine throughout the reduction period.

*Reduction of L5 onto S1 by about 90% and a TLIF at L5-S1 was completed utilizing a 13 mm PEEK cage, packed with demineralized bone matrix, as well as autologous bone graft and a BMP sponge.* One of the S[4] SRI jigs was removed to place autologous bone graft with a BMP sponge anteriorly in the disc space, followed by impacting a 13 mm cage filled with BMP and demineralized bone matrix. A 50 mm lordotic rod was placed on the side where the S[4] SRI jig was removed. Compression was effected across the L5-S1 screws and locked with locking caps, further reducing L5 on S1.

Bone admixed with demineralized bone matrix was placed posterolaterally between the transverse process of L5 and the sacral ala bilaterally. The surgery took approximately six hours. AP and lateral x-rays on sagittal fluoroscopy, using the C-Arm showed near complete reduction of L5 on S1. (Fig. 3, Fig. 4)

Gelfoam® was placed over the laminectomy defect. A Hemovac drain was placed deep and the deep fascia was closed with interrupted, figure-of-eight, #1 Vicryl. The skin was then closed with subcuticular stitches. Sterile dressings were then applied and the Hemovac drain was connected to suction. The patient was awakened, extubated and sent to Recovery in satisfactory condition. Blood loss was about 300 to 400 cc. Antibiotics were given during the case and scheduled to be given again PAR. Vital signs remained stable throughout the operation.

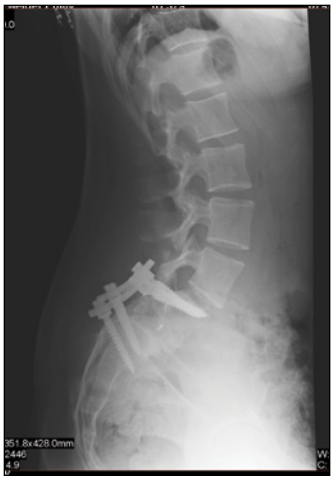

Fig. 3 Post-op

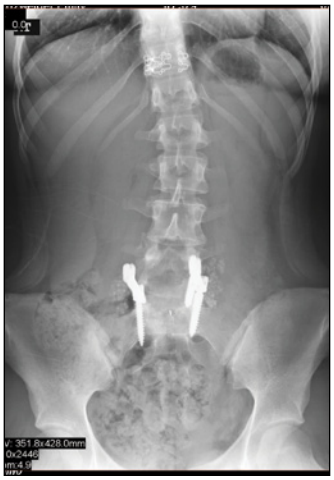

Fig. 4 Post-op

## Discussion

This was an interesting case with several treatment options: in-situ fusion with no hardware; instrumented in-situ posterolateral fusion; an instrumented interbody fusion; or an instrumented interbody fusion with reduction.

The decision was made to do an instrumented interbody fusion with reduction to support the anterior column during fusion and to restore sagittal balance and improve cosmesis. The goal was to reduce L5 on S1 for the above reasons. The treatment plan dictated a posterior operative procedure to correct the deformity and the sagittal instability. To successfully treat spondylolisthesis, the reduction maneuver must be precise and controlled to reduce the risk of possible nerve damage incurred during a free-hand reduction or with a reduction instrument inserted into the anterior disc space. To address the problem, the Aesculap S[4] Spinal System, specifically the specialty Spondylolisthesis Reduction Instrumentation, was used. A PEEK Cage at L5-S1 was also required for anterior column stability

## Device

### Aesculap Implant System's S[4] Spinal System Spondylolisthesis Reduction Instrument (SRI)

In this case, the Aesculap S[4] SRI, a complement of the Aesculap S[4] Spinal System, was necessary to facilitate simultaneous correction of translation and slip angle. It allowed reduction of L5 on S1 with ONLY a single-level fusion, sparing adjacent healthy motion segments. The S[4] SRI was very helpful in making the proper adjustment to bring the curvature of the spine back into normal sagittal alignment.

"The Aesculap S[4] SRI is very powerful instrumentation that allowed us to reduce the listhetic vertebral body along the same curved displacement route, minimizing interference with anatomical structures and eliminating neurologic deficits that might result from initial over- distraction of an already stretched nerve root. The Aesculap S[4] SRI enabled simultaneous reduction and distraction making it easier to use while reducing overall procedure time. The reduction maneuver was precise and controlled, and reduced the risk of inadvertent movements," said surgeon, Terrence Piper, MD.

The Aesculap Implant System's S4® Spinal System SRI is a reduction instrument for simultaneous translational and rotational correction of spondylolisthesis. (Fig. 5)

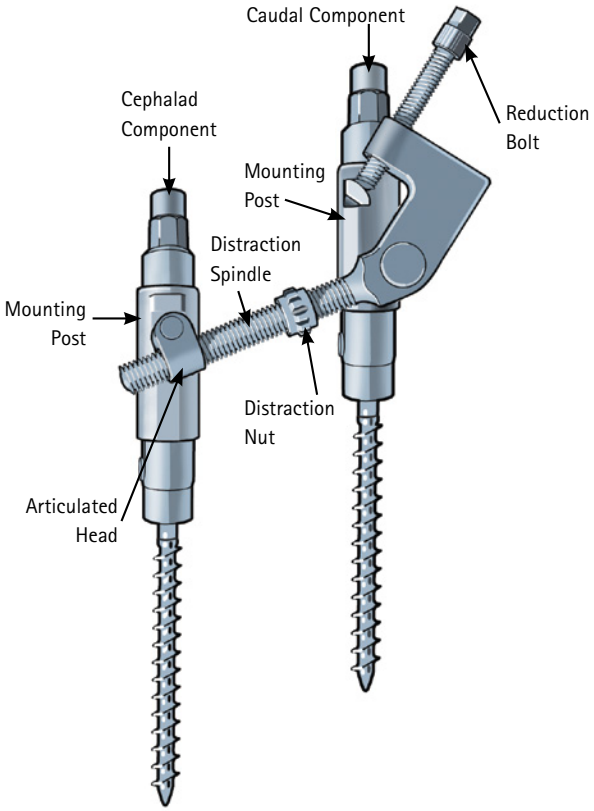


Fig. 5 S4 SRI

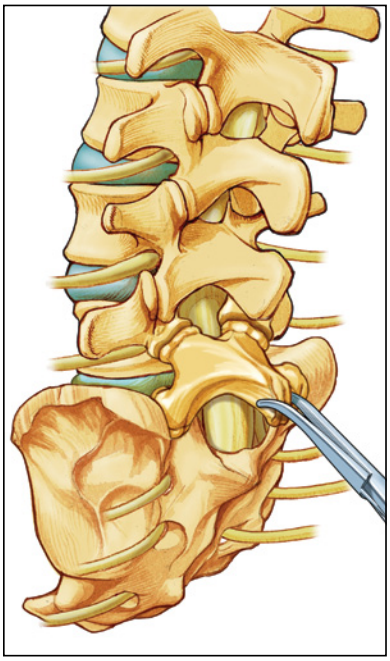

Fig. 6

In this surgery, the decompression was performed with a standard Gill Procedure, (Fig. 6) during which a complete resection of the posterior arch of L5 pars was done to fully decompress the exiting nerve roots.

The screws in the cephalad-vertebral body were placed parallel to its superior endplate. The caudal vertebra screws were placed parallel to the cephalad vertebra screws in both planes to

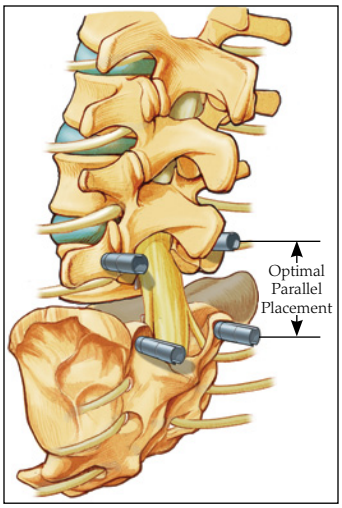


Fig. 7 Optimal Parallel Placement

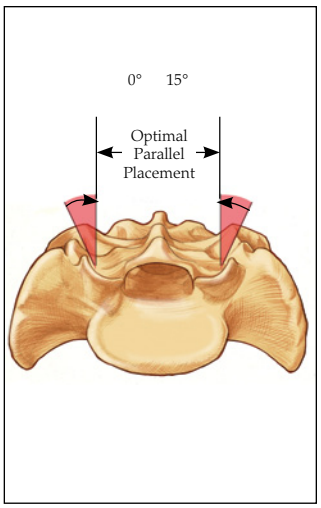


Fig. 8 Optimal Parallel Placement

allow for optimal operation of the reduction instrument and easier rod placement. (Fig. 7, Fig. 8)

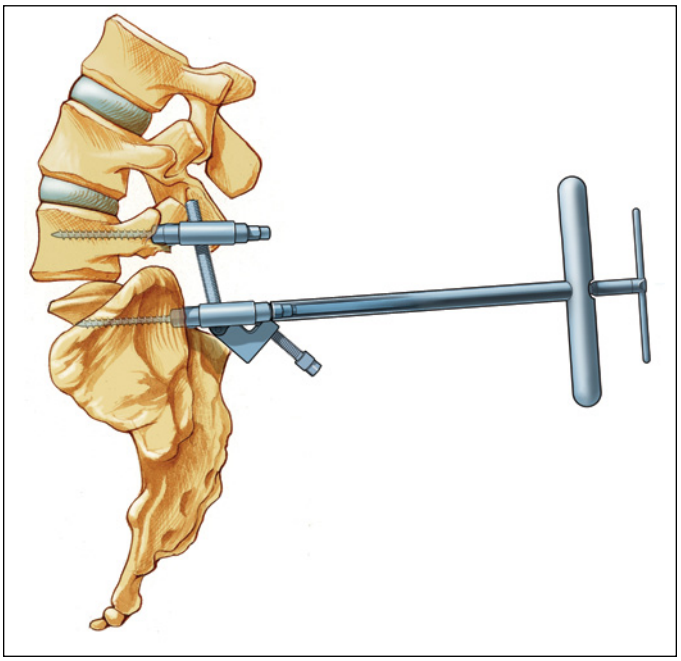

Fig. 9

Once the instrument was attached and positioned properly, the t-handles (Fig. 9) were used to advance the caudal and cephalad components together in an alternating fashion. Tightening of the SRI mounting post was accomplished by holding the smaller t-handle and using it to apply counter torque while tightening with the larger t-handle. The large outer t-handle on the reduction bolt was turned clockwise to reduce the spondylolisthesis under C-arm control (Fig. 10).

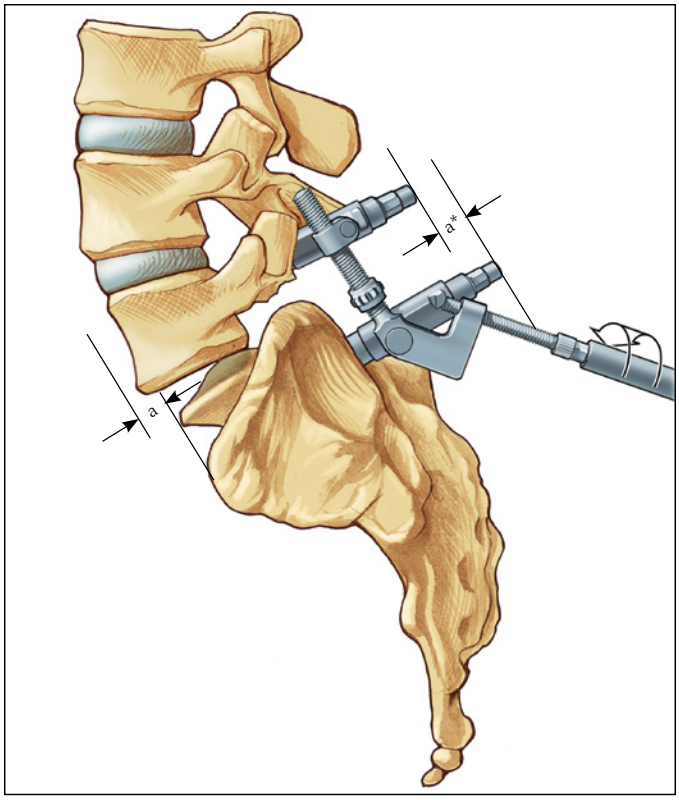


Fig. 10 *Screw depth should be adjusted to achieve a distance at least equal to the translation of the slip (Fig. 10 Distance a)

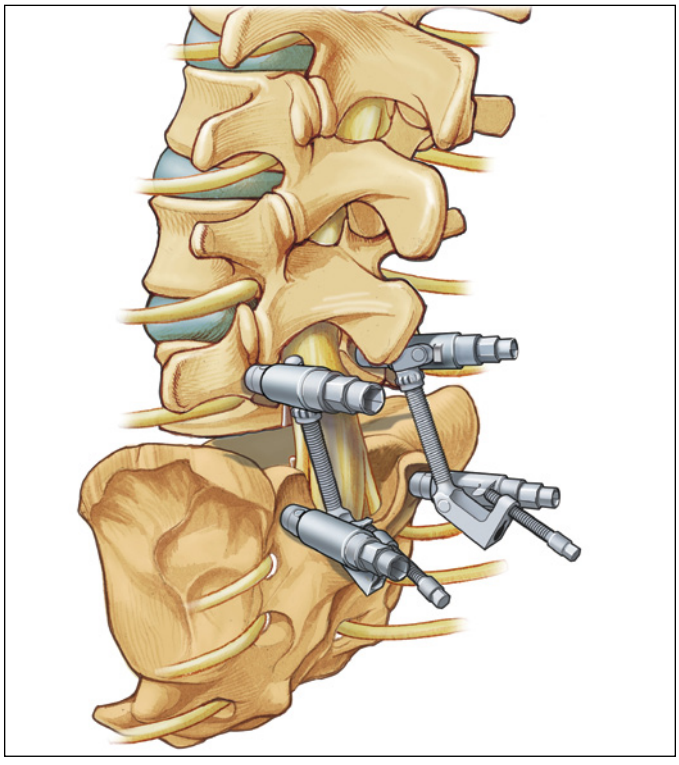

Fig. 11

The S4® distractor in the S4 Spinal System set was used to spread the S4 SRI device to achieve the desired distraction before locking the distraction in place with the distraction nut on the threaded distraction spindle. (Fig. 11)

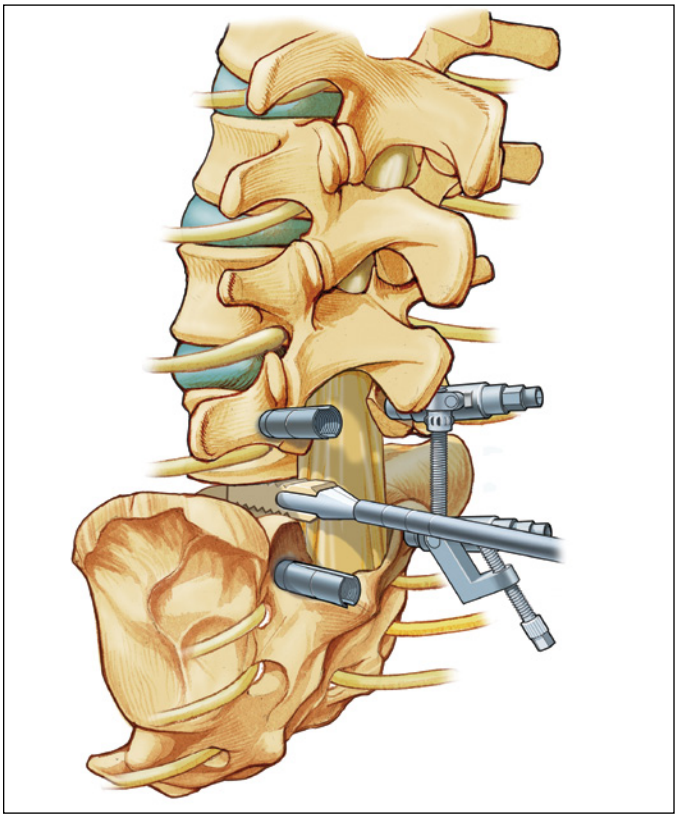

Fig. 12

The S4 SRI jig was removed from one side by applying counter torque with the t-handles and a routine TLIF was performed (Fig. 12) with the Aesculap TSpace® PEEK system.

## Outcome

After a 2-year follow up, the patient's grade III spondylolisthesis was almost completely reduced with bony fusion occurring at L5-S1. Her buttocks were less kyphotic and there was more of a normal lumbar lordosis. She sits, stands, ambulates without difficulty and is neurologically intact. There is no focal weakness and her leg and back pain have resolved. She is totally asymptomatic and has returned to full activities, including swimming the butterfly stroke.

## Physician Disclosure

Terrence L. Piper, MD, is the founder of Piper Spine Care in St. Peters, MO. Dr. Piper is a paid consultant for Aesculap Implant Systems, LLC.

## About Aesculap Implant Systems, LLC

Aesculap, a B. Braun company, founded in 1867 in Tuttlingen, Germany, is the world's largest and one of the most respected manufacturers of surgical instruments and sterilization container systems. Aesculap is a leading, privately-owned manufacturing company, passionately committed to providing high-quality, innovative products and services to all surgical disciplines, with particular focus in the fields of General, Neuro, Spine, and Orthopaedics.

Aesculap Implant Systems, LLC, established by Aesculap, Inc. in 2005, focuses on delivering innovative solutions to the spine and orthopaedic markets. Aesculap Implant Systems maintains a surgeon/patient focus with the goal of improved operative procedures and patient outcomes leading to an improved quality of life. For more information about Aesculap Implant Systems or its medical products, please call 1-800-234-9179, e-mail info@aesculap.com or visit www.AesculapImplantSystems.com.

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