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The Wilhelm Tell technique for anterior lumbar interbody fusion

Technical note

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Experience indicates that stand-alone cages may lack the necessary stability to secure highly unstable motion segments at the lumbosacral junction.

The authors have designed a special carbon fiber composite interbody cage that allows additional screw placement in anterior lumbar interbody fusion procedures performed at the lumbosacral junction.

KEY WORDS • spine • spinal instability • fusion • internal fixation • anterior lumbar interbody fusion

DER Apfel ist getroffen!" — "He's hit the apple! [Friedrich Schiller, Wilhelm Tell, Act Three, Scene Three.]

We have used CFCI cages for anterior cervical, anterior thoracic, and ALIF as well as for PLIF.[1,2,4,5] Interbody fusion is performed regularly with plate or screw/rod instrumentation with the exception of ALIF at the L4–5 and L5–S1 segments.

Because of experience indicating that stand-alone cages lead to a higher rate of nonunion than instrumented cages,[4,6–8] we have designed a special CFCI cage that allows additional screw fixation in ALIF procedures performed at the lumbosacral junction for highly unstable motion segments (Fig. 1).

It is the aim of this report to present the technique of this variant of ALIF with screw fixation: the novel Wilhelm Tell procedure.

Operative Technique

The day before the operation the patient's bowel is completely emptied. Before surgery, a ureteral catheter is introduced to facilitate intraoperative exposure of the lower anterior lumbar spine and the lumbosacral junction. General anesthesia is induced, and, with the patient supine, the operating table is bent to access the lumbosacral junction. A midline laparotomy between the navel and the symphysis is performed. The abdominal wall and muscles are displaced using retractors mounted on a ring. Thereafter, depending on the surgeon's preference, the approach to the lumbosacral junction may be transperitoneal or retroperitoneal. If the transperitoneal route is chosen, the abdominal contents are further retracted using towels and retractors. In this way the mesenterial root is exposed caudad to the bifurcation of the iliac vessels. Using fluoroscopy, the L5/S1 interspace is verified. The mesenterial layer of the sigmoid mesocolic attachment covering the anterior aspect of the L5–S1 segment, the middle sacral vessels, the L-5 vessels, lymphatic promontory tissue, and the anterior longitudinal ligament are transected and reflected back by using microtechniques (Wild Leica M 655 microscope; Leica, Switzerland). During exposure of the L5/S1 interspace, care is taken not to injure the nerve fibers of the superior hypogastric plexus. When making the retroperitoneal approach (midline or pararectal skin incision) the peritoneal sac is gently displaced (in most cases to the right

Abbreviations used in this paper: ALIF = anterior lumbar interbody fusion; CFCI = carbon fiber composite interbody; PLIF = posterior LIF.

side) and the exposure of the anterior aspect of the spine is achieved as described previously. This approach allows better visualization of the superior hypogastric plexus. When performing interbody fusion at the lumbosacral junction the exposed L5–S1 intervertebral disc is incised and totally removed. Bone spurs, if found, are removed and any unevenness of the endplates is corrected. After complete freshening of the endplates the appropriate "Wilhelm Tell" CFCI cage (Fig. 1 *upper*) matching the shape of the interspace (corresponding to 9 × 7 mm with 5° lordosis in most cases with discarthrotic instability and 13 × 7 mm, 13 × 9 mm up to 15 × 9 mm and 7, 9, or 13° in cases of isthmic spondylolisthesis with resection of the sacral dome) is filled with cancellous iliac bone graft (Fig. 1 *lower*) and inserted using a hammer. Using microtechniques the anterior aspect of the L-5 vertebral body is exposed as far rostral as the bifurcations of the great veins and arteries permit. The drilling of the canal and insertion of the screw is controlled under posterior and lateral C-arm fluoroscopy. The initial drilling point is in the upper third of the anterior wall of L-5 approximately 2 cm cephalad to the endplate of L-5. The bone canal is drilled in a oblique way vertically to the cage. The drill is directed through the large hole of the cage (Fig. 1 *upper*) and enters the posterior cortical layer of the sacrum. We begin drilling with a 3.5-mm and then a 4.5-mm mesh. A short threaded, spongious screw, usually between 60 and 95 mm long with a diameter of 6.5 mm, is inserted into this canal. In cases of fragile bone quality a washer can be mounted on the screw to prevent screw displacement into the vertebral body. Provided that there is solid purchase of the screw, it can also be placed in the cancellous part of the sacrum. The bowel is then replaced and the laparotomy is closed with an Everett loop suture.

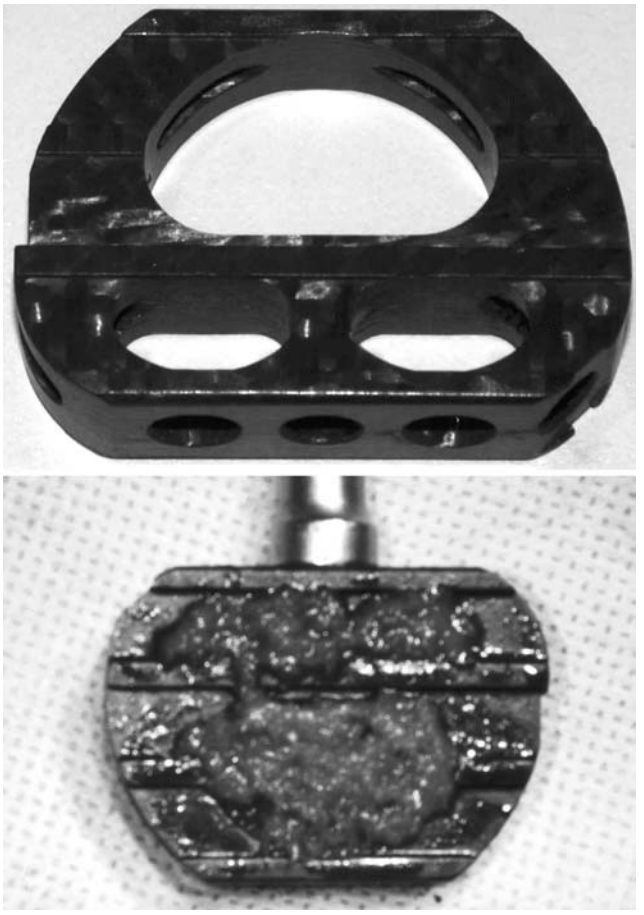

FIG. 1. Photograph of the ALIF Wilhelm Tell cage *(upper)* and the ALIF Wilhelm Tell cage filled with cancellous bone graft *(lower)*.

The Wilhelm Tell ALIF Cage

The Wilhelm Tell ALIF cage was designed by the authors in collaboration with the manufacturer (Fig. 1). It is a lumbar Osta-Pek cage (Co-Ligne AG, Zürich, Switzerland), measuring 9 × 7 mm, 5° for the L5/S1 interspace. Larger dimensions are used in cases of isthmic spondylolisthesis in which osteotomies of the sacral dome are performed to attain firm purchase on the sacral endplate.

Postoperative Treatment Protocol

Patients are allowed to eat after surgery as soon as normal bowel sounds indicate physiological peristalsis. Patients wear a plastic jacket or a soft-tissue brace for 3 months and the sitting position is restricted. Anteroposterior and lateral x-ray films are obtained after 6 and 12 weeks to assess cage and screw position as well as ossification within the CFCI cage (Fig. 2). Additional follow-up imaging studies are planned at 1 and 2 years after surgery, according to the multicenter cage study protocol.

Summary of Operative Cases

Twenty-three patients (10 women and 13 men) with an average age of 29.3 years (range 17–51 years) have thus far been treated with this technique at the L5/S1 level. The indications for internal fixation and fusion were complaints of spinal instability because of isthmic spondylolisthesis in 19 patients and discogenic destabilization of a lumbar motion segment in four. Five patients underwent surgery by means of a transperitoneal approach and 19 patients by means of a retroperitoneal approach.

To date, the results appear promising, with an average follow-up period 10.5 months (range 2–18 months). Fusion, based on clinical and radiographic observations, is progressing as would be expected for a 360° fusion technique.

Three patients required additional treatment. In one patient additional posterior fixation was required, probably because of high body weight (body mass index 34.03 kg/m^2) and insufficient stabilization provided by an anterior construct only. In another patient deep venous thrombosis of the left leg occurred; phlebography showed an obstruction of the venous system up to the left internal iliac vein, leaving the common iliac veins patent. In another patient we had problems with screw insertion because we were unable to sufficiently mobilize the vascular structures in front of the L-5 vertebra. Subsequently, in this patient, cage extrusion occurred. He underwent repeated surgery and the same cage was repositioned and fixed with a screw; however, despite operative support from a vascular surgeon, this was a risky procedure.

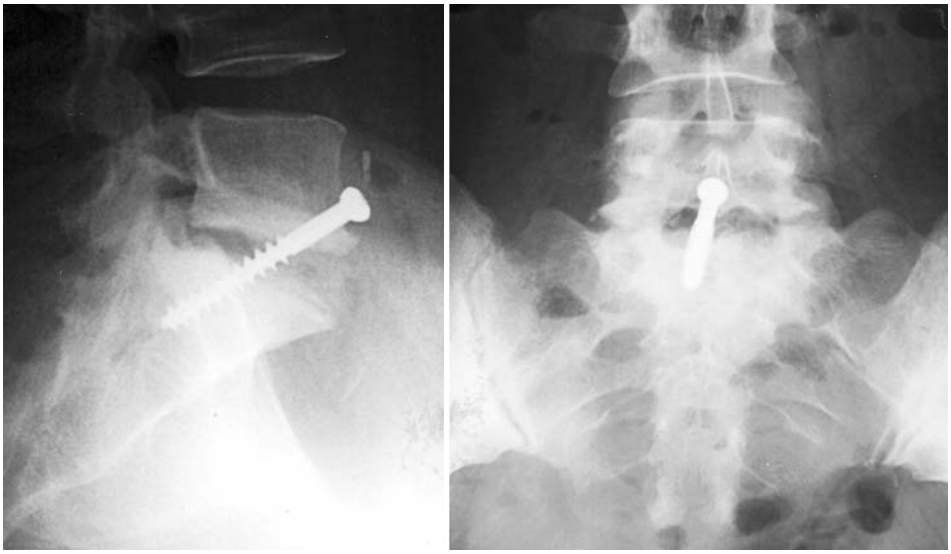

FIG. 2. Lateral *(left)* and anteroposterior *(right)* radiographs obtained 3 months after a Wilhelm Tell procedure.

Discussion

Until 1990, the Louis technique of anterior screw fixation for interbody fusion of the L4–5 segment or the lumbosacral junction[3] had been our surgical technique of choice for ALIF procedures at the L5–S1 and L4–5 segments. Briefly, the latter consists of inserting a large corticocancellous bone graft or fibular strut grafts into the intervertebral space and fixating the graft by using a screw that passes from the anterior superior edge of the upper vertebra down through the graft into the posterior wall of the lower vertebra.[3]

Since 1990, we have used the CFCI cage for ALIF. Laloux and colleagues[1,2] have reported on a series of 244 patients who underwent ALIF procedures in which this type of interbody fusion cage was used, with a very high rate of fusion. Additional posterior instrumentation was required in 50% of these patients, however, mostly because of highly unstable isthmic spondylolisthesis.

For highly unstable conditions it became desirable to use the Louis anterior screw fixation technique with a cage to avoid having to perform a subsequent pedicle fixation approach. Furthermore, the authors hoped this would avoid cage dislocation and pseudarthrosis formation found after stand-alone cage procedures.[4,6]

A review of the literature concerning the biomechanics of stand-alone ALIF cages in human cadaveric specimens[6] led to the following observations: intervertebral motion was reduced for flexion, extension, axial rotation, and lateral bending to 60, 0, 60, and 50% of the intact motion, respectively. To fuse a highly unstable motion segment, these data demonstrate the need to add instrumentation to an ALIF cage. Our CFCI cage, which is designed to accommodate screw fixation, achieves this goal entirely by using the anterior approach (Fig. 1). The screw maintains rotatory stability in the y axis by forcing the ridges of the cage into the adjacent endplates. By analogy to the Swiss saga interpreted by the poet Friedrich Schiller the screw has to pass through the hole of the cage in the same way as Wilhelm Tell's arrow had to hit the apple placed on the head of his son (Etienne Laloux).

Anterior lumbar interbody fusion surgery of the lower lumbar spine is associated with numerous early and late complications such as vascular ruptures, lesions of the superior hypogastric plexus, bowel perforation, postoperative paralytic ileus, formation of bowel adhesions with additional consequences later in life, venous thrombosis in the lower extremities, and subsequent lung embolism, as was the case in one of our patients.

These complications are mainly in relation to the operative approach and handling of the prevertebral structures. They can be considerably reduced through the use of

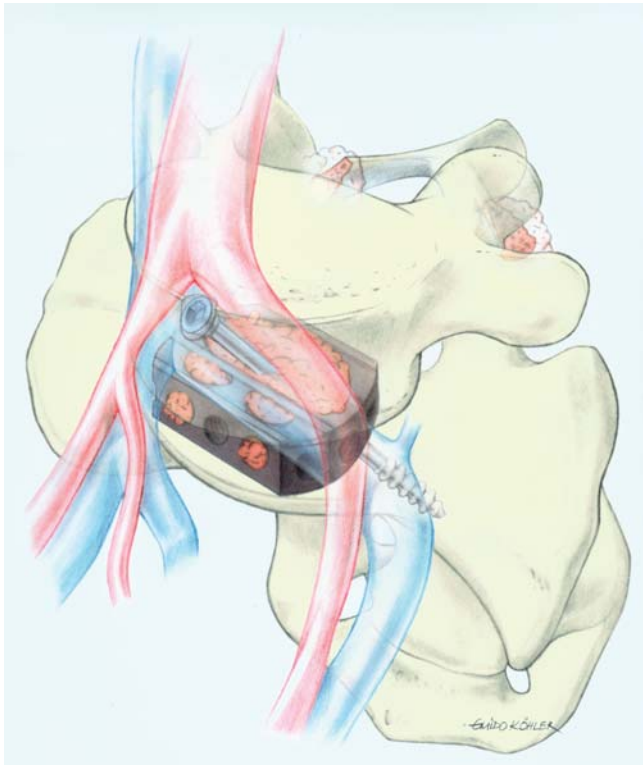

FIG. 3. Artist's drawing of a Wilhelm Tell construct.

microtechniques that allow a surgeon to recognize and avoid injury to the vascular and neural structures in the retroperitoneal space. To avoid late erosion of a vessel, attention must be paid to embedding the head of the screw into the anterior wall of the vertebra if vascular structures come in direct contact with the implant.

Although it is desirable to use a minimally invasive approach, the insertion of the screw often requires cranial extension of the wound incision to enable the surgeon to expose the anterior upper third of the anterior wall of L-5. As an alternative, the screw can be introduced through a separate skin incision. The latter allows the correct oblique angle (~ 45°) for screw insertion. Attention must be paid to avoid a vascular laceration or a bowel injury during screw fixation. The open view is probably mandatory for this procedure.

We understand there are limitations to this technique when using fluoroscopy. The surgeon must imagine with precision a three-dimensional placement of the screw. Spine surgeons are also confronted with similar dangers when performing an anterior screw fixation for an odontoid fracture. Years ago, the same concerns were voiced about pedicle fixation; both techniques today are routine. We believe our technique deserves exploration. Furthermore, we are confronted with a considerable number of patients with discogenic instability of the lower lumbar spine in whom a posterior approach will create unneccessary lesions to the posterior soft-tissue structures, such as the muscular apparatus. We have had no experience with the Wilhelm Tell technique at L4–5 until now but we have successfully used the anterior screw fixation technique, according to Louis, at that segment in the past in combination with fibular strut grafts.

In conclusion, we recommend, even if technically demanding, performing an ALIF at L5–S1 by using a cage with additional screw fixation. This technique is reserved for patients with a highly unstable motion segment in whom circumferential anterior and posterior fixation would be the alternative surgical method. Our technical variant is contraindicated in osteoporotic patients because of the risk of insufficient screw purchase. Although this technique shows promise, our series is small. The treatment of more patients with longer follow-up evaluation will be required to determine the safety and usefulness of the Wilhelm Tell cage procedure (Fig. 3).

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Disclosure

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