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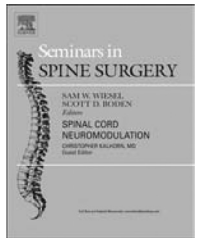

Vertebral body resection and lumbar corpectomies

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ABSTRACT

Corpectomies in the lumbar spine are unique operations with important and well-deserving nuances that determine their ultimate safety and efficacy. Lumbar vertebral resections are indicated in deformity and non-deformity settings. For deformities, they are reserved for those that are severe and rigid. Infections, fractures, and tumors that compromise the weight-bearing capacity of the anterior and middle columns of the spine are also indicated for lumbar vertebrectomy. Anterior column structural support is required in non-deformity situations and may be accomplished with the use of polymethyl methacrylate (PMMA) cement, osseous strut grafts (i.e. allografts/autograft), or titanium cages (static vs. expandable). The newest generation of cages have wide, rectangular footprints that span the apophyseal ring and provide a sound biomechanical environment and minimize the risk of cage subsidence compared to those with circular footprints. Neural decompression and placement of structural support can be accomplished by a variety of surgical approaches. While a traditional anterior approach is the gold-standard for lumbar vertebrectomies, minimally invasive lateral approaches and a posterior-only approach are viable management strategies. Supplemental fixation is also required and may be achieved with anterior-only instrumentation, posterior-only instrumentation, and circumferential instrumentation. In the review to follow, an evidence-based approach will be used to outline appropriate indications, surgical technique, and concomitant reconstructive and stabilization options for lumbar corpectomies. The discussion to follow ideally will help optimize outcomes for patients treated with vertebral resection and lumbar corpectomies in the lumbar spine.

1. Introduction

Corpectomies and vertebral column resections of the lumbar spine are important tools in the spine surgeon's surgical armamentarium. Currently, lumbar vertebrectomies are indicated for severe and rigid coronal and sagittal spinal deformities and pathology that jeopardizes the weight-bearing capacity of the anterior and middle columns of the spine (i.e. infections, fractures, and tumors). Refinements in surgical approaches and advances in spinal instrumentation over the last 50 years have made performing a lumbar vertebrectomy safer and more durable. In the discussion to follow, we present a comprehensive and evidence-based review of the indications and various surgical techniques and approaches for lumbar corpectomies. A particular focus will be paid to unique attributes of and technologic advancements in reconstructive and stabilization options for these diverse, complex, and important operations.

2. Anterior techniques

2.1. *Surgical approach & decompressions*

Pathology of the lumbar spine's vertebral bodies was first and traditionally removed surgically via one of four anterior approaches. Choice of anterior surgical approach is dictated by the level at which the pathology is located and unique adjacent visceral and neurovascular structures. For example,

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for disorders that afflict the most caudal segment of the lumbar spine (L5) a traditional transperitoneal or retroperitoneal approach via Pfannensteil or paramedian incisions should be utilized (Fig. 1). While these two approaches may be used to address anteriorly-based pathology more cranially (i.e. L3 and L4), accessing levels cranial to L3 with this approach is not possible given that the renal vasculature branches from the major vessels and crosses the spine around L2. The gold-standard to perform corpectomies at L4 or more cranially is the anterolateral retroperitoneal approach, as it allows excellent visualization of anatomy and direct decompression of neural elements (Fig. 2). However, it may result in significant morbidity, including incisional pain, excessive blood loss, and permanent injuries to the diaphragm and abdominal wall.[1,2] Therefore, "mini-open" surgical techniques that employ tubular retractors to access the retroperitoneal space have been developed and utilized safely and effectively to perform lumbar corpectomies[2–7] (Fig. 2). For example, in a case series of patients with burst fractures at L1-L3 treated with a mini-open, lateral, trans-psoas corpectomy, Theologis et al. reported good physical and mental health outcomes post-operatively, no approach-related complications, and an average incision length of 6.4 cm (range, 5-8 cm) that caused mild pain/disability and was aesthetically acceptable to the large majority of patients [6]. It is important to note; however, that the trans-psoas, lateral approach should not be used to perform lumbar corpectomies at L4 or L5 given the potential risks of lumbar plexus and neurovascular (i.e. iliolumbar, common iliac) injuries.

After the appropriate vertebra is accessed anteriorly, performing the vertebrectomy proceeds through a series of several common steps that may be performed in a variety of sequences. To successfully perform a lumbar corpectomy via an anterior approach, complete discectomies above and below the disease vertebra are removed. This is followed by removal of the osseous body using a rongeur, burr, and/or curettes. In the setting of tumors, infection, and fractures with concomitant neurologic compromise from anterior compression, the retropulsed/diseased posterior wall is removed to alleviate pressure on the neurological elements. The anterior wall is rarely removed so as to minimize risk to the major vessels anteriorly. Alternatively, the anterior and posterior walls are routinely removed in their entirety when performing an anterior corpectomy for deformity correction as the first stage in a VCR.

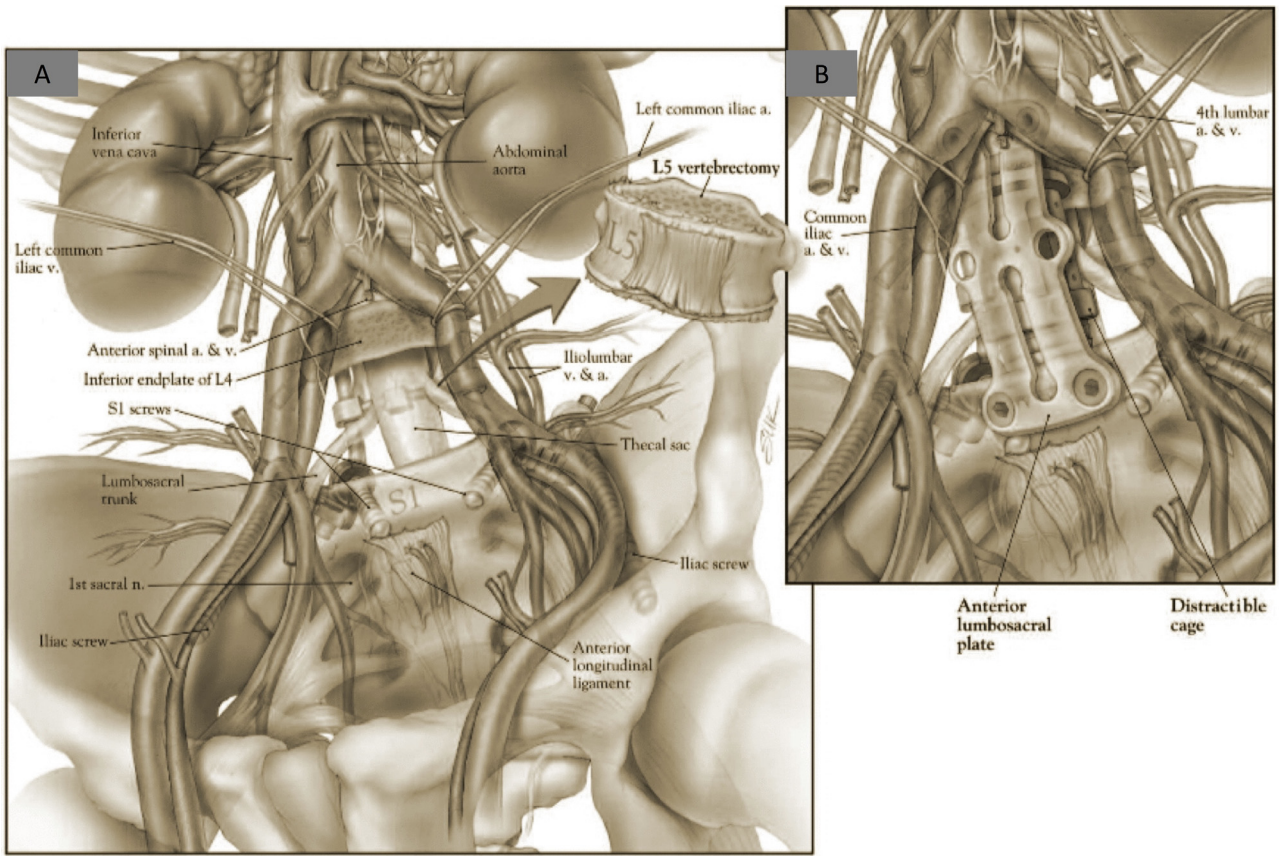

Fig. 1 – Illustrations of relevant adjacent neurovascular structures during corpectomy and anterior reconstruction of L5 performed via a transperitoneal or retroperitoneal approach (A, B). Note that adequate resection and reconstruction of the L5 vertebra is performed between the common iliac vessels. (B) Anterior reconstruction can be accomplished with a titanium expandable cage and anterior plate, as shown. Other reconstructive options include osseous strut grafting, cages, and cement. Anterior plating is optional if posterior stabilization is also performed concomitantly. [Reprinted with submission from *J Neurosurg Spine*. 2007;(1):103-11[60]].

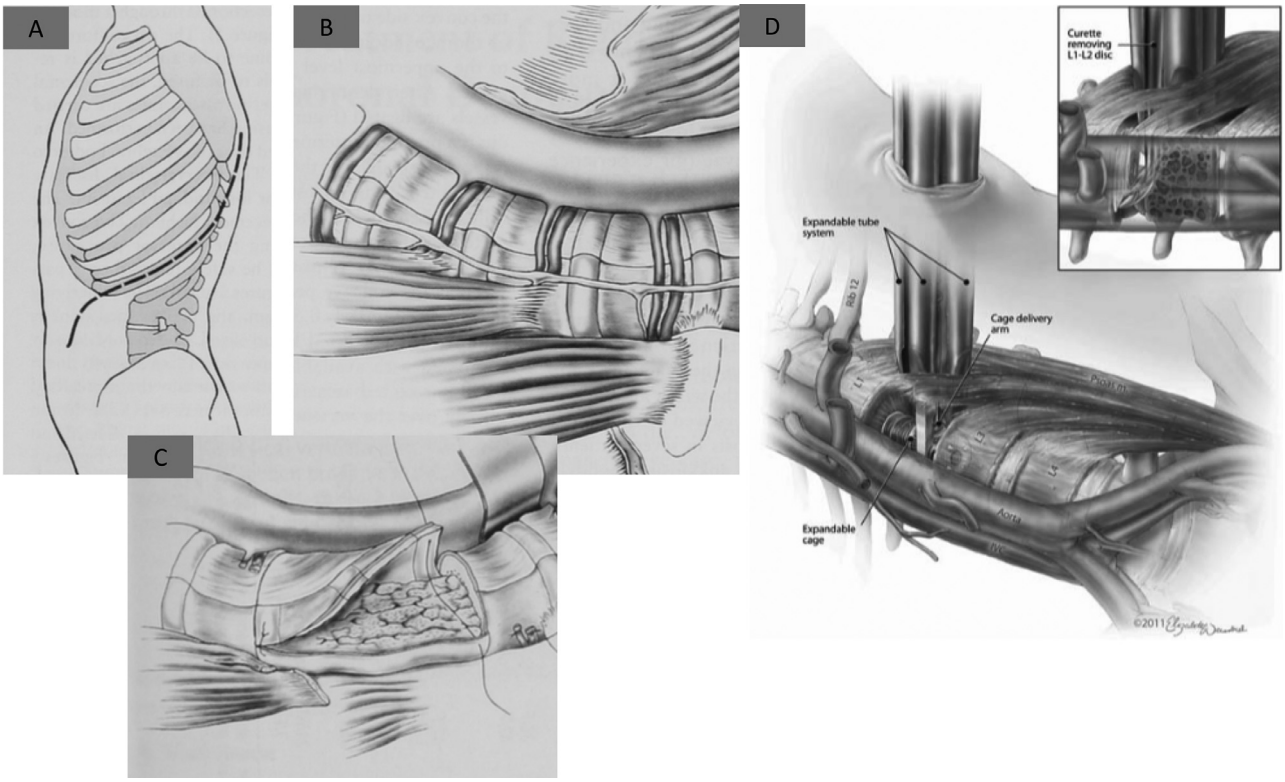

Fig. 2 – Pictorial representations of the incision of the traditional anterolateral approach to the retroperitoneum and mid-lumbar and upper lumbar spine (A). Note the visualization of surgical anatomy afforded by this approach (B). When used for deformity correction, no structural support is desired for the anterior column. Instead, morselized bone graft is placed in the vertebrectomy site to induce fusion and allow shortening through the defect (C). An alternative to the traditional anterior approach, is the mini-open, lateral, trans-psoas retroperitoneal approach performed through tubular retractors, as depicted pictorially (D). Compared to the traditional approach, incision size and approach-related complications are minimized. [A-C: reprinted with submission from *Spine(Phila Pa 1976)* 1997;22:1590-1599[61]. D: reprinted with submission from *J Spinal Disord Tech* 2015;28(2):53-60[7]].

2.2. *Anterior column reconstruction*

Structural support of the anterior column is required to stabilize and maintain height and alignment of the spinal segment after removal of a lumbar vertebra. James et al. reported that 60% of a motion segments stability in flexion depends on the integrity of the anterior load-bearing column.[8] As such, early attempts at anterior spine surgery that involved no anterior column structural reconstruction/support resulted in progressive deformity from postoperative instability.[9] The exception to this is when a lumbar corpectomy is performed as the first stage of a VCR for deformity correction because shortening through the corpectomy site is what allows for deformity correction. In this case, the vertebrectomy site is filled with morselized bone graft and not a structural graft (Fig. 2).

Support of the anterior column was traditionally accomplished with osseous strut grafts. The two most common options for osseous grafts are tricortical iliac crest and allograft (i.e. rib, femur, fibula). Autograft is considered the gold-standard, as it has consistently been shown to provide higher rates of fusion than allografts. However, autograft has several important associated limitations, including pain, neural injury, loss of structural support, risk of soft-tissue herniation, infection, and the possibility of a limited quantity for adequate reconstruction.[10–12] Additionally, rib autografts are not structurally sufficient in the lumbar spine, except if combined with another osseous strut graft.[11,13] As allograft struts circumvented the need to harvest autograft and provided a larger supply and more size and shape options, they were initially thought to be a viable alternative to autograft. However, their disadvantages (i.e. slower vascular penetration, longer fusion times, immunologic host rejection, risk of disease transmission, graft fracture) made it apparent that osseous strut grafts were not ideal reconstructive material in all circumstances of lumbar corpectomies.[12,14]

Over the last two decades, synthetic vertebral body replacements (VBR) made of titanium and other inert materials were designed to address the limitations with osseous strut grafts. All of these cages provide axial load-bearing capacity for the anterior column and have a central canal in which morselized bone graft can be placed and through which fusion can be achieved. Two generations of VBRs exist (Fig. 3). The first generation are “static” cages, as they are manufactured in premade lengths and diameters that can be cut to the appropriate height and sagittal plane of a corpectomy site (Fig. 3). The second generation of VBR cages are considered

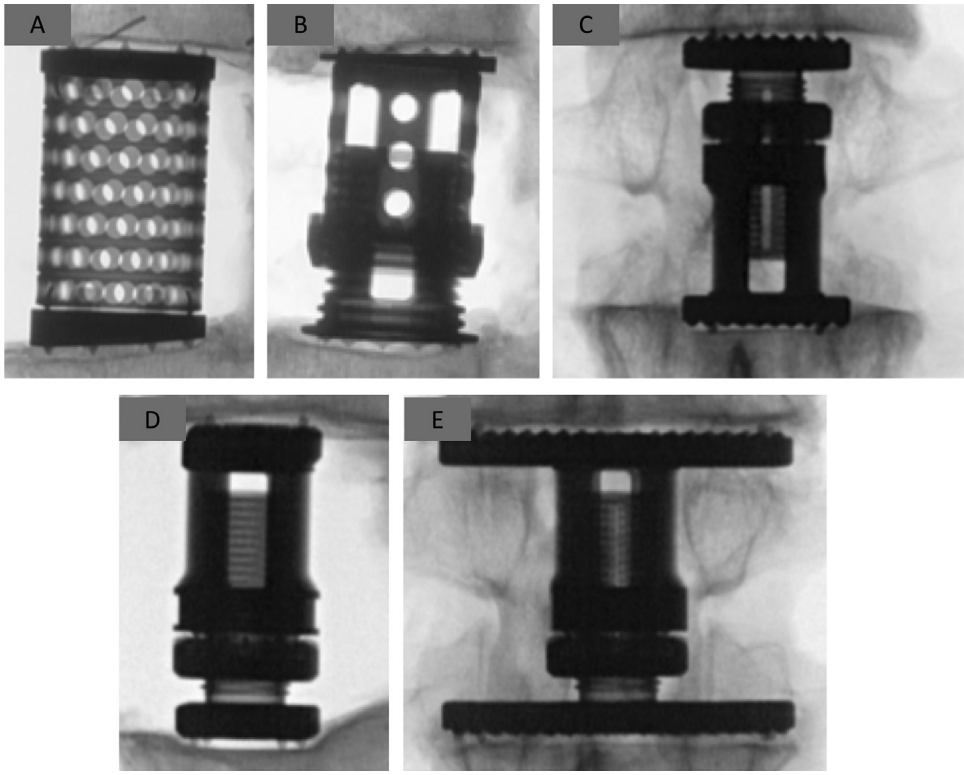

Fig. 3 – Radiographic examples of the various generations of interbody titanium cages for lumbar anterior column reconstruction. First generation cages were considered "static" (A). Second generation cages are considered "dynamic", as they are expandable *in vivo* (B-E). Original designs of expandable cages have circular footprints (B, C); while newest iterations of expandable cages have wide, rectangular footprints that span the apophyseal ring (D,E). [A, B: reprinted with permission from *J Neurosurg Spine*. 2012 Oct;17(4):321-6[16]; C-E: reprinted with permission from *J Clin Neurosci*. 2014 Sep;21(9):1632-6[24]].

"dynamic", as they can be expanded *in vivo* (Fig. 3). This gives them more versatility than first generation VBRs. In cadavers with L1 corpectomies reconstructed with one of three expandable cages or a static cage and stabilized with an anterior plate, Pflugmacher et al. found no significant differences between properties of expandable and static VBR cages and no differences in different designs of expandable VBR cages.[15] However, Pekmezci et al. found that expandable cages have higher contact area, higher endplate forces, and higher subsidence rates than fixed cages in cadaveric L1 and L4 corpectomy models.[16,17] As expansion torque did not correlate with final endplate forces and edge loading risks subsidence and intraoperative endplate fracture, it was advised that surgeons not solely rely on tactile feedback during deployment of expandable cages.[16,17] It is important to note that these studies were performed using cages with cylindrical endplates. As strength of endplates is not distributed evenly and that the periphery of the endplate (posterolateral) has been shown to be stronger than the endplate's center (Fig. 4), the ideal interbody implant should rest upon the endplate's periphery.[18–23] An expandable cage with a rectangular footplate has been designed to span the ring apophysis to accomplish this goal. In an *ex vivo* biomechanical analysis, Pekmezci et al. found that an expandable cage with a rectangular footplate was more resistant to subsidence than a cage with a circular footplate.[19] This was corroborated by Deukmedjian et al.[24] Additionally, it has been noted that the rectangular footprint design had higher load to failure, even in the presence of a central defect in the endplate.[19] Clinically, expandable cages with wide, rectangular endplates have been shown to have significantly lower rates of subsidence than cylindrical

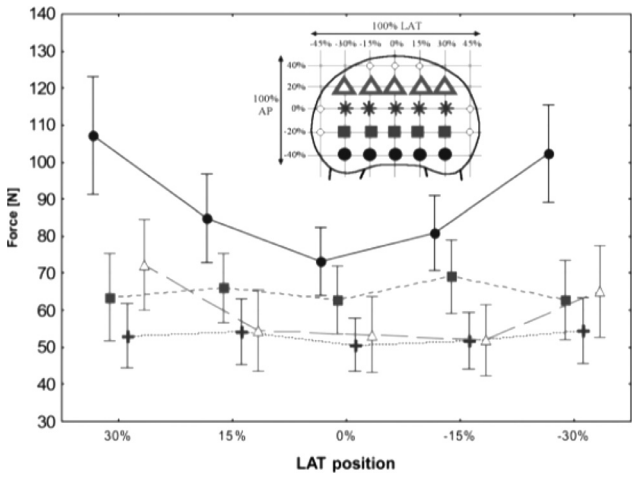

Fig. 4 – Graphical data demonstrating varying strengths of the lumbar spine's endplates. Note that the strongest areas of the endplate are located laterally, particularly posterolaterally. [Reprinted with permission from *Spine(Phila Pa 1976)* 2011;36:124–8[18]].

expandable cages.[6,25,26] For example, Smith et al. noted a subsidence rate of 13.5% for cylindrical cages compared to 0% for cages with wide, rectangular endplates in 52 patients with thoracolumbar burst fractures.[25] Additionally, the only cage subsidence requiring revision surgery in the cohort of patients with lumbar burst fractures presented by Theologis et al. occurred in an osteoporotic patient who had undergone corpectomy and anterior reconstruction with a telescoping cage whose footprint was smaller than adjacent endplates[6] (Fig. 5).

2.3. *Stabilization*

Supplemental stabilization of anteriorly reconstructed lumbar corpectomies is essential for maintaining appropriate alignment and achieving fusion. In a canine model, Zdeblick et al. reported 100% pseudarthrosis rate of lumbar corpectomies reconstructed with an osseous strut graft without supplemental fixation.[27] Supplemental fixation can be achieved with a variety of instrumentation types, which include: anterior-only plating, anterior-only rod/screw systems, posterior-only segmental fixation, and circumferential fixation using anterior and posterior instrumentation. Examples of anterior plates include, but are not limited to, the Anterior Thoracolumbar Locking Plate (ATLP) (Synthes), Z-Plate (Sofamor-Danek, Medtronic), Profile plate (Depuy), Texas Scottish Rite Hospital (TSRH) plate, University Anterior Plating System (Acromed, Inc.), and the macTL implant system (Aesculap).[14,28–32] Dick et al. reported a significantly higher fatigue life for the ATLP and Z-Plate than for the Profile and TSRH plates.[29] Anterior rod/screw instrumentation consists of single rod constructs (Dwyer, Zielke) and double-rod constructs with or without cross-connectors (Ventrofix, Kaneda, ALC).[28] In an *in vitro* L1 corpectomy model, Reddy et al. found that a single-rod construct is significantly less rigid in axial rotation and that dual-rod constructs with or without cross-connectors behaved biomechanically similar to an intact spine.[33] Comparing different plate types and rod/screw systems in an *in vitro* biomechanical model of simulated vertebral corpectomies, Brodke et al. found that load sharing and implant style (rod *v.* plate) were not correlated and that stiffness varied by instrumentation system rather than by plate/rod design.[28]

Clinically, stabilization of a lumbar corpectomy site via an anterior approach using anterior-only instrumentation is attractive, as it allows one to avoid a second surgical procedure and increased physiological burden on a patient. Sasso et al. noted a 95% fusion rate and clinical success for

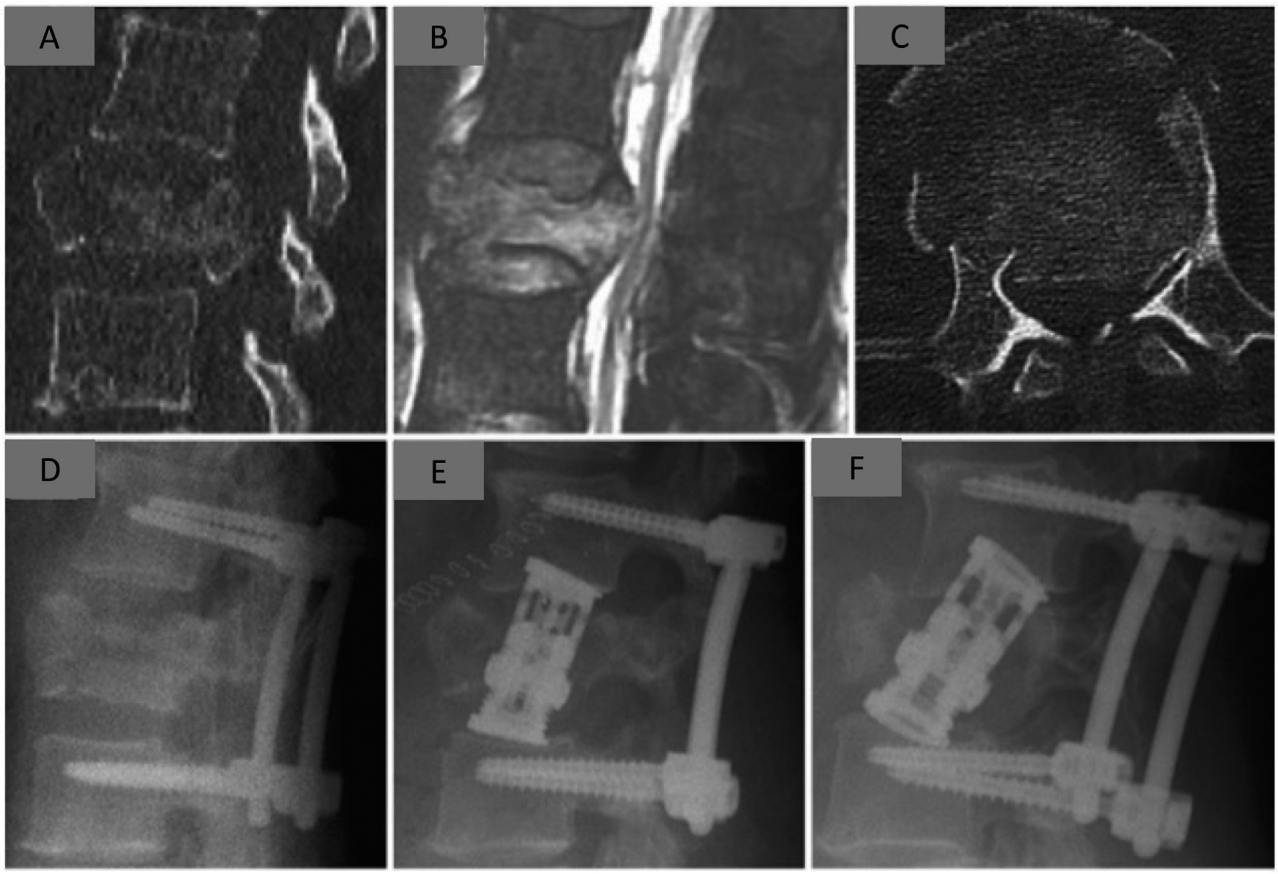

Fig. 5 – Imaging of an elderly woman who sustained a L3 burst fracture without neurologic deficits (A–C). After percutaneous posterior, short-segment instrumentation (D), anterior column reconstruction with an expandable cage with circular footprints was performed via a mini-open, lateral, transpsoas approach (E). Two weeks post-operatively, endplate fracture and subsequent cage subsidence were noted (E,F) that ultimately required a revision and extension of her posterior instrumentation. She healed uneventfully thereafter. [Reprinted with permission from *J Neurosurg Spine*. 2016 Jan;24(1):60-8[6]].

3-column unstable thoracolumbar injuries treated with an anterior-only approach (decompression, reconstruction, instrumentation/stabilization).[31] However, several authors have raised concerns about the biomechanical suitability of anterior-only instrumentation in the setting of anteriorly reconstructed lumbar corpectomies.[15,30] Harris et al. cautioned against their use, as anterior plates significantly decreased compression through the corpectomy site graft, which was felt to be a contributing factor to pseudarthrosis and device-related osteoporosis.[34] Additionally, in cadavers with L1 corpectomies reconstructed with osseous strut grafts and stabilized with anterior plates, *Schreiber et al.* observed a sufficient reduction in flexion/extension and lateral bending, but an increase in range of motion in the axial plane, which was thought to increase the risk of loosening of the anterior plate before union.[30] As such, they recommended that an additional posterior fixation device be considered in this setting.[30] In a similar experimental set-up, Pflugmacher et al. also reported that isolated stabilization with anterior plates combined with expandable cages with circular footprints was not able to restore normal stability of the motion segment (decreased stiffness and increased range of motion in all directions).[15] Therefore, it was recommended that the isolated use of anterior stabilization of cages with circular endplates should not be used for vertebral body replacement in the thoracolumbar spine.[15] However, Mundis et al. observed that supplemental stabilization of expandable cages with wide, rectangular footprints with only anterior plates restored rigidity in all directions to an intact spine.[35] This was similar to stabilization with posterior-only constructs, suggesting that anterior-only stabilization and reconstruction with plates and cages with wide, rectangular endplates may be the most suitable anterior-only combination for lumbar corpectomies.[35]

Supplemental posterior fixation is an important option for stabilization of anteriorly decompressed and reconstructed lumbar corpectomies. Posterior instrumentation can be used in isolation for stabilization (i.e. no anterior plate) or it can be used to complement stabilization of an anterior plate to achieve circumferential stabilization. While posterior instrumentation after an anteriorly approached lumbar corpectomy requires a second operation, posterior fixation in either setting has several benefits. Circumferential stabilization has consistently been shown to provide the most biomechanically robust environment after an anteriorly approached lumbar corpectomy.[9,15,35–39] Ideally, bilateral segmental posterior instrumentation should be the goal when attempting to achieve circumferential stabilization. However, if bilateral fixation is not achievable, Bishop et al. noted that unilateral posterior instrumentation (ipsilateral or contralateral to the plate) can provide additional stability to an anterior-plate construct.[9] Although circumferential stabilization is ideal, the use of anterior plates can be time-consuming, costly, difficult to achieve (i.e. lumbosacral junction), and associated with acute or delayed vascular complications. Thus, understanding the biomechanical suitability of posterior-only stabilization after an anteriorly approached lumbar corpectomy is important.

Biomechanical results of stabilization of anteriorly reconstructed lumbar corpectomies with posterior-only instrumentation is mixed. Schultheiss et al. found that a strut graft experienced no axial compression during maximal extension when stabilized with posterior instrumentation.[40] For expandable cages with circular footprints stabilized with bilateral pedicle screws, Bishop et al. reported significantly higher flexion/extension than intact spines and anterior-only plates.[9] Knop et al. also observed that posterior fixation offered superior stability compared to anterior-only plate stabilization for L1 corpectomies[41] (static and expandable cages). Furthermore, after a L2 vertebrectomy, Vahldiek et al. demonstrated that anterior instrumentation showed greater motion than the intact spine (especially axial rotation), while posterior instrumentation had greater rigidity than anterior instrumentation, especially in flexion-extension (2.1^0 *v.* 12.6^0).[37] For expandable cages with wide, rectangular endplates that span the apophyseal ring in a L1 corpectomy model, Mundis et al. reported that posterior-only stabilization resulted in greater rigidity than the intact spine in all directions.[35] Clinically, no study has documented failure of expandable cages with wide, rectangular footprints stabilized with posterior instrumentation placed open or percutaneously.[6,25] The same cannot be said for circular cages stabilized with posterior-only instrumentation[6,25] (Fig. 5). While the aforementioned discrepancies in biomechanical and clinical results are likely a result of differences in experimental design, injury models, testing parameters, instrumentation, and interbody reconstruction, stabilization of anteriorly reconstructed lumbar corpectomies with posterior-only instrumentation performed percutaneously or open is a durable option, particularly with cages that have wide, rectangular endplates that span the apophyseal ring (Fig. 6).

3. Posterior techniques

A posterior-only approach is another option to perform lumbar corpectomies. For adult and pediatric deformities, a posterior-only approach for vertebral resection is a well-established and accepted surgical technique to address both rigid coronal and sagittal deformities of the lumbar spine.[42–47] Lumbar hemivertebra excision, albeit only a variant of a corpectomy, performed via a posterior-only approach has been performed since the 1990s.[47] In 2002 Suk et al. first reported the use of posterior-only vertebral column resection for pediatric and adult thoracolumbar deformities.[48] In 2005, Suk et al. presented a case series of patients treated safely and effectively with a posterior-only approach for rigid lumbosacral deformities.[46] This approach is feasible for deformity correction, as placement of structural support into the vertebrectomy site was neither required nor desired. However, many have been less enthusiastic about performing corpectomies through a posterior-only approach for non-deformity pathology of the lumbar spine (i.e. tumor, trauma, and infection) given concerns about inadequate neural decompression and apprehensions about reconstructing the weight-bearing capacity of the anterior column adequately and safely.

Placement of appropriately-sized cages and osseous strut grafts anteriorly between the lumbar nerve roots was historically not felt to be possible. As such, initial attempts at lumbar corpectomies via a posterior-only approach utilized polymethyl methacrylate (PMMA) cement and wires/

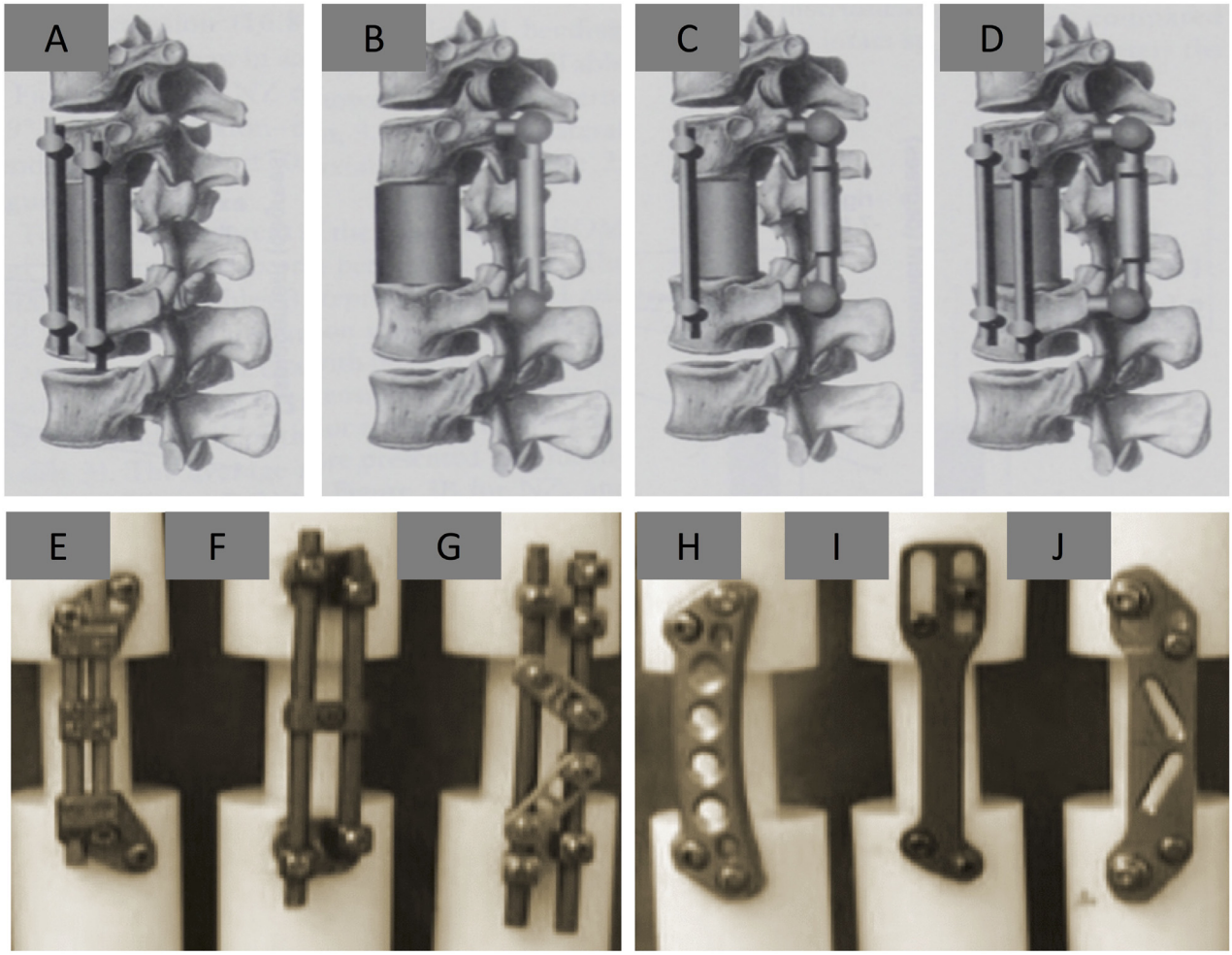

Fig. 6 – Pictorial examples of various stabilization options for lumbar corpectomies. Anterior-only instrumentation with rod/screw construct (A). Posterior-only instrumentation (B). Circumferential stabilization accomplished with either a single (C) or double (D) anterior rod/screw instrumentation. Examples of double rod/screw anterior instrumentation (E-G) (E: Synthes Ventrofix; F: Acromed Kaneda Device; G: Acromed ALC). In addition to anterior rod/screw constructs, anterior stabilization can be achieved with a variety of anterior plates (H-J) (H: Synthes ATLP; I: Sofamor-Danek Z-Plate; J: DePuy Profile). [A-D: reprinted with permission from *Spine(Phila Pa 1976)* 1998;23(5):543-50 [37]. E-J: reprinted with permission from *Spine(Phila Pa 1976)* 2003;23(5):543–550[28]].

pins.[49–52] In a human cadaveric corpectomy model stabilized with multilevel posterior pedicle screw instrumentation, Shannon et al. found that anteriorly placed PMMA/pins provided more stability than anterior plating and rib graft reconstruction in compression and flexion testing.[49] Clinically, several authors have presented good results with PMMA reconstruction.[50–52] For example, in a case series of 25 patients with metastatic disease reconstructed with PMMA cement, Bilsky et al. reported immediate stability in all patients, significant pain relief, and improvement or stabilization of neurologic symptoms in 92% of the patients.[50] No cement-related complications were reported.[50] Elarky et al. found no differences in pain, kyphosis correction, estimated blood loss, complications, overall performance status, and survival between patients with metastatic disease treated with PMMA or expandable cage anterior column reconstruction.[51] Additionally, Rajpal et al. found patients reconstructed with PMMA had fewer revision surgeries (0%) compared to osseous struts (40%) and metallic cages (3.7%), but similar overall complication rates to osseous struts (20%) and fewer complications than metallic cage reconstructions (52%).[52] Despite these promising clinical results, risk of thermal injury to spinal nerves during the curing process of PMMA[53] was the impetus for attempting to refine the process of safely reconstructing the anterior column with metallic cages and osseous strut grafts.

3.1. *Surgical technique*

Meticulous surgical technique is required to successfully perform a lumbar corpectomy through a posterior-only approach. The technique described below is to access the vertebral body bilaterally. Accessing the vertebral body unilaterally has been described and has the advantage of preserving

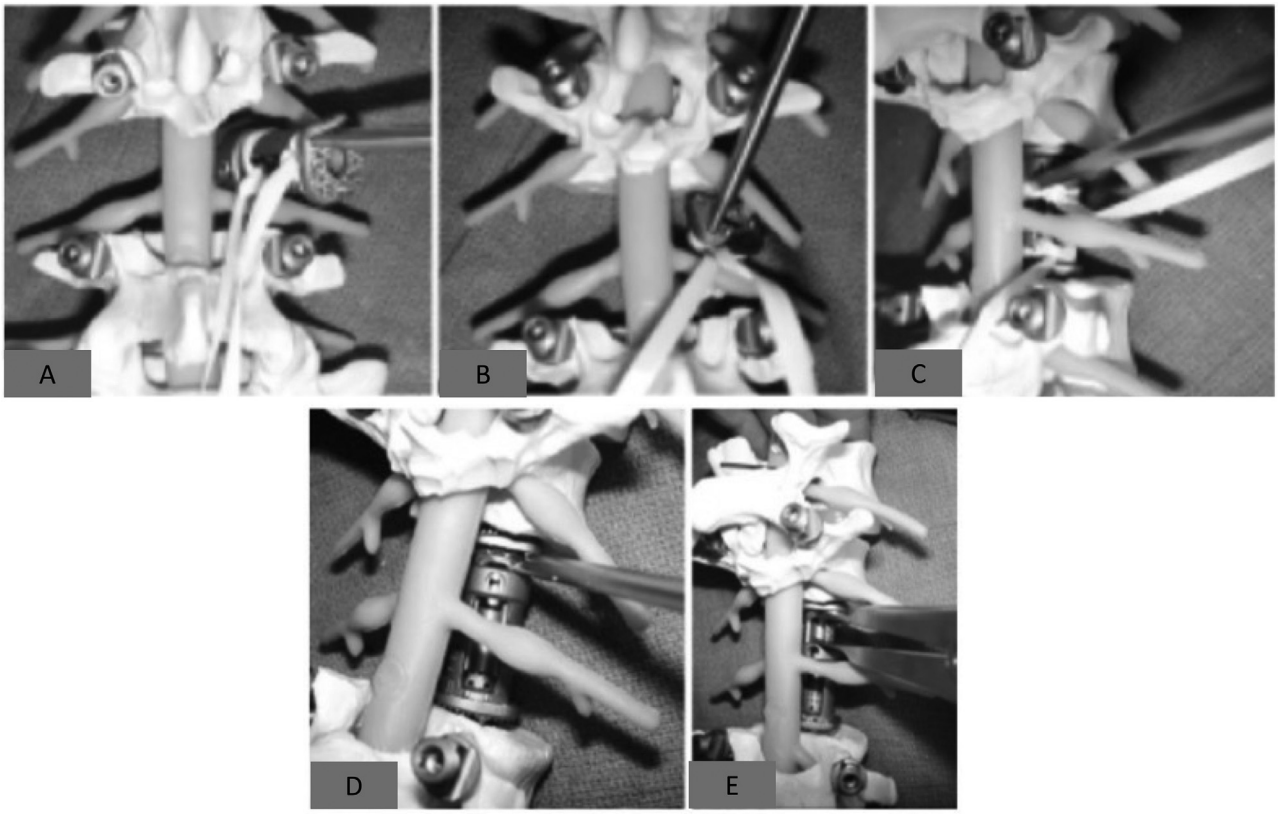

Fig. 7 – Representative images of sequential steps in anterior column reconstruction of a lumbar corpectomy with an expandable cage via a posterior-only approach. After tying Mersilene tape/thread around each end of an expandable cage, the cage is placed between the nerve roots in a lengthwise/parallel fashion (at 90° from its final position) (A). The more oblique inter-nerve root corridors in the lower lumbar levels facilitate easier placement of the cage, as less of a turn is required to align the cage in the vertebrectomy site (B). After the cage is inserted into the vertebrectomy site, the caudal tape/thread is retrieved beneath the traversing nerve root (C). Curved bone tamps and traction on the Mersilene tapes are used to flip the cage into the appropriate position (D). The cage is then expanded to the suitable height (E); it has been advised to have the caudal portion of the cage telescope inferiorly with expansion. [A-E: reprinted with permission from *J Neurosurg Spine* 5:271–274, 2006[54]].

posterior bone for fusion. However, removal of the entire lumbar body is difficulty if performed only via an unilateral approach.

The spine is first approached via a midline posterior incision with subperiosteal dissection carried out to the tips of the transverse processes bilaterally. Posterior instrumentation is then placed above and below the planned corpectomy site. This is followed by a full laminectomy extending from one pedicle above and below the vertebral level of interest and bilateral facetectomies above and below the vertebrectomy site. [If a L4 corpectomy is performed, a laminectomy from the L3 pedicle to the L5 pedicle and bilateral L3-4/L4-5 facetectomies should be performed. This allows the L3, L4, and L5 nerves bilaterally (6 total) to be visualized]. This is followed by removal of the transverse processes bilaterally and skeletonization of each pedicle at the vertebrectomy site. Before proceeding with removal of any portion of the vertebral body, unilateral provisional fixation should be placed across the vertebrectomy site by securing a rod to one or two screws cranial and caudal to the vertebrectomy level (if a unilateral approach is used, provisional rod fixation is not required). The body is then accessed via the pedicle and between the exiting and traversing nerve roots. Curettes, Kerrison rongeurs, and pituitary graspers are ideally used to remove the vertebral body and adjacent discs. If neural decompression is required, the posterior wall of the vertebral body is also freed from the dural sac and carefully pushed into the vertebrectomy site. The anterior longitudinal ligament and annulus laterally are preserved.

If being performed for scoliosis correction, appropriate deformity corrective maneuvers follow the aforementioned steps, which are beyond the scope of this chapter. If the vertebrectomy is performed for a tumor, infection, or fracture, the next surgical steps are aimed at anterior column reconstruction. There are several options for this, which include the placement of PMMA cement, a structural osseous graft, or an interbody cage (static *v*. dynamic). If PMMA cement is used, it is important to inject the cement between the nerve roots and fill approximately 75% of the vertebrectomy site. Freers are used to contain the cement within the defect and ensure that it does not contact the neural elements. Care should be taken to not overfill the corpectomy void. If an osseous strut graft or cage is used for anterior reconstruction, care should be taken to avoid injury to lumbar nerve roots during their

placement. Several authors have described special techniques to safely place a cage between lumbar nerve roots from a posterior approach.[54–58] Hunt et al. first described tying Mersilene tape around each end of an expandable cage and placing the cage between the nerve roots in a lengthwise/parallel fashion (at 90° from its final position)[54] (Fig. 7). The use of silk threads has also been described.[55] The trajectories of the nerve roots from L2 to L5 progress from lateral to oblique.[56] The more oblique inter-nerve root corridors in the lower lumbar levels facilitate easier placement of the cage, as less of a turn is required to align the cage in the vertebrectomy site.[56] After the cage is inserted into the vertebrectomy site, the caudal Mersilene tape/silk thread is retrieved beneath the traversing nerve root.[54,55] Curved bone tamps and traction on the Mersilene tapes/silk threads are used to flip the cage into the appropriate position[54] (Fig. 7). The cage is then expanded to the suitable height; it has been advised to have the caudal portion of the cage telescope inferiorly with expansion[56] (Fig. 7). Fluoroscopy is used to confirm its appropriate position and the Mersilene tapes/silk threads are cut and removed. Placement of expandable cages with wide, rectangular footprints via a posterior approach for lumbar anterior column reconstruction have not been described.

3.2. Clinical safety and efficacy

Clinical reports on the safety and efficacy of lumbar corpectomies reconstructed through a posterior-only approach are few, although encouraging. In a series of 11 patients with metastatic disease, Jandial et al. reported an average EBL of 1618 cc (range, 900–4000 cc), average surgical duration of 6.6 hours (range, 4.5–9 h), 4 patients regained the ability to walk, 2 reoperations, one delayed hardware failure (cage subsidence that did not require revision), and 3 incidental durotomies (none of which required reoperation).[56] No patient had an anterior operation or had worse neurologic function postoperatively.[56] *Morales* presented a case report of a 17-year-old girl with a L5 benign fibrous histiocytoma causing 11 months of progressive low back pain and left leg weakness (3/5 proximal; 2/5 distal) who was treated with a posterior-only corpectomy.[55] Post-operatively, slight deterioration in distal muscular strength for 2 days was observed, which subsequently improved (4/5 strength) before discharge.[55] She walked independently at the time of discharge.[55] Postoperative imaging also demonstrated complete resection of the tumor and proper cage placement.[55] In the trauma setting, Pham et al. reported on 7 patients with lumbar burst fractures (L1-4; L2-1; L4-2) reconstructed via a posterior-only approach.[57] At an average follow-up of 45.3 months, no gross hardware failure, pseudarthrosis, or adjacent segment disease was noted and motor function improved in 2 patients.[57] In a series of 14 patients with thoracolumbar burst fractures (9 lumbar) decompressed and reconstructed with an expandable cage via a posterior-only approach, Sasani et al. reported an average EBL of 596 cc, average surgical time of 188 min, 1 patient with worsening neurologic function, 1 pseudarthrosis, significant improvement in VAS pain scores (pre-op: 8.2 *v.* post-op: 2.7), and improvement of kyphotic angles (pre-op: 10.6^0 *v.* post-op: 13.6^0).[58] Additionally, Elnady et al. reported no cage or neurologic complications in 17 patients who underwent a posterior-only corpectomy for L5 pathology.[59] While encouraging, these results should be confirmed with studies involving larger cohorts. Additionally, future studies will ultimately help define a more accurate safety profile of the posterior-only approach for lumbar corpectomies.

4. Conclusions

Lumbar vertebrectomies are unique operations that are indicated in deformity and non-deformity settings. They are particularly beneficial for severe, rigid, coronal and sagittal deformities in children and adults as well pathology that jeopardizes the weight-bearing capacity of the anterior and middle columns of the spine (i.e. infections, fractures, and tumors). For non-deformity pathology, anterior column structural support is required and may be accomplished with the use of PMMA cement, osseous strut grafts (i.e. allografts/autograft), and titanium cages (static vs. expandable). Wide, rectangular footprints that span the apophyseal ring provide a sound biomechanical environment and minimize the risk of cage subsidence compared to those with circular footprints. While traditional anterior approaches are the gold-standard for lumbar vertebrectomies, a “mini-open” lateral approach through tubular retractors and a posterior-only approach are newer options. Supplemental fixation should always accompany lumbar corpectomies and may be achieved with instrumentation placed only anteriorly, only posteriorly, or both anteriorly and posteriorly. Ultimately, a fundamental understanding of appropriate indications, surgical techniques, and concomitant reconstructive and stabilization options are critical for the safe and effective execution of corpectomies and vertebral column resections in the lumbar spine.

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