

28

Complications of Interbody Fusion Cages

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I. INTRODUCTION

Since the Bagby and Kuslich cage (BAK cage, Spine-Tech, Minneapolis, MN) received FDA approval for lumbar interbody spinal fusion in 1996, interbody cage usage by spine surgeons has grown significantly. In the last 5 years, more than 80,000 lumbar interbody fusion cages have been placed, and in the United States over 5000 cages are surgically placed each month (1). The initial prospective multicenter clinical trial of the BAK interbody fusion system by Kuslich et al. claimed promising results: 98.3% fusion at 36 months, 91% return-to-work at 36 months, 85% pain improvement at 24 months, and 90.7% functional improvement at 24 months (2). To quote the authors verbatim, who incidentally were also involved in the innovation of the BAK cage, "carefully selected middle-aged patients with chronic low back pain secondary to degenerative disk disease can be treated effectively and safely by skilled surgeons using the BAK device for one- and two-level interbody fusion." However, there were some basic design flaws with the study, including a follow-up of only 25% of the original group who underwent the procedure. Needless to say, not everyone has been able to reproduce these results. O'Dowd et al. reported an overall failure rate requiring revision of 31% of the cages due to clinical failures at a mean period of 15 months (3). Elias et al. reported a radiographic failure rate of 28% and additional surgery rate of 21% (4).

The ideal interbody graft should be able to withstand the compressive, shear, and torsional loads across the disk space and at the same time be able to provide a matrix with osteoconductive, osteoinductive, and osteogenic properties. The gold standard for this matrix is autogenous corticocancellous bone graft, which, however, has less than ideal mechanical strength. It was using this premise that the threaded interbody fusion cage was designed. It is metallic but hollow to accommodate autogenous iliac crest cancellous bone graft and fenestrated to allow fusion bone mass to interdigitate with the cage. This construct combines the mechanical strength of the cage to counter disk space compressive, shear, and torsional forces, with the favorable biological properties of the autogenous cancellous bone to encourage fusion mass formation. Unlike allograft bone dowels,

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titanium interbody cages are not subject to supply shortages and processing problems (i.e., compromise of biomechanical properties, disease transmission, etc).

Since Kuslich's initial modification of the "Bagby basket" (an interbody device used for cervical spine instability in horses) for use in the human lumbar spine, interbody fusion cages have undergone several design advancements with the help of spine surgeons (5). As a result, there exist several versions of the latest generation of the cage. Examples include the BAK cage, the Ray TFC (Surgical Dynamics, Norwalk, CT), the LT cage (Medtronic Sofamor Danek, Memphis, TN), and the INTER FIX cage (Medtronic Sofamor Danek, Memphis, TN). These devices have been designed to improve on the older models with regard to restoration of intervertebral height while promoting fusion. The operative insertion techniques and tools have also been improved and simplified for the surgeon.

II. CAGE DESIGN CONSIDERATIONS

Despite the improvements in design of the interbody fusion cage, there remain some fundamental issues with its basic construct. The metallic cage itself can withstand tremendous loads before failure. However, it is a stiff object and prevents the bone graft inside from experiencing any significant biomechanical load. This may reduce the quality and quantity of bone interdigitating through the cage. A partial solution has been to pack bone graft around and between the cages to expose them to some physiological biomechanical loads. However, a very stiff cage will prevent physiological load transmission across the rest of the intervertebral space as well.

Another issue is the limited surface area of fenestrations through which bone graft can grow. There is an obvious compromise between cage mechanical strength and size or number of fenestrations. As mentioned above, packing bone graft around and between the cages helps alleviate this problem as well, increasing the surface area of the vertebral endplates exposed to bone graft while simultaneously helping seal the cage in the fusion mass. Another solution has been to use stronger materials to construct the cage, allowing larger or more fenestrations. However, on the flip side, a stronger but stiffer cage is less advantageous due to stress shielding as explained above.

Another problem is that the cages do not cover the entire cross-sectional area of the intervertebral space, even when two are used at a level. Compared to ringed (such as the femoral ring allograft) or boxed structures, the cross-sectional area presented by a cylindrical cage surface and endplate is only about 10% of the total endplate surface area (6). A smaller graft area means higher peak stresses, increasing the risk of graft or endplate collapse and disk space subsidence. Closkey et al. concluded that the interbody bone graft area should be significantly greater than 30% of the total endplate area to prevent failure (7). However, in the case of a cylinder, to expose more surface area for fusion, additional endplate and subchondral vertebral bone will have to be cored out. This means that more of the cylinder will lie inside the vertebral bodies. Not only will this risk subsidence due to removal of the mechanically stronger subchondral bone, but less diameter of the cylinder is available to distract the intervertebral space.

If only a cylindrical channel of disk material and endplate is removed for each cage, a significant amount of disk material and endplate is left untouched, limiting the fusion area. The obvious solution is to remove as much disk material as possible, prepare the endplates, and apply autogenous cancellous bone graft throughout as much of the disk space as possible. This technique has been shown by McAfee et al. (8) to significantly improve



Figure 1 Standalone interbody fusion cage with flattened sides (Medtronic Sofamor Danek).

fusion rates. Fusion was originally prepared and surgical time.

Yet another issue is that the diameter has increased with the increase in width and centered vertically. In their final preparation, the flattened sides of the cage were flattened to two-thirds of the original diameter. Fortunately, the vertebral space is easily inside the cage.

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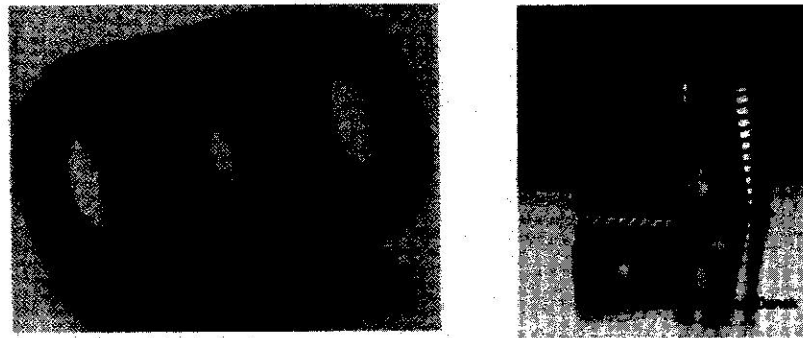


Figure 1 Standard cylindrical cage (left, BAK Cage Spine-Tech, Minneapolis, MN) and cages with flattened sides for closer placement and taper for recreating lumbar lordosis (right, LT Cage, Medtronic Sofamor Danek, Memphis, TN).

fusion rates. However, this reveals a major weakness of the cage fusion technique, which was originally designed to be a quicker and easier procedure than formal endplate preparation and bone grafting. Obviously, adding this step entails additional morbidity and surgical time. This is especially true in laparoscopic cage insertion.

Yet another problem with the cage is that to attain more disk space distraction, the diameter has to be increased. In the case of a cylinder, an increase in diameter also increases width. This makes it more difficult to accurately place two cages symmetrically and centered within the disk space. This can result in the second cage being placed too far lateral, compromising its stability or causing posterior impingement. A solution has been to flatten two sides of the cylinder so that the pair of them can be placed closer together. In their final positions, the threaded portions bite the superior and inferior endplates and the flattened sides are adjacent. The LT cage is an example of this modification (Fig. 1). Fortunately, well-placed cages have been shown by Sandhu et al. (9) to maintain intervertebral space distraction better than bone dowels, so cages larger than those that fit easily inside the disk space are not usually necessary.

Another issue with the cage's shape has been the difficulty in recreating the lumbar lordosis accurately with cylinders. The disk spaces are responsible for most lordosis in a normal lumbar spine. Cylindrical cages placed in such disk spaces are uneven in terms of their bony purchase and suffer either little endplate purchase anteriorly or excessive subchondral bone removal posteriorly. Such cages have increased risk of migration or subsidence with lumbar motion and loading. However, there are now tapered cages in the market that have greater height anteriorly and that use tapered reamers to prepare the disk space. Again, the LT cage incorporates this design modification as well.

III. NEED FOR ADDITIONAL STABILIZATION

Although originally designed for specific indications as stand-alone devices, there are certain other scenarios where threaded cylindrical interbody cages are being used but for which their use without additional posterior stabilization may not be appropriate. Authors who have not had great success with cages alone have in fact recommended routine posterior adjunctive stabilization for most indications. Biomechanically, the most compelling indication for posterior instrumentation of an interbody cage approach is

spondylolisthesis and any significant instability, especially when the cage is inserted through a posterior approach (5). Tsantrizos et al. performed biomechanical comparisons of posteriorly placed interbody cylindrical cages, box-like cages, and trapezoidal allografts, and found that posterior (pedicle screw) instrumentation is needed in all three constructs to confer adequate initial stability (10). Dimar et al. found that posteriorly placed interbody cages did not increase spine stiffness significantly in any tested range of motion in a human cadaveric model (11). Supplemental posterior pedicular screw/rod instrumentation, however, significantly increased stiffness. Cagli et al. evaluated the biomechanics of lumbar cages and pedicle screws for treating spondylolisthesis in a human cadaveric model (12). They concluded that biomechanically, cages or dowels alone were suboptimal for treating lumbar spondylolisthesis, especially when compared to pedicle screws and rods. Threaded cages or dowels used together with pedicle screws and rods created the most stable construct.

A less invasive method of posterior lumbar spine stabilization in conjunction with interbody cage fusion is translaminar facet screw fixation. This method, devised by Magerl (13), has demonstrated success with few complications in several studies. Heggeness and Esses showed increased lumbar and lumbosacral spine stiffness after translaminar facet screw fixation (14). This was corroborated by Vanden Berghe et al., who conducted biomechanical studies to show significantly increased stability in flexion, extension, and rotation with translaminar facet screws (15). Zhao et al. showed that even in a posterior lumbar interbody fusion with a single cage (unilateral facetectomy), translaminar screw fixation of the remaining facet added significant stability in all directions (16). This study also showed that posterior two-cage placement with bilateral facetectomy was the least stable construct, driving home the points that PLIF procedures are most likely to benefit from additional posterior stabilization and that translaminar facet screws are sufficient for this.

As far as number of levels is concerned, authors have reported acceptable results of cage fusions for one- or two-level degenerative disk disease, but outcomes may be less than optimal for more than two levels of fusion and may require posterior stabilization as well. The original clinical trials for BAK cages specifically recommended their use for one or two levels (2).

IV. COMPLICATIONS

Complications are associated with interbody fusion cage application and can be divided into two main categories: approach related and cage related. Interestingly, the majority of complications are still approach related (2,17,18). Although complications exist with both anterior and posterior approaches, there are many theoretical advantages to an anterior approach for an experienced surgeon, such as (a) ease and duration of dissection, (b) reduced operative time and blood loss (19,20), (c) avoidance of inciting posterior element pain generators (e.g., facet joints), (d) direct removal of the anterior discogenic pain source, (e) avoidance of dissecting and injuring the posterior muscles, (f) avoidance of retracting the spinal cord or nerve root, and (g) avoidance of scarring in the spinal canal. Approach-related complications are discussed in more detail in other chapters in this book, so we will focus on cage-related issues here.

It is most important to mention that overlying all possible complications in interbody fusion using cylindrical cages is the importance of proper decision making, especially in patient selection. As with any surgical treatment, the patient's psychology,

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issues of secondary gain, and third-party claims should be appropriately investigated. Diagnostic tests used to determine the need for surgery should be proven and reliable, and the use of stand-alone cages for disorders other than that recommended by the designers and manufacturers should be avoided (e.g., for multilevel disease and/or instability).

A. Approach-Related Complications

1. Complications Associated with the Anterior Approach

Complications associated with the anterior approach include superficial or deep wound infection, wound dehiscence, incisional hernia (21), ileus, bowel obstruction (22), hematoma, seroma, retrograde ejaculation, major vessel damage (23,24), thrombosis (25), thrombophlebitis, atelectasis, pneumonia, urological complications (ureteral damage, testicular swelling, prostatitis, epididymitis, etc.) (26), and others (gastrointestinal bleeding, drainage, anemia, etc.) (2). These are discussed in a separate chapter in this book.

2. Complications Associated with the Posterior Approach

Complications associated with the posterior approach include superficial or deep wound infection, ileus, hematoma, seroma, bleeding, thrombosis, thrombophlebitis, dural tears, neurological injury, and others (anemia, drainage, etc.) (2). Extended rehabilitation time due to posterior muscular dissection injury is expected (19,20). Violation of the integrity of certain posterior elements may theoretically produce pain generators (e.g., facet joints). Again, these approach-related complications are discussed in a separate chapter.

3. Complications Associated with the Laparoscopic Anterior Approach

The laparoscopic approach has an inherently higher complication rate compared to open surgery, especially during a surgeon's learning curve for the technique. With a laparoscopic approach, it is easier to simply ream and place two cages in a disk space than to perform a complete discectomy, endplate preparation, and bone grafting, which often improves the chance of fusion as suggested by McAfee et al. (8). However, with proficiency comes the potential to substantially reduce perioperative morbidity by reducing blood loss, ileus, rehabilitation time, etc. Regan et al. have shown that this is a promising technique (18,27). Zdeblick and David found no significant difference in operative time, blood loss, or length of stay using the laparoscopic technique compared to the mini-ALIF (anterior lumbar interbody fusion) approach, but did find a significantly increased complication rate (20% vs. 4%) (28).

B. Cage-Related Complications

Complications associated with interbody fusion cages are usually due to one of three reasons: error in placement, failure of fixation, or failure of healing. (Note that these are most often due to surgeon errors and/or patient biology, and not due to any intrinsic flaw of the cages themselves.). These result in implant malposition, migration, or pseudarthrosis and other associated problems. Unlike corticocancellous grafts, however, there have been no reported case of structural failures of the cages themselves.

1. Cage Malposition

The recommended interbody fusion configuration is two parallel cylindrical cages oriented parasagittally across the disk space, symmetrical on each side of the midline. Studies have

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more lateral) they have to be. To minimize this compromise, a new design change has been to flatten two sides of the cylinder. This allows placement of the cages closer to each other near the midline when the flat edges are aligned next to each other (Fig. 1).

Intuitively, a cage that is too small will be unstable. Using an undersized cage reduces contact area with the vertebral bone and by decreasing distraction will impart less stabilizing load to the cage. Stability with distraction occurs because of tensioning of the surrounding annulus in the disk space. A narrow cage results in "looser" cage-vertebrae contact due to inadequate soft tissue tension, increasing the risk of cage slip during lumbar spine motion.

An oversized cage may experience large peak forces because of excessive distraction, causing the threadbone interface to fail catastrophically and the cage to be thrust out during lumbar spine motion. This is compounded by the fact that large cages may make the entire motion segment more unstable. Several biomechanical studies have shown that anterior interbody devices improve overall spine stiffness, but are least rigid in extension and axial rotation (35,39,40). This was initially thought to be due to the sectioning of the anterior longitudinal ligament. However, Lund et al. showed that extension instability occurred with posteriorly placed interbody cages as well (41). Oxland et al. concluded that this lack of rigidity was due to excessive distraction of the facet joints after interbody cage placement (39).

A weakened bonecage interface refers mainly to the quality of bone at the bone surface interface rather than any deficiencies with the cage itself. Structural failure of the cage itself has not been widely reported. The thread dimensions on a cage affect pullout strength, but mechanical failure almost always occurs in the vertebral bodies adjacent to the cage implant. Assuming a uniform thread design, the bone quality is the main variable in this problem.

The strongest bone in the vertebral body lies in the subchondral region of the cortical endplate. However, it is necessary to ream this vertebral endplate to prepare the pair of adjacent circular holes for the cages, exposing the weak but vascular cancellous bone, especially at the apex of the cavity. Excessive tightening of the threaded cage can easily result in stripping of the bonecage interface at this level, which can be a set-up for implant migration.

To optimally utilize the endplate, the surgeon can perform minimal shaving of the endplate and use a precisely conforming bone graft or implant to share the load evenly over more of the endplate surface. This allows a greater surface of contact between the graft and vertebral body. Wang et al. showed that these steps reduce peak stresses in the graft (42,43). Unfortunately, this is not possible using cylindrical threaded cages.

3. Pseudarthrosis

There are few large studies documenting rates of fusion using interbody cages. In one of the original large studies, Kuslich et al. claimed a fusion rate of over 98% (2). Blumenthal et al. also found a low overall revision rate of about 3% (44). However, not all surgeons have enjoyed that kind of success, and several studies with smaller patient pools have reported higher rates of pseudarthroses (3,4,35).

Failure of fusion may be a long-term consequence of any of the above-named cage-related complications. Moreover, pseudarthrosis can occur without any evidence of cage-related complications, or fusion may very well occur despite obvious evidence of less than ideal cage placement. This is because fusion can be described as a race between bony healing and implant loosening or failure. The patient's biology plays a big role in the ultimate effect of cage malposition, migration, or settling on spinal fusion. Thus the

patient's general health and nutrition, medications, any history of irradiation, or smoking should be explored thoroughly, as they can significantly affect healing.

Infection can also cause loosening and pseudarthrosis, especially in the setting of previous or current infection at or near the operative site. The inherent stability of the spine plays another big role. Cages are not indicated as stand-alone devices for multilevel disease or significant spinal instability. In such cases, additional posterior stabilization may be helpful and is recommended (10,11,45-48).

V. MANAGEMENT OF CAGE COMPLICATIONS

A. General Cage Revision Concepts

There is a dearth of literature on revision strategies for failed interbody fusion with cylindrical cages. McAfee et al. identified several cage-related complications that could benefit from revision surgery (35):

- Undersized cages
- Malpositioned cages
- Migrating cages
- Spinal canal stenosis
- Disk herniation with neural impingement
- Pseudarthrosis

Of course these complications must lead to symptoms before the patient is subjected to any revision surgery. Symptoms may manifest as residual back pain, new back pain, residual radiculopathy, or new radiculopathy. If the symptoms are significant or do not improve with nonoperative management, a work-up must be initiated to identify whether the problems listed above are responsible.

Radiographs that show inadequate distraction across the disk space are diagnostic for undersized cages. This may be seen immediately postoperatively or later with progressive settling of the vertebrae around the cages. MRI or CT-myelogram may show neural impingement across the foramina due to inadequate distraction. Similarly, malpositioned and migrating cages can be diagnosed by plain radiographs. Patient symptoms may be explained by CT scans (with or without contrast) showing implant migration into the spinal canal or foramina. A disk herniation can be seen with an MRI or CT-myelogram as well.

A history of a pain-free interval is probably the most sensitive indicator of possible pseudarthrosis (1). The next step is to obtain plain A-P and lateral flexion-extension radiographs. These can be difficult to interpret. Pseudarthrosis can be presumed based on motion of the cages on lateral flexion-extension views, lucencies around the entire implant, or late and/or progressive migration of the cages (17,49,50) (Fig. 2). However, the radiographic thresholds to diagnose fusion or lack thereof are very controversial. Allowable motion differs from 1 to 5° in various studies (2,8,17,38,51,52). A false diagnosis of fusion can be made as often as 20% of the time based entirely on flexion-extension films alone versus including other criteria such as peri-implant lucencies (17,53).

Some authors suggest that the best indication of fusion with threaded interbody implants is the presence of a "sentinel sign"—radiographically evident bridging trabecular bone anterior to the interbody device (17,35). In order to improve clinical results and assist in fusion determination, the concept of "ream long, fuse short" has been proposed.



Figure 2 Radiograph showing a threaded interbody cage at the lower level of the spine.

The threaded cage was reamed and tapered to fit the packing of the cage in radiographs.



Figure 3 (A) Radiograph showing a BAK fusion cage at the L5-S1 level, with a solid trabecular bridge visible anterior to the cage, indicating fusion after a long ream.

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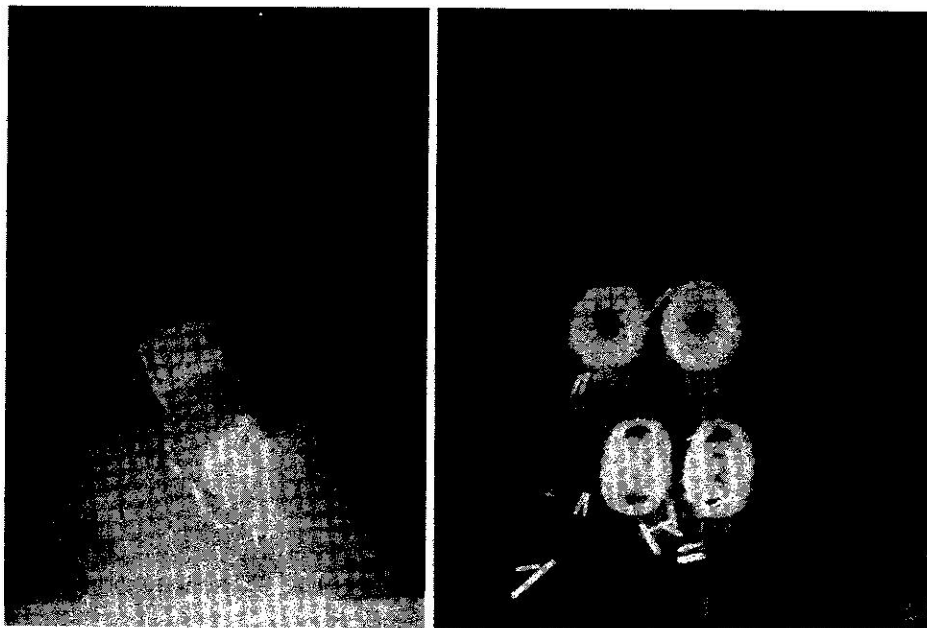


Figure 2 Radiographs of two-level anterior cage interbody fusion with obvious pseudarthrosis at the lower level with radiolucency visible surrounding both cages.

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The threaded cylindrical interbody device is placed at the far posterior portion of the reamed and tapped channel, allowing room in the interspace anterior to the device for the packing of cancellous bone graft. This allows for a large sentinel sign to be visible in radiographs later on if fusion is successful (Fig. 3). However, it must be borne in mind

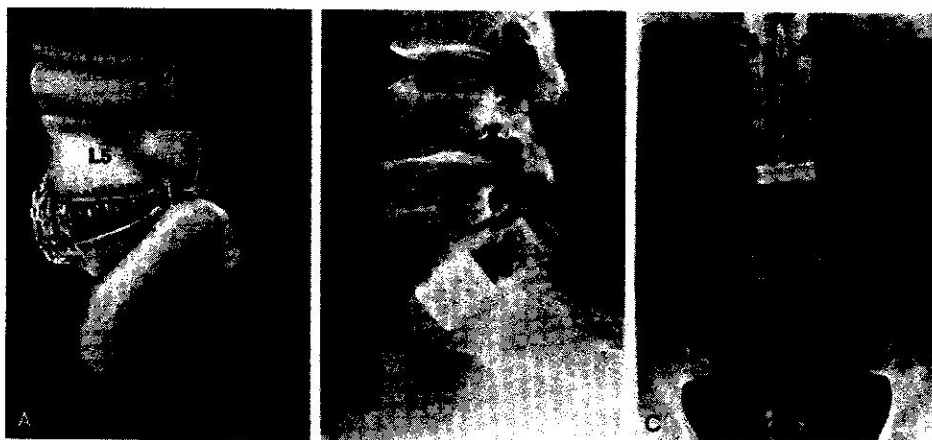


Figure 3 (A) The principle of “ream long and cage short” in more than 200 Bagby and Kuslich (BAK) fusion cage procedures was the most reliable assurance of a solid arthrodesis documented by solid trabecular bony bridging anterior to the cage. (B) Solid bone incorporated anterior to an L5-S1 BAK procedure. (C) Continuous bone in continuity bridging L3 to L4, a sentinel sign of fusion after a laterally inserted BAK device. (From Ref. 17.)

that such placement may increase the risk of settling since the interbody implant is not resting on the anterior cortical margin, but on the softer cancellous endplate.

CT scans can add detail to radiographs in assessing fusion across cages, although they are occasionally more difficult to interpret because of metal artifact (in contrast with the use of bone dowels). A lack of viable bone extending through the cage into the vertebral marrow on reconstructed thin-section, high-resolution CT suggests lack of fusion. Despite this, studies have shown that CT scans are not completely reliable in diagnosing fusion across cages (6,8,49,54). Even when bridging bone is seen entering the cage through its fenestrations on a CT scan, histological analyses of retrieved cages have shown that the quality of the bone can be suboptimal and their structure noncontinuous (35,49,54).

B. Specific Cage Complications and Their Management

Early postoperative cage removal is simpler because of the lack of scar and bony ingrowth. Although it is preferable to use the previous incision for significant malposition or migration of the implant, the surgeon may have to use a new approach. Late cage removal can be more difficult because of scar and bony overgrowth. Specific cage revision tool sets have been developed to remove implant interbody cages. Some of the basic tools that are very effective in extracting well-fixed cages include (Figs. 4-6):

- Curved or angled osteotomes
- Hollow reamers
- Rongeurs
- Burrs
- Disk space distractors
- Awls
- Implant graspers

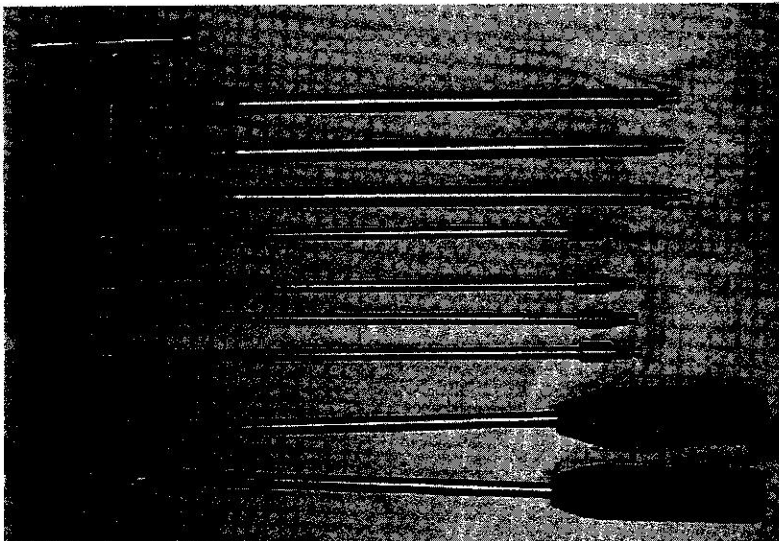


Figure 4 Hollow reamers, angled osteotomes, and threaded cage drivers designed to remove surrounding bone or scar tissue and extract the cage. (From J. S. Thalgott M.D., International Spinal Development & Research Foundation, Las Vegas, NV.)

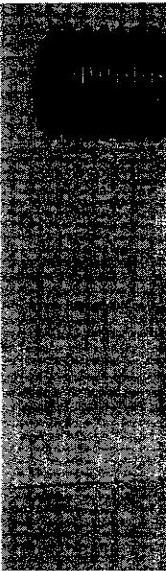


Figure 5 Threaded cage driver. (From J. S. Thalgott M.D., International Spinal Development & Research Foundation, Las Vegas, NV.)

1. Undersized

Cages are usually used because of the fact that threaded devices may have extruded posteriorly to decompress the part of a well-fixed cage. A simple burr approach is to remove the bone around the

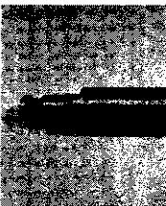


Figure 6 For useful extraction. (From Ref. 17.)

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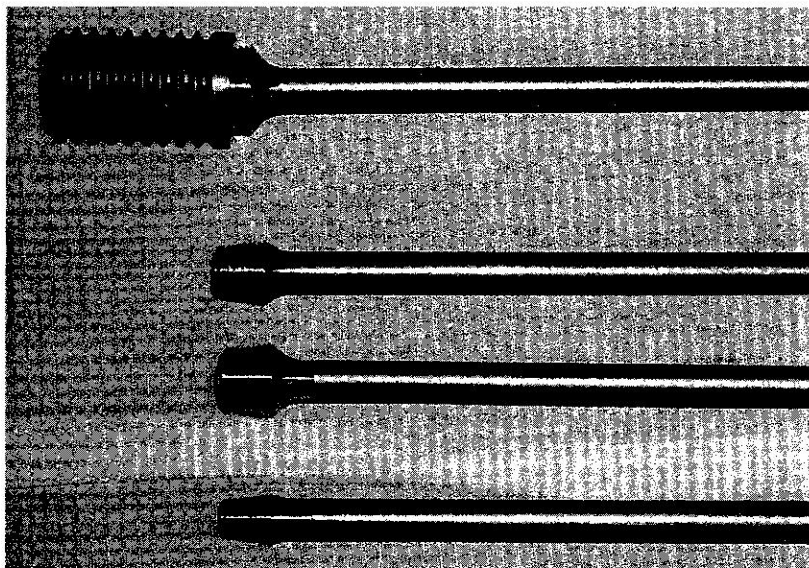


Figure 5 Threaded cage drivers that can be inserted inside the cage and then used to twist it out. (From J. S. Thalgott M.D., International Spinal Development & Research Foundation, Las Vegas, NV.)

1. Undersized, Malpositioned, or Migrating Cages

Cages are usually more easily removed anteriorly, regardless of the original approach, because of the risk of damage to neural tissues with posterior extraction of a malpositioned device. However, when deciding on an approach, consideration must also be given to the fact that threaded extraction devices may only be able to fit into one side of the cage. If a threaded device cannot be used to grip the cage from inside, an inordinate amount of bone may have to be removed from around it. If the cage is completely or significantly extruded posteriorly, it may be necessary to remove it with a posterior approach and decompress the nerve(s) or spinal cord. A posterior approach may also be chosen if only part of a well-fixed cage is causing impingement, in which case it may be possible to simply burr it down. A key technical point in removing cages through a posterior approach is to translate the cage laterally within the disk space before extracting it posteriorly through the spinal canal (35). This may require clearing off more disk or bone around the lateral aspect of the cage before pulling it out. Minimizing nerve root

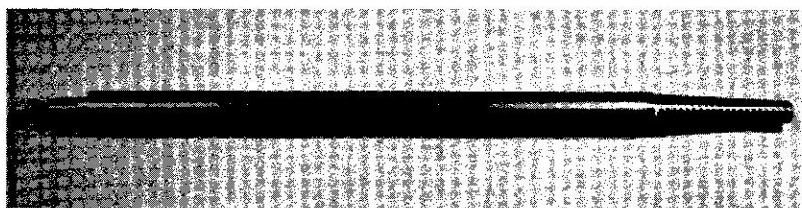


Figure 6 For cages suboptimally placed or compressing neurologic structures, a T-shaped awl is a useful extraction device. The awl atraumatically unscrews the cage and breaks up fibrous adhesions. (From Ref. 17.)

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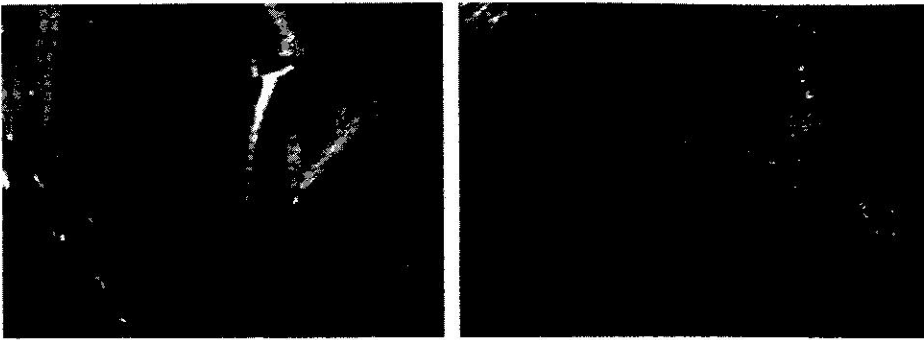


Figure 7 After the disk space is approached, a rongeur is used to remove overlying scar tissue and expose the face of the cage. (From J. S. Thalgott M.D., International Spinal Development & Research Foundation, Las Vegas, NV.)

mobilization is obviously much more difficult in a repeat posterior approach compared to the original procedure because of epidural fibrosis.

Osteotomes or hollow reamers are needed to remove well-fixed cages from surrounding bone or well-healed scar tissue. To avoid removal of excessive bone, curved osteotomes of various radii of curvature are available to fit around cages of different sizes. Once the overgrown bone and adherent scar tissue are released from the cage surface (Fig. 7), an awl or a grasper may be used to remove the cage. If the exposure is end-on to the cage end-face, it can be spun out with the threaded awl (Fig. 8). This awl is a specialized tool that has a tapered end with reverse threads, which inserts into the open end of the cage and progressively grips it tighter as it is twisted in a counter-clockwise direction, while at the same time unscrewing the cage from its bed. However, if the cage cannot be turned so its end-face is visible, substantially more bony excavation and disk-space distraction may be needed.

If a malpositioned cage is intruding into the canal or foraminal space and it is well fixed, a partial vertebrectomy may have to be performed to remove the cage (55). If the offending segment of the cage is within reach, but it is still difficult to remove the entire cage, a burr may be used to smooth down that segment. If the entire cage is

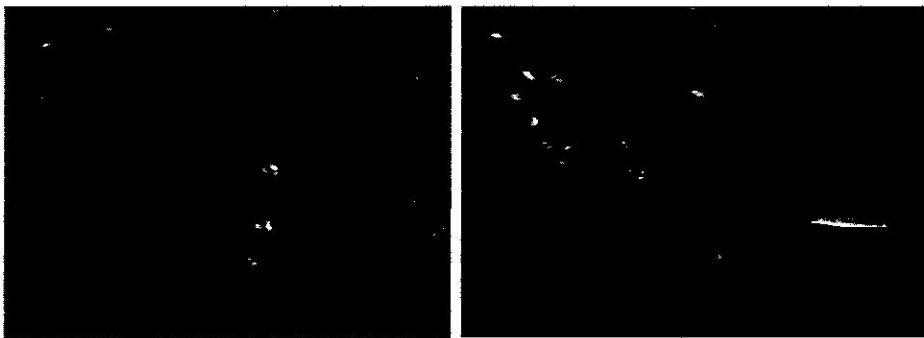


Figure 8 A well-fitting threaded awl or cage driver can then be inserted and used to unscrew the cage from the disk space. (From J. S. Thalgott M.D., International Spinal Development & Research Foundation, Las Vegas, NV.)



Figure 9 A 45-year-old patient with two Bagby cages obtained 6 weeks postoperatively. A computed tomography scan showed the cages completely out of place. To anchor the cages, follow-up, the patient

removed, there was no end the procedure. A bigger cage, obviously case

Removal of a cage due to its exposed and a cage may be placed with threads. Distraction. Extraction of a cage through laparoscopic migrated cages. extraction described

2. Spinal Canal

A patient with a herniation caused during a herniation may cause itself can be period, with the down the offending

3. Pseudarthrosis

Symptomatic pseudarthrosis instrumented fusion position (i.e., sagittal) if the cages have bone or height

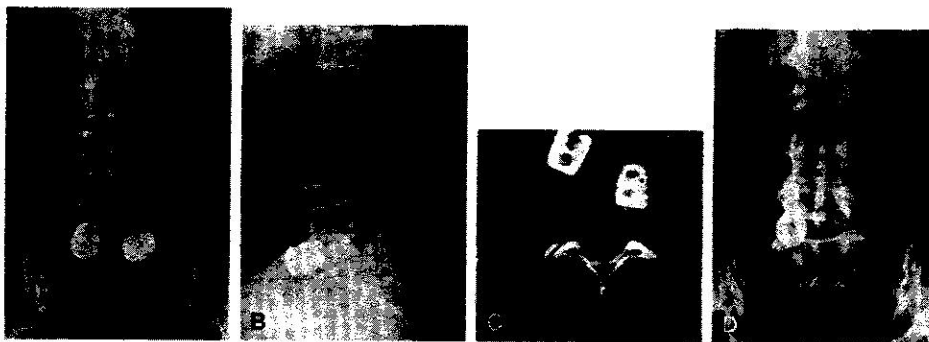


Figure 9 A 45-year-old woman had undergone laparoscopic L5-S1 fusion and instrumentation with two Bagby and Kuslich (BAK) devices. The (A) anteroposterior and (B) lateral radiographs obtained 6 weeks later show that one cage had dislodged anterior to the L5-S1 disk space. A computed tomographic scan through the L5 vertebral body (C) shows that the right cage is completely out and the original seating was too far lateral with a lateral bony bridge insufficient to anchor the cage. The dislodged cage was removed laparoscopically. (D) At long-term follow-up, the patient had a successful clinical result and arthrodesis. (From Ref. 17.)

removed, there is no consensus on what to do next. The surgeon must decide whether to end the procedure, add bone graft (cancellous versus structural), reorient the cage, use a bigger cage, or use a different structural device altogether if needed. The decision is obviously case dependent (35) (Fig. 9).

Removal of a migrating cage is often less complicated than removing a poorly placed cage due to its inherent looseness. To remove a loose cage, the intervertebral space is exposed and a grasping tool is used to attach to the cage. In some cases a threaded awl may be placed within a circular cage and removed in a reverse direction of the cage threads. Distraction of the intervertebral space may be needed to ease cage extraction. Extraction of progressively migrating cages that are easily accessible may be possible through laparoscopic techniques (35). Occasionally, if not discovered early enough, the migrated cages may become fixed in their new position, requiring techniques of fixed-cage extraction described above.

2. Spinal Canal Stenosis or Disk Herniation with Neural Impingement

A patient with symptomatic canal or foraminal impingement by a cage or disk herniation caused during cage placement may require surgical decompression. A symptomatic disk herniation may be treated with a posterior decompression. Neural impingement by the cage itself can be addressed by removing the cage, especially in the early postoperative period, with the techniques mentioned above. If the cage is well fixed, simply burring down the offending part posteriorly may be sufficient (Fig. 10).

3. Pseudarthrosis and/or Loose Implant

Symptomatic pseudarthrosis after cage interbody fusion is usually treated with a posterior instrumented fusion using pedicle screws (Fig. 11). If the cages are in a non-offending position (i.e., still inside the disk space), they do not need to be removed. However, if the cages have grossly migrated out of the disk space and there is significant loss of bone or height in the motion segment, it may not be enough to revise the construct

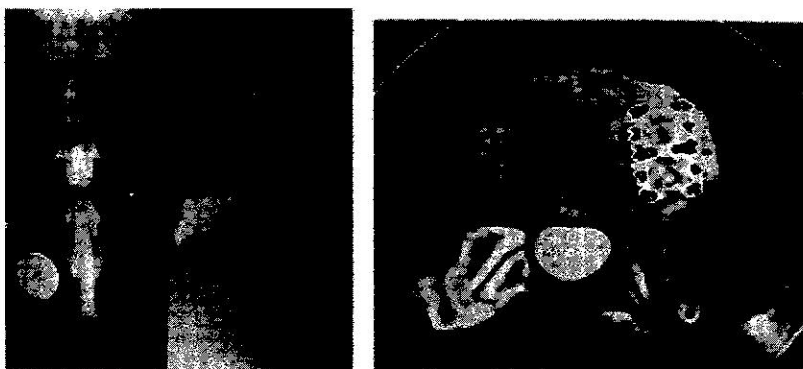


Figure 10 A 45-year-old man had undergone laparoscopic cage placement at L4-L5 and had left-side leg pain 4 days after the procedure. Only one cage had been placed because of technical difficulties in mobilizing the vessels during the procedure. (A) An anteroposterior and lateral myelogram was largely normal, because the nerve root compression was farther lateral than the myelographic dye filling of the nerve root. (B) A computed tomographic scan shows narrowing of the foramen blocking the left L4 nerve root. Patient underwent posterior decompression with resolution of symptoms. (From Ref. 17.)

with posterior instrumented fusion alone (1). Such situations may require cage removal and anterior column reconstruction to obtain a solid fusion and pain relief. The reconstruction may involve using structural bone graft or a larger noncylindrical cage with bone graft. Anterior reconstruction techniques are discussed in a separate chapter in this textbook.

4. Infection

Infection can result in implant loosening and pseudarthrosis through osteolysis. Although there are other factors that can lead to infection and pseudarthrosis, patients with diabetes are at a higher risk for development of these complications (56). There are no reports in the

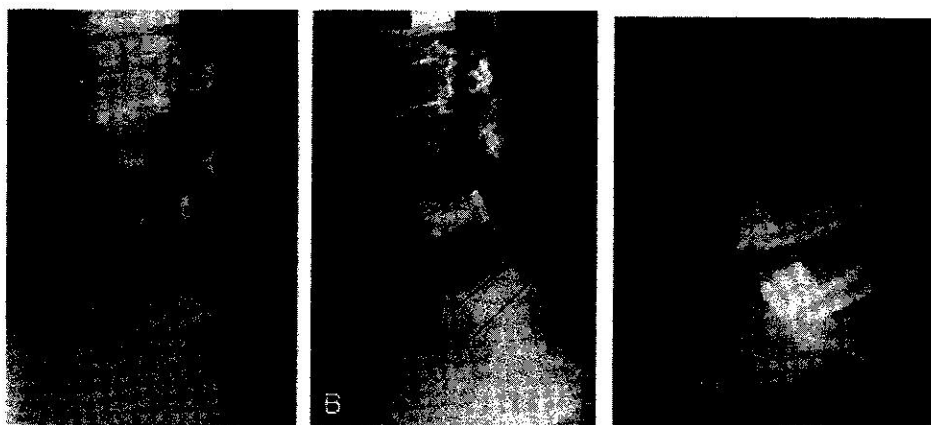


Figure 11 Lateral flexion and extension radiographs show motion at the L4-L5 interspace at 9 mm with flexion and 15 mm with extension, demonstrating pseudarthrosis with cages in acceptable position. This can be treated with posterior instrumented fusion, as shown. (From Ref. 17.)

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literature on the management of infected cages other than anecdotal accounts. It only makes sense that an infected and loose cage will need to be removed, since it will not provide any stability to the spine and as a foreign body will only make it difficult to eradicate the microorganism. The other cage may be left in place if not loose, because it may provide enough stability to forgo a posterior stabilizing procedure. If both cages are grossly infected and unstable, removal of both devices and a complete debridement may be necessary, followed by anterior reconstruction with bone graft. McAfee et al. described their treatment of a patient who developed back and leg pain and a deep wound methicillin-resistant *Staphylococcus aureus* infection (35). One of the cages had subsequently loosened and retracted into the spinal canal. The patient was managed with a surgical debridement, extraction of only the migrated cage, 6 weeks of intravenous antibiotics, and two reconstructive procedures. Ultimately a solid arthrodesis was achieved with resolution of the spinal infection.

VI. CONCLUSIONS

Most complications related to lumbar interbody fusion cages are failure of surgical technique or poor patient selection rather than an intrinsic defect in fusion cage technology (1,35). The optimal candidate is a patient with symptomatic degenerative disk disease at a single level with decreased disk height. The major factors associated with failure of the original insertion procedure include failure to achieve adequate distraction of the annulus fibrosus; use of undersized cages, especially in the PLIF approach; cerebrospinal fluid leakage or pseudomeningocele; presence of type 2 diabetes mellitus; use of local bone graft rather than iliac crest bone graft inside the cage; an ALIF approach with insertion in a position too lateral resulting in symptoms similar to a far lateral disk herniation; and failure to identify the vertebral midline. Salvaging failed cages consists of removing the offending cages and/or adding stabilization with instrumentation and bone graft. In the future, cages may be inserted using minimally invasive posterior stabilization techniques, thereby decreasing patient morbidity and length of acute hospital stay.

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