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## Cages: outcome and complications

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**Abstract** The coincidental development of minimal intervention techniques for carrying out anterior lumbar spinal fusion and the introduction of cages to provide mechanical support of introduced bone graft led to the development of a type of cage suitable for both minimal intervention use (laparoscopic) and for the standard open procedure (the BAK cage). Reported results concentrated in the main on feasibility, safety and fusion rate achieved, rather than clinical outcome. Laparoscopic insertion

at the lumbosacral level was as safe as if the procedure was an open one, although there was a slighter higher incidence of retrograde ejaculation. Immediate post-operative morbidity was less with the laparoscopic procedure and discharge home and return to work was earlier. There was no long-term benefit from the laparoscopic procedure. Laparoscopic insertion at the L4/5 level was attended by a greater incidence of complications, and had a longer learning curve.

Anterior spinal fusion was a well-established technique in the 1950s and 1960s, but fell out of favour as method of spinal fusion, being deemed inferior to a posterolateral fusion because of associated complications and uncertainty of fusion rate [2, 15]. One particular problem was the fact that any anterior graft had to have both a biological function and a mechanical supporting function whilst it was incorporated. Although autologous bone was the optimal material, to ensure that it had mechanical load-bearing qualities pelvic tricortical graft or fibula graft was required, and these were associated with significant donor site problems, with still no guarantee that the biological function and the mechanical function would be optimal. The combination of a rigid cage (providing mechanical support) filled with autologous cancellous bone (providing biological material to encourage union) was an attractive concept. However, as this concept was being introduced, the concept of minimal intervention was developing in parallel. As a consequence, cage design was affected as manufacturers were encouraged to design cages that were appropriate for use in minimal intervention techniques and in open techniques. In the lumbar spine this required the use of two cages side by side to provide stability.

To allow us to assess the particular effect on complications and results of doing a procedure by a minimal intervention technique, it is necessary to look at the results and complications of the technique done as an open procedure, and compare those results with reported results using minimally invasive spine surgery (MISS). The initial study of the use of cages in lumbar interbody fusion, using an open procedure, reported by Kuslich et al. in 1988 [6], was a multicentre study involving 42 surgeons at 19 centres. Clearly such heterogeneity precludes any judgement as to results, but the surgeons at the participating centres would probably have reported the complications of the technique. Apart from making the comment that two-level cases were more likely to have operative complications, the paper does not itemise complications in relation to the level done, or specify whether two levels were being done when a complication occurred. It does state, however, that 48% were two-level cases (Table 1).

It is therefore appropriate to compare this incidence of complications with the same procedure done using a MISS approach as reported by Regan [13]. Regan compares the MISS complications with complications using an open technique [13]. Like the initial Kuslich study, the

**Table 1** Complications of anterior surgery (Kuslich et al. [6])

Retrograde ejaculation	4%
Vessel damage	1.7%
Superficial infection	3.1%
New radicular pain	1.3%
Neurological problems	2%
Implant migration	2.3%
Phlebitis-pulmonary embolism	0.7%

**Table 2** Complications of anterior fusion using BAK cages (Regan et al. [13]): one-level cases (MISS minimally invasive spine surgery, IVC inferior vena cava)

	MISS	Open
Retrograde ejaculation	5.1%	2.3%
Vessel damage: major aorta or IVC	0	0.7%
Superficial infection	1.4%	2.0%
Leg pain	0.5%	0.7%
Disc herniation	2.8%	0
Implant migration	0.5%	0.7%
Pulmonary embolism	0	0.3%

**Table 3** Complications reported by O'Dowd et al. [12]. For ease of comparison, figures are presented as percentages, with the number of cases in parentheses (CIA common iliac artery, CIV common iliac vein, DVT deep venous thrombosis)

	Open (n = 23)	MISS (n = 28)
Retrograde ejaculation	4% (1)	0
Vessel damage: aorta, IVC	0	0
Lesser vessel injury		
CIA	0	3.5% (1)
CIV	8% (2)	3.5% (1)
Radicular symptoms	11% (3)	32% (8)
Infection donor site	4% (1)	3.5% (1)
Possible deep infection	4% (1)	0
Implant migration	0	0
DVT	4% (2)	0

series was prospective but not randomised and was multi-centre (Table 2).

The only difference in complication rates that reached statistical significance in the Regan study was disc herniation, presenting presumably as a neurological complication. It is likely that this is related to the fact that in the MISS technique disc clearance is less complete, and the cages may push disc out posterolaterally. This particular complication was a significant one in the series reported by O'Dowd [12] (Table 3). Regan concluded that the laparoscopic procedure is associated with a learning curve, but once mastered it is effective and safe.

The radicular problems reported by O'Dowd occurred early in the series and were judged as being due to three causes.

1. Lateral placement of the cage, producing an entrapment of the fifth root in the foramen and extra foraminal area.
2. Displacement of disc material posterolaterally. This was remedied by a more complete removal of the disc, which required angled ronguers, and was always less effective than removal achieved in the open procedure. It was also felt that the more complete the removal of the disc, the less stable was the remaining construct. Supplemental posterior fixation was therefore frequently carried out, using laminar screws in the main.
3. Excessive distraction of the disc was thought to be a cause of radicular problems, especially in cases where MRI and CT showed neither disc material nor a misplaced cage. Kuslich (private communication) suggested this mechanism, and these patients responded well to a root block with steroid and local anaesthetic.

It was generally agreed that a laparoscopic approach to the L4/5 level was much more hazardous than a similar approach to the lumbosacral level, and Regan [13] specifically addressed this problem in a review of his personal experience. Great technical expertise was required, and a very careful appreciation of the position of the bifurcation of the great vessels. Despite his great experience, cage placement was on occasion difficult, and sometimes it was only possible to place one cage.

In summary, as far as complications go, laparoscopic cage placement using two cages at the lumbosacral level does not have a higher rate of operative complications than an open procedure.

McAfee [10] describes the use of two cages introduced retroperitoneally by a minimal approach, placed transversely across the disc space and suitable for levels above the lumbosacral level. McAfee emphasises that the incidence of retrograde ejaculation is lower in retroperitoneal approaches, which is a finding supported by the Regan results shown above (open procedures were retroperitoneal).

### MISS in the thoracic spine

Whereas in lumbar spine surgery using MISS techniques requires a cavity to be created, in the thoracic spine one is already there. The standard surgical approach to the front of the thoracic spine involving thoracotomy is clearly a much more intrusive procedure than creating a number of portals to allow use of a thoracoscope and appropriate instrumentation. With this scenario, MISS has proved to be a very significant advance in anterior spinal surgery of the thoracic spine [3–5, 7, 15]. However, many of the procedures now performed thoracoscopically do not require the use of cages, such as releases in scoliosis, thoracic disc herniation, plate stabilisation of a fracture, etc. while when cages might be appropriate, such as in stabilising the spine after a vertebrectomy, cage size may dictate that

an open procedure is required. However, Huang et al. [4] describe what they term the “extended manipulative channel method”, in which operating portals of 3–4 cm are used, allowing larger instruments to be employed. Clearly, using this technique, a cage suitable for vertebral replacement could be used.

However, the approach itself is not without complications. Huang et al. [3] describe some 30 complications in a series of 90 consecutive patients, including two deaths (one due to pneumonia, and one due to blood loss. Other complications included intercostal neuralgia, lung atelectasis, subcutaneous emphysema, and one inadvertent penetration of the pericardium. However, there is now a wealth of literature detailing the technique of thoracoscopic surgery, and the complication rates and post-operative morbidity are lower than those associated with an open procedure.

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### Results of anterior lumbar fusion (ALIF) using cages

All those who have mastered the technique of laparoscopic fusion agree that compared with an open procedure the operating time is shorter, blood loss is lower and the immediate post-operative recovery is more rapid [8–12]. O’Dowd et al. carefully assessed recovery time in the two groups, and found gain to be modest, with the laparoscopic group being 1 day ahead of the open group. How much of this perceived difference is related to doctors’ perceptions that laparoscopic fusion is a more minor procedure, leading to those patients being encouraged to get going more rapidly, is difficult to assess. During the last few years the open approach has been considerably modified from the earlier destructive muscle-cutting oblique incision to much less destructive approaches, culminating in the mini-ALIF approach of Mayer [11]. The introduction of specific retractors has also reduced the required size of incision and the degree of damage to the anterior abdominal wall in open procedures. As the laparoscopic procedures in the lumbar spine aim to do the same internal operation as an open procedure, one would not anticipate any difference in the long term results.

What is disappointing is that the introduction of cages using both open and laparoscopic techniques has not led to any dramatic improvement in the results of anterior lumbar fusion for low back pain. Unfortunately, many papers concerned with cages concentrate on fusion success and lack of complications, rather than clinical outcome. In the major series of some 947 patients reported by Kuslich et al. [6], which was not independently assessed, 90.7% of the patients were recoding as having improved at 2 years. However, this is describing an average improvement in their function of one-third – hardly a dramatic change. The results reported by O’Dowd et al. [12] are reported in greater detail, using the Oswestry Disability Index, and are apparently even more disappointing. No significant

difference was found between open procedures and laparoscopic ones. However, the Oswestry Disability Index showed an improvement on average of 22%, and a pain analogue improvement of some 30%. In all ALIF procedures (open MISS), subjective self assessment of the result by the patient indicated that 45% thought they were better (15% excellent, 30% good, 9% fair), 36% the same, and 10% worse. Whitecloud et al. [17] reported in detail the results of circumferential fusion using cages anteriorly, and despite a high fusion rate (94%), they report substantial pain relief in only 46% of patients, rather similar to the O’Dowd results.

Most reported series concerning the use of cages for anterior lumbar fusion claim fusion rates in excess of 90% McAfee [9], in a recent comprehensive review article concerning cages, points out the great difficulties of assessing whether fusion is present, and the great variety of criteria different authors have used. It is clear that, in the main cages maintain disc height, thus opening up the foramen, and maintaining lordosis if this is achieved primarily. In experienced hands, laparoscopic placement of the cages does mean a slightly more rapid post-operative recovery. It would not be anticipated that a laparoscopic placement of the cages in itself would affect the long-term results, and hence papers dealing with the laparoscopic technique have concentrated on the technique and immediate benefits and disadvantages rather than the long-term results. However, the laparoscopic technique requires the use of two cages, which can create, as we have seen, problems in correct placement of them both. It has not been established whether the clinical result may be affected by the failure of one or other of the cages to fuse, or whether the load transmission may be greater through one cage than the other. Certainly in the O’Dowd series there were a number of patients who, despite apparently solid fusions, still suffered unremitting low back pain for which no cause could be found. The load transmission through two cages fused in the main to endplate within the annulus, which probably always passes through the cage material rather than the bone within it, is very different from the load transmission that usually occurs across a segment. It also differs from that which occurs in a bony fusion that involves the whole endplate and has remodelled accordingly, and this difference may be of clinical significance in relation to pain relief. It is worth noting that McAfee [9] makes the point that the development of bone bridging outside the cage, in effect beneath the annular and cortical region of the disc space, is evidence of a satisfactory fusion and a good clinical result.

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### Conclusions

Laparoscopic anterior fusion at the lumbosacral level is not associated with more complications than an open retroperitoneal procedure, although the incidence of retro-

grade ejaculation may be increased. It is associated with a more rapid post-operative recovery, lower blood loss and in experienced hands is a shorter procedure. There is no evidence that it affects long-term results, but the need to use two cages may produce an inferior result in the long term to a single large cage; this has yet to be substantiated.

At the L4/5 level the risks of complications are greater, the learning curve longer, and the newly introduced Mini Lap retroperitoneal approach of Mayer [11] or the minimally invasive retroperitoneal approach of McAfee [10] may be more appropriate.

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