Posterior lumbar interbody fusion (PLIF) has been—and remains—quite controversial. Its proponents have been especially enthusiastic, while many other spine surgeons have been critical of the technical difficulties inherent in the procedure. Theoretically, the PLIF has many advantages, including:

1. Posterior exposure for complete visualization of the neural elements
2. Distraction or disc space restoration maintaining lateral canal patency
3. Fusion stops progressive deterioration of the diseased motion segment
4. Interbody fusion near the center of motion of the motion segment under compression
5. Potential for early stability facilitating rapid postoperative comfort and mobility
6. No necessity for hardware and its unique complications

On the other hand, we believe there are some real disadvantages present, including the following:

1. In its classic form, a high degree of technical difficulty exists requiring more operative time per level than most other fusion techniques.
2. The procedure tends to involve more neural element manipulation than other procedures.
3. Unique complications relating to demands of interdiscal bone graft placement through a limited (posterior) approach are present, including:
   a. Posterior and posterior lateral displacement of bone graft material, which may result in neural element damage or irritation (Fig. 30-1)

Fig. 30-1 Posterior migration of graft.
Failed Posterior Lumbar Interbody Fusion

Fig. 30-2  A and B, Graft collapse with lateral subluxation and instability. C and D, Refusion
with instrumentation.
b. Damage to neural elements while trying to position grafts in the interspace

c. Collapse of vertebral body sometimes resulting in destabilization of the fusion complex (Fig. 30-2)

CLINICAL SERIES

There have been many substantial series on the PLIF, especially in recent years. Variations in techniques are present in each series that make it difficult to accurately judge the procedure in general. Cloward's ingenuity and technical skill in development and refinement of this operation cannot be overemphasized. In 1953 he first published a series of 321 patients with a 1- to 8-year follow-up and reported an 85% cure rate. There were six cases of graft absorption and failure of fusion; four of these required refusion and there was one case of graft dislodgment reported. Homograft was used for the intervertebral space. In 1963 Cloward reported a series of 100 unselected cases with 84% being completely asymptomatic and 12% good with occasional minor symptoms. Bone grafts had resorbed with questionable fusion in seven out of 100. Four out of these seven were asymptomatic.

In 1964 Wiltberger described a series of 192 patients with 2- to 9-year follow-up. A dowel technique was used in 153 of these. There were no or minimal symptoms in 65%. The postoperative regimen included 8 months in a brace preceded by 3 weeks in bed. He reported 21% nonunion in the two-level cases and 13% nonunion in the one-level cases. There were five wound infections, two graft extrusions, and three patients with permanent foot drop.

Blume, using a unilateral dowel technique, reported 216 cases in 1981 with 95% good and excellent results. Of these cases, 10% showed shifting of the interbody autologous dowels. There was one case with dislodgment, which required reoperation. There was one case of anterior extrusion compressing the common iliac vein, which did not require surgery. There were three cases of postoperative lateral stenosis requiring surgery, as well as two infections and a traumatic neuroma.

Lin, a neurosurgeon, in 1982 presented 50 consecutive cases evaluated by two orthopaedists. His technique utilized autologous posterior iliac graft and homograft with retention of the spinous process interspinous ligament complex. In 45 of 50 patients that were examined an 82% fusion rate was present. Good and excellent results overall were found in 69% of the cases. In Lin's series, 500 cases reported in 1983, complications included 5% neurologic deficits, 5% thrombophlebitis, and two cases of urinary incontinence. There were four cases that required immediate reoperation because of graft displacement, and approximately 3% required reoperation for pseudarthrosis.

In 1982 Cloward reported another series of 100 patients evaluated by two orthopaedists. This series had 90% good and excellent results with 60% of the patients being followed greater than 10 years. Of 34 worker's compensation cases, 28 returned to their previous jobs after 6 months. Five patients required reoperation; however, 73% had solid fusions. There were 10 definite pseudarthroses, six of which were asymptomatic.

In 1983 Ma reported 100 consecutive cases with 74% good and excellent results despite a high percentage of patients having secondary gain. Ma has developed mortising chisels and other specialized instruments to shape the interspace and facilitate the procedure; as does Cloward,
Ma uses cadaveric bone graft. In this series, 70% returned to their original jobs. Complications included a 6% graft extrusion rate and a 15% pseudarthrosis rate.

In 1983 Hutter reported his series of 500 cases with an average follow-up of greater than 5 years. There was a 90% fusion rate with 82% excellent and good results. Autologous iliac crest grafts were used. There were technical difficulties in 5%. The series included five infections, five venous thromboses, 18 cases of residual paresis in the affected nerve and three displaced bone grafts. In 88 of the cases that were revisions, there were 64% good and excellent results.

In 1985 Collis reported 950 posterior interbody fusion levels in 750 patients; 50 patients were studied. Of these, 25 patients had previous surgery and 25 had not. The results of 25 cases without prior surgery were all satisfactory. In the 25 patients with prior surgery 84% had satisfactory results. The results with four patients in the group who had previous surgery were considered failures. In addition, 47 patients obtained bony fusion. Three patients with fibrous unions had good clinical results. Out of his series of 750 cases there were four dural tears, four cases of graft extrusion requiring surgery, and three minimal graft displacements that did not require surgery. There were six cases of nerve deficit, all of which were temporary.

In our combined series 120 consecutive cases were performed with a minimum of 9-month follow-up. Of these, 17% had previous chemonucleolysis or surgery. Approximately 33% were performed using bilateral posterior dowel autologous graft from the iliac crest or allograft with instrumentation designed by Dr. H. Crock; 40% were performed using bone blocks in the manner of Cloward. In 20% posterior instrumentation with Luque segmental wiring or interlaminar wiring was added to the PLIF. Autologous chip grafts were used in 10%. About 50% of the cases used autologous bone, and one half used allograft. There was no significant difference in results according to the variation in techniques or the type of bone graft used. Zucherman reviewed the patient results of all three authors of this chapter. The patients' results were categorized into excellent, good, fair, and poor. Excellent was defined as asymptomatic, taking no medicines, and returning to full activities; good was defined as much improved from preoperative state, returning to work with minimal or no limitations with the need for occasional non-narcotic medication; fair was defined as significantly improved from preoperative state but with significant functional limitations and feeling the need to take medications several times a week; poor was defined as the same or worse from the preoperative state with marked functional limitations and the need for pain control measures and medications. Approximately 50% had good and excellent results with 40 patients considered excellent and 21 considered good. There were fair or poor results in 57 patients, 29 fair and 28 poor.

One patient died from apparently unrelated causes 1 month after the procedure. In one case the technique was abandoned because of technical difficulties during the procedure. There was a 17% (20 patients) reoperation rate. In 16 cases these were revisions resulting from graft retropulsion or vertebral subluxation with graft collapse (Figs. 30-3 through 30-5). In three patients hardware was removed only. One patient had a reoperation to remove a drain tip. There was no significant difference in the rate of graft dislodgment by surgeon or by technique.
Fig. 30-3  Lateral subluxation after PLIF treated by posterior lateral fusion.

Fig. 30-4  Migration of chip grafts posteriorly.
Fig. 30-5  A, Posterior migration of PLIF.  B, Revision with instrumentation.

TECHNICAL ASPECTS

Graft extrusion is one of the principal unique PLIF complications. As Hutter points out, the positioning of the patient is the key factor. If one uses one of the knee-chest frames to free the abdomen from pressure, an increase of lumbar lordosis is also created, which will tend to result in shaping the vertebral space in such a way as to encourage posterior migration of the grafts (Fig. 30-6, A); the lumbar lordosis should be reduced (Fig. 30-6, B).

When grafts are inserted into the disc space, the upper exiting nerve root traverses the interspace often just out of direct view in the remaining undecompressed lateral recess (Fig. 30-7, A). Great care must be taken by both the surgeon and the assistant that the superior lateral corner of the bone graft being inserted does not damage the upper traversing nerve (Fig. 30-7, B). Depending on the individual anatomy, it may be difficult or impossible to insert bone grafts without undue traction on neural elements, such as in the case of a conjoined nerve root covering the posterior lateral portion of the disc.

It is essential to be able to slide the grafts across the disc space if bone graft blocks are used. The most inaccessible part of the disc that may block graft positioning is in the midline under the posterior longitudinal ligament (Fig. 30-8, A). This is most easily removed with a down-pushing curette or by totally excising the posterior annulus and ligament (Fig. 30-8, B).

Although extremely rare, anterior vessel damage by penetrating the annulus is an ever-present danger. A lateral x-ray film with an instrument in the disc space is helpful to gauge its depth. Chisels and curettes can be permanently marked so that their exact depth in the disc space can be gauged readily at any time during the procedure.
Fig. 30-6  A, Operation with the patient in increased lordosis encourages posterior graft migration. B, Appropriate positioning.
Fig. 30-7  A, Exiting roots just out of view under facet joints. B, Roots in jeopardy when grafts are inserted.

Fig. 30-8  A, Removal of lateral most disc. B, Midline disc is easily overlooked.
Excellent visualization and exposure is mandatory in this procedure. Hypotensive anesthesia is extremely useful in minimizing bleeding. Epidural veins are controlled with bipolar coagulation and tamponade with Gelfoam or Surgicel. A head lamp is the most effective technique for illumination in our experience.

Although we saw no difference in results using bone-bank bone or autologous bone, there was definitely diminished operative time and technical difficulty using bone-bank bone. In the case of the dowel procedures, using precut dowels seems to significantly reduce the technical difficulties of the procedure.

Osteoporotic patients present a greater technical challenge. Chances of vertebral body collapse with resulting destabilization and bone graft migration are increased. If autogenous bone is used, the variable of bone graft of inadequate strength to support the interspace is introduced. It seems preferable to correct osteoporosis as much as possible before the procedure.

Although some surgeons believe that postoperative epidural fibrosis is minimized because of immediate stabilization, we think that this has been a definite problem with the procedure because of wide posterior decompression and increased manipulation of the neural elements. We have seen great amounts of epidural fibrosis, both in our own cases and in other cases performed by expert PLIF surgeons. The use of fat grafts or Gelfoam around the neural structures appears to help somewhat in reducing scar, perhaps by minimizing postoperative bleeding and dead space.

Although Cloward has reported excellent results in spondylolisthesis, the technical problems are certainly magnified in this situation. It would seem prudent to become very experienced in this technique before attempting it in these cases.

From the series reviewed it is clear that the PLIF can be an effective surgical treatment in some experienced hands. A question that must be answered is what real advantage does it have over other fusion techniques. Another issue is the “learning curve” in perfecting the technique.

Fig. 30-9 Clinical series of posterior interbody fusion and posterior lateral fusion.
In DePalma's series of 89 patients with 173 levels fused posterior laterally, 76% good and excellent results were reported. Stauffer and Coventry report 81% of 177 patients returning to their original job, with 356 levels posterior laterally fused. Selby and White have reported 85% and 70% satisfactory results respectively using posterior lateral fusion with Knodt rods. These results appear to fall within the range of the results reported by various PLIF surgeons (Fig. 30-9).

Our experience and that of other spine surgeons who have recently begun doing PLIFs is of occasional technical complications resulting in poor clinical outcomes. These difficulties are unique to PLIF and are not present in the posterior lateral fusion techniques. Results in worker's compensation cases for the state of Washington have been so dismal that posterior interbody fusions are no longer authorized by the Department of Labor and Industries, based on results in 117 cases.

**SUMMARY**

PLIF can be effective in the most experienced hands but may not be the easiest or most effective way to accomplish fusion with posterior visualization and decompression. The learning curve in this operation is longer than in others that may accomplish the same goals. Theoretical appeal and the "neatness" of an operation should certainly be secondary consideration to clinical efficacy. We believe that the classic PLIF should be considered only in an ideal setting; that is, performed by very experienced spine surgeons who have had training from an expert in PLIF surgery with an equally qualified assistant. The specialized instrumentation specifically designed for this procedure is mandatory before it should be attempted. Availability of hypotensive anesthesia and a bone bank to diminish technical difficulties is recommended.

**REFERENCES**

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