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The use of allograft (and avoidance of autograft) in anterior lumbar interbody fusion: a critical analysis

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Abstract The aim of this report is to analyze the validity of allograft in anterior lumbar interbody fusion. Forty-three patients underwent anterior lumbar interbody fusion using allograft in the period between 1995 and 1998. All suffered from crippling chronic low back pain with or without sciatica. Discogenic disease was verified in 40 cases by discography. All patients were investigated preoperatively with magnetic resonance imaging (MRI). The surgical technique is described. Follow-up radiographs were performed postoperatively, then at 1.5, 3, 6 and 12 months, as required. Radiological

fusion was confirmed in all single-level fusions (100%, $n=24$). In two-level fusions the rate was 93% ($n=28/30$). However, radiological union could only be confirmed in 11 of the 12 levels in the three-level fusions. Allograft offers a better alternative to autograft for anterior lumbar interbody fusion. Donor site morbidity is avoided, hospital stay is shorter and fusion rates are satisfactory.

Keywords Lumbar spine · Low back pain · Interbody fusion · Allograft · Surgery

Introduction

Allograft has been used successfully in bone tumor surgery since the late 19th century [10]. However, its use in scoliosis surgery has been flawed, with poor results in the 1960s. Advocates of autograft attribute superior fusion and biocompatibility properties to autograft when compared with allograft; the main disadvantage with autograft being its limited supply [13]. Most studies comparing autograft and allograft fusion rates in different spinal fusion settings found no significant difference [2, 4, 15]. The senior author (J.O.B.) has been using a hybrid graft (allograft and autograft) in place of autograft since 1989 for lumbar interbody fusions [5, 8, 9]. From 1995 onwards, this has been substituted by an allograft/allograft composite. In this report we aim to analyze the fusion rate in a group of patients who underwent anterior lumbar intervertebral fusion using this composite graft made of femoral cortical allograft rings packed with cancellous allograft bone chips (North London Tissue Bank, Deansbrook Road,

Edgware, Middlesex, UK) and none of the patient's own bone.

Materials and methods

Forty-three consecutive patients were operated upon by the senior author (J.O.B.) between October 1995 and December 1998. All patients suffered from intractable low back pain with or without sciatica. Failure of conservative treatment was a prerequisite for consideration of operative management. Patients who underwent autograft fusion for different reasons (e.g., discitis) were excluded from the study. There were 20 men and 23 women. The average age was 40 years (range 19–64) at the time of surgery. Previous lumbar spine surgery only influenced the type of posterior fixation planned (translaminar facet screws or pedicle screw fixation). Discogenic disease was confirmed by discography in 40 patients. In the rest, the preoperative MRI clearly demonstrated the diseased level and the underlying pathology e.g., spondylolisthesis. Sciatica demanded special attention to the lateral recess and exit foramina, and consequently, nerve canal surgery was included in the operative planning.

All patients had radiological follow up at 6 weeks, 3 months, 6 months and 1 year after surgery. Clinical follow-up was mini-

mum 1 year and maximum 5 years, with an average of 24.4 months.

Radiological investigations

All patients were investigated preoperatively with MRI. Provocative discography was performed in all cases where the MRI showed more than one-segment pathology. Correlation between the clinical findings, MRI findings, and discography was essential if operative treatment was to be offered to the patients.

Routine postoperative radiographs were done immediately and at 6 weeks and 3 months. Immediate (48 h) postoperative plain antero-posterior (AP) and lateral views centered on the operated segment(s) were followed by lateral tomography at 6 weeks and lateral tomography at 3 months. Further tomography was carried out at 3-month intervals only if the arthrodesis was in doubt. If clinical suspicion warranted, the instrumentation was checked with plain radiographs obtained outside these fixed stages.

All radiological investigations were reviewed and reported on by a single orthopedic radiologist (P.R.). Radiological fusion was diagnosed when the lucent line at the entire host-endplate interface had disappeared on lateral tomography.

Technique

The anterior retroperitoneal approach to the lumbar spine has been described elsewhere [3, 12]. A radical discectomy is performed. The cartilaginous endplate is scraped to expose the bony and freshly bleeding endplate. Herniating disc fragments in the spinal canal are nearly always identified and extracted by careful manipulation. The disc space is measured in three dimensions (anterior height, posterior height, and depth). Suitably sized cortical femoral allograft rings are then carefully drilled to these measurements using a high-speed air drill. No sharp edges, which would cut into the relatively soft subchondral bone, are left on the ring. In the meantime, allograft bone chips are mixed with the patient's own blood in a container. The mixture is then impacted into the center of the allograft ring to produce a convex surface at both ends. The authors believe that this is vital for load transmission across the allograft chips, thus ensuring optimal conditions of compression for osteogenesis. The allograft ring is then impacted into the disc space and secured anteriorly by cancellous AO screws and washers drilled into the body of adjacent vertebrae. The fusion was complemented in 41 patients by posterior fixation to provide rigid segment stability. No postero-lateral grafting was used.

Table 1 Levels operated

Levels	N
L2/3	2
L3/4	8
L4/5	22
L5/S1	30
Total	62

Table 2 Results (M male, F female)

No. of levels	N	Average age	%	Fusion rate (%)
One	24 (11M/13F)	40.9	55.9	100
Two	15 (8M/7F)	44	34.8	97.7
Three	4 (1M/3F)	46.2	9.3	91.7
Total	43 (20M/23F)	40	100	

Patients are usually mobilized within 24 h, and a rigid lumbar brace is worn for a period of 6–8 weeks. Currently the authors are investigating the need for the lumbar brace in single-level fusions.

Results

Sixty-two levels were operated upon in 43 patients. Table 1 and Table 2 show the different levels and the number of levels per patient operated upon respectively. Average length of stay was 10 days (range 7–13) for three-level fusions, 8 days (range 6–17) for two-level fusions and four days (range 3–12) for single-level procedures.

Evidence of a fusion was demonstrated as early as 2 months after surgery, by absence of the lucent interface between the allograft center and the bony endplate on lateral tomography (Fig. 1). Figure 2 shows a plain radiograph of the same patient taken at the same time as the tomogram. Full incorporation of the graft was found to take at least 9 months. Satisfactory fusion was demonstrated radiologically in all one-level procedures (100%). The fusion rate per operated level in two-level procedures was 93%. In one patient the graft reabsorbed, as was evident on the 9-months post-fusion tomogram (Fig. 3). In three-level procedures, one patient had radiological evidence of a non-fusion at one level, thereby reducing the rate of fusion per operated level to 91.7%.

Figure 4 demonstrates the overall rate of fusion with allograft ring. Twenty-one out of 43 patients (48.8%) had sound radiological fusion by 3 months post surgery, and 77% ($n=33$) were fused by 6 months.

Fig. 1 Lateral tomogram, 2 months after surgery. Fusion is evident from the absence of a lucent interface between the allograft center and the bony endplate

Fig. 2 Plain radiograph of the same patient as Fig. 1, taken at the same time

Fig. 3 Tomogram taken 9 months after fusion, showing graft resorption

Figure 5 and Table 3 demonstrate the rate of fusion per number of levels per patient. Of single-level fusions, 45% were radiologically fused by 3 months and 86% by 9 months. Interestingly, in two-level fusions, 53% were fused within 3 months and 80% by 9 months. Half of three-level fusions were fused within 3 months (two out of four patients).

Five patients (11.6%) required subsequent surgery to the lumbar spine. Four had lateral recess decompression at the level of fusion (post-fusion stenosis) after an average of 2.5 years, with excellent outcome. One patient underwent a posterior interbody fusion in the adjacent level 4 years after the original fusion, with poor outcome.

Fig. 4 Overall rate of fusion with allograft ring

Fig. 5 Rate of fusion per number of levels per patient

Table 3 Time fusion occurred (in months after surgery *m*), by number of levels operated

	One level		Two levels		Three levels	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
≤3 m	11	45	8	53	1	25
3–6 m	8	33	3	20	1	25
6–9 m	2	8	1	7	0	0
9–12 m	2	8	0	0	1	25
≥12 m	1	4	1	7	0	0
Total	24	100	13	87	3	75

Discussion

The problem with donor (iliac bone or rib) site morbidity is two fold: complications at the donor site (hematoma, infection, fracture) and delayed mobilization because of local pain. Reported complication rates at the donor site vary from 2.3% to 25% in the larger series [6, 14]. In allograft fusion, donor site morbidity is avoided, which in turn reduces the total operative risk. Also, the absence of donor site pain allows early mobilization. In the present series, all patients were mobilizing within 24 h following the procedure. The average length of hospital stay for

Fig. 6 Computer tomographic scan of a patient who demonstrated long-term cortical femoral allograft resorption. The center of the graft continues to show solid arthrodesis, while the allograft ring exhibits mottling and disintegration spreading across its diameter

three-level fusions was 10 days; it was 4 days for single-level fusions.

We used lateral tomography exclusively to assess the graft-host interface, and hence, the fusion. We concur with the conclusions of Kant et al. [7] of the restricted value of plain radiographs in assessing lumbar spine fusions. In relation to confirming arthrodesis, plain radiographs demonstrated only a 68% correlation with the intra-operative findings, on re-exploring 75 posterior lumbar fusion patients. The re-exploration was for removal of posterior instrumentation 1 year after surgery. Similarly, plain radiographs with dynamic views are of restricted value in providing information on spinal stability. We find that patients in the recovery period (up to 6 months) experience muscular pain at the ends of flexion and extension, rendering this investigation of limited value at this stage.

Our reported fusion rates (87%–100% according to number of levels operated) are similar to those reported by Molinari et al. [11], who evaluated 20 patients with an-

terior allograft constructs supplemented by posterior fixation, over a 5-year follow-up. Holte et al. [5] found a reduced fusion rate in patients who received no posterior fixation (98% vs 75%). In our series, out of the three patients with non-fusions, one received no posterior fixation. In this patient the non-fusion could not be attributed to lack of posterior stabilization, as graft absorption was caused by the inadvertent placement of the AO screw into the graft itself (Fig. 2). We believe firmly in the importance of providing posterior stabilization for the anterior construct, either by translamina facet or pedicle screws, depending on the surgeon's training. All five patients who underwent subsequent posterior lumbar surgery had posterior fixation, and none had intra-operative evidence of a pseudoarthrosis.

Long-term cortical femoral allograft resorption has been observed in the few patients who required revision lumbar surgery. The center of the graft continued to show solid arthrodesis on CT scan (Fig. 6), while the allograft ring exhibited mottling and disintegration that spread across its diameter. The authors do not believe that the integrity of the arthrodesis is compromised by resorption of the allograft.

Graft transmitted infection (viral or bacterial) might be of concern. The official stance of several renowned medical bodies [1] stresses how extremely low the risk of graft transmitted infections is when proper preparation and sterilization procedures are employed. Since the start of the use of allograft by the senior author in 1989 [5], there have been no graft-related infections.

Conclusion

Allograft provides a better alternative to autograft in lumbar interbody fusion. The technique is uncomplicated and fusion rates are excellent. Radiological assessment of fusion is best achieved by lateral tomography done once at 6–8 weeks after surgery, and only repeated at 3-months intervals if there is a lucent line between the graft and endplate. In comparison to other implants, it remains the most cost effective.

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