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ORIGINAL ARTICLE

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The use of 'hybrid' allografts in the treatment of fractures of the thoracolumbar spine: first experience

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Abstract Harvesting autogenous bone grafts of the iliac crest carries complications and lengthens operative times. Allografts are preferred to avoid these problems. Fusion after using allogenic bone grafts has been well studied, by examining trabeculations and remodelling on anteroposterior and lateral radiographs. However, the question remains whether one can rely on radiographs alone to determine fusion. 'Hybrid' fresh-frozen allografts from the femur or tibia were used in 11 adult patients with a mean age of 56.4 years (range: 30–78 years) to stabilize the thoracolumbar spine after anterior decompression for trauma. In one case two adjacent levels were fractured, in another case two fractures occurred at different levels. Fresh-frozen allografts of the femur (in ten cases) and tibia (one case), filled with autogenous cancellous bone graft or pieces of rib, were used to reconstruct the anterior column of the spine. Stabilization was performed by means of a Kaneda device. Anteroposterior and lateral radiographs and, additionally, computed tomography (CT) examinations with reconstructions were used to study fusion. One patient died 1 month after surgery. At follow-up in ten patients, after a mean time of 30.2 months (range: 18–42 months), ten allografts showed a grade I fusion and one a grade III fusion. Additional data from the CT examination with reconstructions, however, showed cross-trabeculations in all cases, and a partially united allograft in the patient with a grade III fusion. Cross-trabeculations between the allograft and vertebral body was observed at 6 months, with remodelling occuring at approximately 2 years. Mean loss of correction was minimal, at 3.6° (range 0°–16°). Fresh-frozen femoral or tibial allografts worked effectively to maintain correction after trauma when combined with anterior instrumentation. CT examinations with sagittal and coronal reconstructions were more effective for evaluation of fusion compared with anteroposterior and lateral radiographs. The high fusion rate and the low morbidity achieved using allografts in this way supports the exclusive use of allografts in the anterior thoracic and lumbar spine in the future.

Keywords Spine injuries · Structural allograft · Fusion rate

Introduction

Anterior procedures to the thoracic and lumbar spine are indicated when there is a need for anterior spinal canal decompression, or to stabilize the spine anteriorly. Structural autogenous bone grafts after corporectomy are considered to be the biological and biomechanical standard to achieve a fusion of the spine [11,12]. However, allografts are recommended as an alternative bone graft, because of the lack of complications associated with harvesting autografts [2, 6, 14, 16, 17, 19, 25, 26,28], their availability and decreased operative time [28].

The use of allografts is becoming increasingly attractive, as limited data in the literature show high rates of bone fusion, exceeding 90% [3, 4, 9, 13, 16, 20, 21,27] without major complications. The time to fusion ranges from 3to 12 months [13, 16, 20,27]. Trabeculation between the allograft and vertebral body can be observed at 6 months, with remodelling at an average of 30 months [9]. Since 1996, we have used hybrid femoral or tibial allografts to replace the vertebral body and adjacent disc after trauma. In this paper we present 11 consecutive cases of traumatic, unstable thoracolumbar fractures in a study of fusion rates by means of anteroposterior radiographs and CT examinations. The object was to determine retrospectively whether CT examinations offered some additional valuable radiographic information.

Materials and methods

Our first experience using allografts comprises 11 consecutive cases of vertebral body replacement using a tibial or femoral allograft. Between June 1996 and May 1998, 11 patients were treated for unstable traumatic anterior lesions of the spine at the University Hospital Gasthuisberg, Leuven. All were treated in the same way, by means of a thoracophrenotomy or thoracotomy, with 80% corporectomy of the injured vertebral body, femoral or tibial allograft filled with autogenous bone graft as a strut graft, and stabilization by means of a Kaneda device (AcroMed). No posterior surgery was performed.

The subjects comprised seven men and four women, with a mean age of 56.4 years, ranging from 30 to 78 years. One patient had a positive serology for HIV (case 4), and one had been receiving long-term treatment with steroids (case 7).

The fracture was located at the level of T7 in one case and at T12 in another case; in three cases it was at the level of T11, in two at the level of L1, L2 and L3 and in one case at the level of L4. In case 6, two fractures occurred at non-adjacent levels (T12, L4) and, in case 8, two levels adjacent to one another (L1, L2) were involved. All lesions were classified according to the AO classification [18]. In nine subjects a compression lesion of the anterior column was noted (type A), in two a flexion-distraction lesion (type B) and in one a flexion-distraction with rotation (type C). A right-sided thoracotomy was performed in case 5, while all others were approached by means of a left-sided thoracophrenotomy: resection of the rib two levels above the fractured vertebra; stripping off the parietal pleura; section of the diaphragm 2 cm from its attachment and keeping retroperitoneal.

The fractured vertebral body was resected together with the adjacent disc. Preparation of vertebral endplates consisted of scraping the endplate until punctate bleeding appeared. The major part of the endplate was preserved to withstand interbody compression and stability [13]. All the allografts were taken from the Tissue Bank, according to the Belgian Transplantation and Tissue Banking law [15, 24]. Fresh-frozen allografts were used to strut the spine at the fractured level. The marrow space of the graft was cleaned thoroughly and filled with autogenous bone grafts of the partially resected vertebral body or resected rib.

A Kaneda device was used in every case to stabilize the anterior column. Care was taken to put the allograft under compression using a compression device. The patients were allowed to mobilize postoperatively as soon as possible, with an appropriate corset over a period of 4 months to support the spine and to prevent patients from doing heavy work.

A neurological evaluation was performed preoperatively and at follow-up, and the results were graded according to Frankel's classification [7].

Fusion was studied on anteroposterior and lateral radiographs at follow-up. The anterior fusions were graded as grade I, grade II, grade III or grade IV, according Bridwell et al. [3]. Grade I was defined as fusion with remodeling and trabeculae present; grade II was assigned if the graft was intact, not fully remodeled and united throughout but with no radiolucencies above and below; grade III was recorded where an intact graft occurred but with a potential lucency at the top or bottom of the graft; grade IV was for cases definitely not fused, with resorption of bone grafts and signs of collapse. Additionally, a computed tomography (CT) examination, with coronal and sagittal reconstructions, was performed in each case to study the radiographic findings: the trabeculations and cancellous bone/cortical bone interface. The radiographs and CT examinations were reviewed by an attending musculoskeletal radiologist. On the lateral radiographs the kyphosis angle was measured at follow-up, according to Cobb, and compared with the postoperative angle.

Table 1 Patient data

	Sex / Age(yrs)	Level	Type of lesion[a]	Pre-op. Frankel	Allograft type	Follow-up (mths)	Fusion grade[b]	Postop. kyphosis[c]	Follow-up kyphosis[c]	Follow-up Frankel grade
1	M / 65	L2	A3.3.1	E	Femur	20	I	–4°	0°	E
2	M / 64	T11	C3.1	A	Femur	19	I	14°	20°	A, incontinence
3	M / 30	T11	A3.2.1	E	Femur	19	I	16°	20°	E, minor urinary problems
4	F / 51	L2	A3.3.3	E	Femur	42	I	2°	2°	E
5	M / 53	T7	A1.2.3	D2	Tibia	41	I	34°	50°	E
6	M / 68	T12 L4	B2.3.2 A3.1.1	B	Femur Femur	41	I III	10° –22°	14° –22°	D2, no incontinence
7	F / 78	L3	A3.3.3	E	Femur	37	I	–12°	–18°	E
8	F / 35	L1 L2	B2.3.2 B2.3.2	B	Femur	31	I	2°	2°	C, incontinence
9	M / 76	T11	B1.2.3	A	Femur	24	I	8°	8°	A, incontinence
10	M / 48	L3	A3.3.3	E	Femur	18	I	2°	2°	E

[a] According to the AO classification [18]
[b] Graded according to Bridwell et al. [3]
[c] According to Cob's sagittal measurement

Results

One patient died 1 month after operation due to extensive medical problems and a severe pressure sore at the sacral region, with progression to a general sepsis. All remaining ten patients were included in the study (Table 1). The mean follow-up of the 11 allografts was 30.2 months (range: 18–42 months).

None of the ten patients experienced backache. Three patients mentioned approach-related problems. One of them complained of minor sensory disturbances and two of almost intractable pain at the level of the incision. On stan-

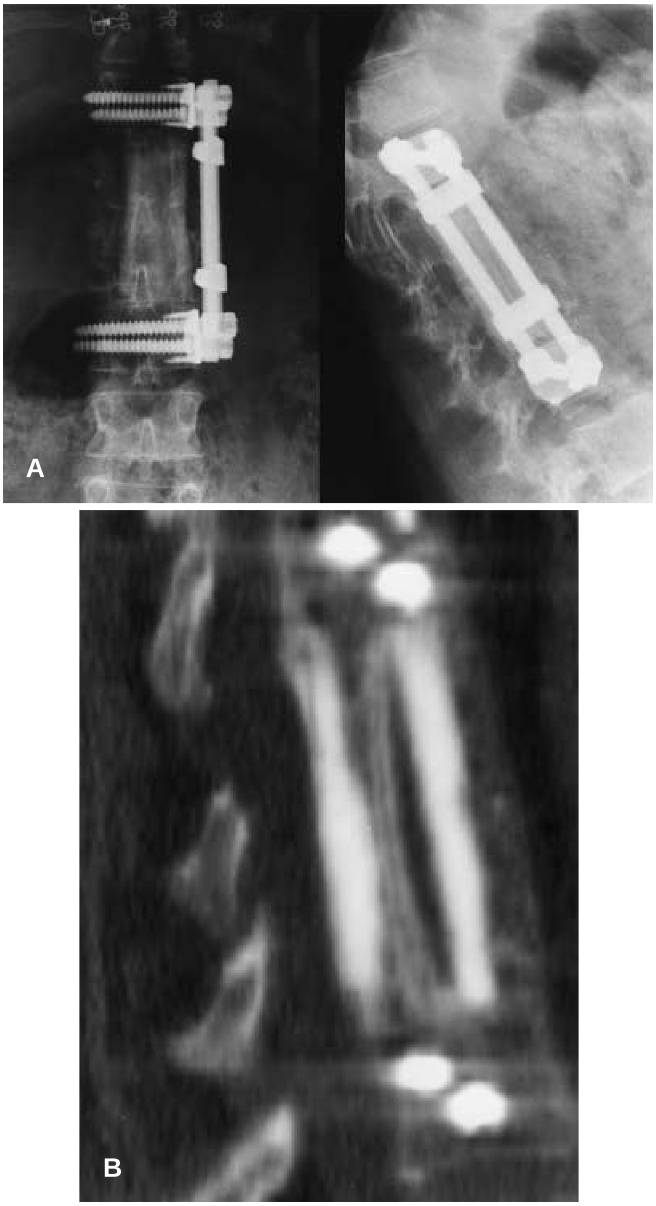

Fig. 1A,B Case 8: a B2.3.2 fracture (AO classification [18]) at the level of L1, L2, treated with an anterior procedure using a femoral allograft filled with a piece of rib and autogenous cancellous bone and stabilized by means of a Kaneda instrumentation. **A** Bone union and remodeling of the graft (grade I fusion) is apparent on radiographs after 31 months. There is no late posttraumatic kyphosis. **B** Computed tomography (CT) examination with sagittal reconstruction confirms the radiographic findings. Trabeculations and bone union are present

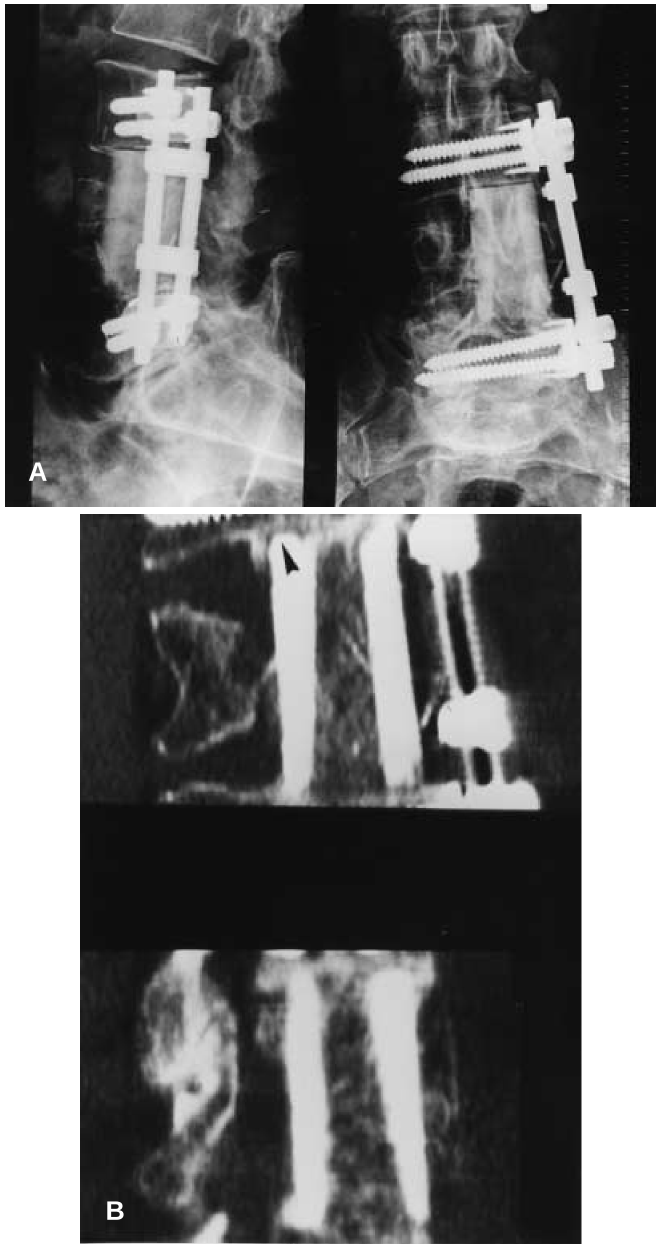

Fig. 2A,B Case 6: a 3.1.1 fracture of L4. **A** Radiographs show grade III fusion at the upper end of the allograft, 41 months after surgery. Cross-trabeculations and bone union are apparent at the lower end. **B** CT examinations with coronal (*above*) and sagittal (*below*) reconstructions show cross-trabeculations at both ends. Furthermore, almost circumferential bone union is present. A radiolucent line can be seen only on the coronal reconstruction (*arrow*) dard radiographs, 10 of the 11 allografts showed a good, grade I, bone fusion. One case (L4 in patient 6) showed a radiolucent line of the allograft to the vertebral body interface at the upper end of the allograft, assessed as a grade III fusion, 41 months after the operation. Cross-trabeculations between the allograft and vertebral body was observed at 6 months, with remodelling at approximately 2 years.

Ten of the 11 CT examinations confirmed the radiological findings (Fig. 1). The case with a radiolucent line on the allograft-vertebral body interface showed good trabeculations at the level of the autograft inside the allograft in connection with the cancellous bone of the vertebral body. However, the cortex of the allograft itself was only partially united on coronal reconstructions, and this was interpreted as a nonunion on radiographic examinations (Fig. 2). The mean difference between the postoperative and the follow-up kyphosis angle was minimal, at 3.6° (range 0°–16°). One patient (case 5) showed an increased kyphosis of 16° and one (case 7) an increased lordosis of 6°. In both cases the lateral radiographs showed evidence of penetration and fusion of the allograft inside the vertebral body. In all other cases, the loss of correction ranged from 0° to 6°, but without penetrating the endplates. The neurological improvement was minor. Two patients were paraplegic on admission, and remained so. Two patients, initially with a type B neurological deficit, improved to a D2 and a C classification on the Frankel scale. The latter one remained incontinent. The patient (case 5) with a D2 neurological deficit showed no evidence of deficit at follow-up. All other subjects were normal on neurological examination before surgery and at follow-up.

Discussion

The tricortical iliac autograft has been used extensively at the thoracic and lumbar spine anteriorly, with resultant high fusion rates, exceeding 90% [11,12]. Although iliac crest is used frequently, donor-site morbidity can be substantial and may delay mobilization. Morbidity consists mainly of donor site pain [2, 14, 16, 17, 25, 26,28]; blood loss [5, 23, 28,29]; hematoma requiring evacuation [2, 14, 26,29]; nerve injuries [6, 14,19]; iliac crest fractures [14, 25,28]; wound infection with dehiscence [2, 14, 17,28] and, finally, cosmesis [26].

Allograft bone products are the most common extenders or substitutes for autogenous bone transplants. These materials are considered highly osteoconductive, weakly osteoinductive and non-osteogenic, because the cells do not survive transplantation [22].

The results of using allograft bone to facilitate achieving spinal fusion depend on the type of allograft bone used [8], the anatomic location of implantation and also the type of stabilization [10, 30,31].

In 1983, McBride and Bradford [20] discussed a procedure to replace the vertebral body with a femoral neck allograft in which a slot had been fashioned to accept a vascularised rib graft. Of the six patients they treated this way, one case was complicated by displacement of the anterior strutgraft, necessitating additional posterior spine instrumentation and re-exploration with reinsertion of the anterior strut graft. The postoperative immobilization period ranged from 7 to 12 weeks. Early bony healing of the vascularized rib graft was evident as early as 7 weeks. All patients demonstrated complete bone union by 12 weeks. Bridwell et al. [3] treated 24 adult patients with a kyphosis or an anterior column spinal defect. They used allografts in 16 patients to span the disc space and in 8 patients to span two discs and the vertebral body. They noted a collapse of the graft in 8.3% of all patients and at 4.1% of all levels. Collapse was not seen with any of the more rigid posterior instrumentation systems. Failure occurred after using Edwards or Harms posterior instrumentation. No collapse occurred in the patients for whom longer allografts were used to bridge vertebral bodies. Kozak et al. [13] reported on a series of 45 patients, using a femoral allograft cross-section and autogenous cancellous bone to replace the disc. A fusion rate of 97% was achieved, based on a flexion and extension analysis with a 6- to 12-month follow-up period. Molinari et al. [21] reported on 16 patients in whom allografts were used to span only the disc space and on four patients in whom the structural allograft spanned the vertebral body and two disc spaces. Of the 67 structural allografts, 66 (98.5%) showed fusion on upright radiographs. None of the allografts showed evidence of collapse. At all grafted levels, and in all patients, there was no difference in sagittal plane measurements immediately after surgery, and at follow-up examinations 2 years and 5 years or more after surgery. Liljenqvist [16] reported on 41 patients after combined anterior and posterior lumbar fusion with femoral cortical allograft to replace the disc. The overall fusion rate was 95.2%, with an average time of 8.7 months: 66.1% fused without significant subsidence, and 18.6% with subsidence due to resorption of the allograft. In 15.3%, a fusion was present with a protrusion of the allograft into the vertebral body. Buttermann et al. [4] treated 38 patients by means of a femoral ring allograft or tricortical iliac autografts at disc level for a degenerative disease. Sixty-four femoral ring allografts and 18 tricortical iliac autografts were used. A pseudarthrosis of 6% was noticed in the group of allografts, and none in the group of autografts. Govender and Parbhoo [9] reported on 47 children in whom fresh-frozen allografts from the humerus were used to stabilise the spine after decompression for tuberculosis. Rejection of the graft or deep sepsis was not seen. Cross-trabeculation between the allograft and the vertebral body was observed at 6 months, with remodelling occurring at approximately 30 months. Silcox [27], using threaded cortical allograft bone dowels, noted only one pseudarthrosis in 25 patients, but acknowledged that the follow-up was only over a short time. Abitbol and Heim [1] used the same method and found that early fusion rates exceeded 90%, accompanied by good patient satisfaction.

The data presented in this study support the limited data in the literature. They indicate that allografts used in the anterior thoracic and lumbar spine to fill structural defects maintain their structural integrity and do not collapse over time. Cross-trabeculations were noticed after 6 months, remodelling after approximately 2 years. Only 1 of 11 allografts showed a grade III fusion on the anteroposterior and lateral radiographs. However, sagittal and coronal reconstructions showed trabeculations across the interface and a partially united allograft.

Conclusion

Anterior fresh-frozen structural allografts are effective in obtaining bone union in the long term, and in maintaining a correction in the sagittal plane when combined with anterior instrumentation alone. The graft should consist of a rigid structure that can withstand greater physiologic loads than would be anticipated in the postoperative period, and its composition should promote arthrodesis. Radiographs are not accurate enough to determine the grade of fusion;CT examinations are better for this purpose, as they visualise more clearly cross-trabeculations at the allograft-cancellous bone interface. Encouraged by the high fusion rates achieved using 'hybrid' allograft bone in combination with Kaneda instrumentation, we believe that exclusive use of allografts in the anterior thoracic and lumbar spine will reduce patient morbidity.

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