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ORIGINAL ARTICLE

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The effect of transpedicular intracorporeal grafting in the treatment of thoracolumbar burst fractures on canal remodeling

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Abstract Short-segment posterior instrumentation for the treatment of thoracolumbar burst fractures has been reported with a high rate of failure. Transpedicular intracorporeal grafting in combination with short-segment instrumentation has been offered as an alternative to prevent failure. However, concern still remains about the potential complication of further canal narrowing or failure of remodeling with this technique. The purpose of this prospective, randomized, controlled study is to evaluate the effect of transpedicular intracorporeal grafting on spinal canal restoration and remodeling in a group of patients treated with short-segment instrumentation for thoracolumbar burst fractures. Twenty-one patients with thoracolumbar burst fractures were randomised into transpedicular grafting (TPG) (*n*=11) and non- transpedicular grafting (NTPG) (*n*=10) groups, and were prospectively followed for an average of 50 months (range 25–85 months). Groups were similar in age, type of fracture, load sharing classification and kyphotic deformity. Preoperative, postoperative and follow-up computed tomographic (CT) images through the level of pedicles were obtained, corrected for differences in magnification, and digitized. Areas of the spinal canals were measured and normalized by the estimated area at that level (average of adjacent levels). Average kyphosis was 19.7°±6.2° at presentation, was corrected to 1.9°±4.9° by operation, but was found to have deteriorated to 9.1°±6.4° at final follow-up. There were no differences between groups regarding the evolution of sagittal deformity. Spinal canal narrowing was 38.5±18.2% at presentation, 22.1±19.8% postoperatively, and it further improved to –2.5±16.7% at follow-up, similar for both groups. Our results demonstrate that transpedicular intracorporeal grafting in the treatment of burst fractures does not have a detectable effect on the rate of reconstruction of the canal area or on remodeling. Spinal canal remodeling was observed to occur in all patients regardless of grafting.

Keywords Thoracolumbar burst fractures · Transpedicular grafting · Surgery · Canal remodeling

Introduction

The treatment of thoracolumbar burst fractures remains complex and controversial. The introduction of transpedicular screw fixation enabled the use of fixation methods with shorter constructs compared to longer ones [10], but the incidence of instrumentation failure is unacceptably high [15, 19, 22, 23, 26]. The cause of this problem appears to be the structural and mechanical deficiency of the anterior column following indirect reduction of the fracture, because of the anterior column defect that invariably emerges as an effect of indirect vertebral height and lordosis restoration. Transpedicular grafting of the involved vertebral body has been offered [7] and performed successfully as an alternative [1, 3, 4, 5, 11, 18, 21, 25, 32, 33], although the authors of some recent studies were against this technique [2, 3, 18, 31].

One of the concerns regarding transpedicular grafting of the fractured vertebral body is the possibility of displacement of the graft fragments into the spinal canal, leading to further canal encroachment [28]. Furthermore, little is known about the potential deleterious effects of transpedicular grafting on the amount of canal area restoration by indirect reduction, as well as the canal area remodeling that is expected to occur over time [14, 34].

The objective of this prospective study was to evaluate the effects of transpedicular intracorporeal grafting on canal area restoration and remodeling in a group of patients with thoracolumbar burst fractures who had undergone short-segment posterior instrumentation.

Materials and methods

Twenty-one consecutive patients with thoracolumbar burst fractures treated with short-segment transpedicular fixation fulfilling the inclusion criteria were prospectively evaluated. Inclusion criteria were fractures between the levels T11 and L3, with no neurological impairment. Average patient age at the time of surgery was 34.8±10.2 (range 18–59) years. There were 10 men and 11 women. Kyphosis exceeding 15° and/or compression of anterior body height exceeding 50% were indications for surgery. Patients were simply randomized into transpedicular grafting (TPG) (*n*=11) and non-TPG (*n*=10) groups. The average follow-up was 49.9±18.3 (range 25–85) months for the entire study group: 53.4±18.5 months for the TPG group and 44.2±17.8 months for the non-TPG group (*P*=0.345).

All patients were instrumented using pedicular screws inserted bilaterally at the upper and lower adjacent levels, connected by bilateral rods contoured to achieve the normal sagittal alignment of the involved level. Reduction of the fracture and indirect decompression of the spinal canal were accomplished by the rod contouring only, without any further effort for decompression. For patients in the TPG group, transpedicular grafting of the involved level was performed as described by Daniaux and co-workers [7], and the voids created within the vertebral bodies were packed with autologous cancellous bone. Posterior fusion with autologous iliac crest bone graft was performed in all patients. Either one of the two instrumentation systems – Isola (Depuy-Acromed, Rotterdam, The Netherlands) or CCD (Sofamor-Danek, Memphis, Tenn.) – was used in all patients, with the same size of screws (6.25 mm) and rods (6.35 mm). All operations were performed by one surgeon (E.A.). All patients were mobilised on the day following surgery, and used total contact braces for 3 months.

Preoperative, postoperative and follow-up CT images through the levels of the pedicles of the involved vertebrae as well as the adjacent levels were obtained, and transferred to computer using a scanner. The images were then transferred to a PC-based design software, AutoCAD, which can measure the area of any geometric shape. The images were calibrated and the canal areas were measured at the involved and adjacent segments. The canal area of the involved segments were normalized by the average of the upper and lower segment areas, and expressed as a percentage of the estimated value [24]. Plain X-ray analysis included measurements of anterior body height compression (%ABC) [24] and sagittal index (SI) [12] to determine and compare the severity of the deformity in both groups. An anterior load sharing index (LSC) [22] was also calculated for each fractured vertebra, to compare the severity of the fracture. All measurements were performed by one of the authors (A.A.) at presentation, postoperatively and at the latest follow-up.

Student's *t*-test for independent samples was performed for statistical analysis, with a confidence interval of 95%.

Results

Groups were similar for age, severity of the deformity, and fracture (SI, %ABC and LSC) (Table 1), as well as levels and subtypes of fracture [9] (Table 2, Table 3). The average time from injury to operation was 85.1±71.6 h (range 10–240 h): 79.4±69.2 h for the TPG group and 91.4±77.5 h for the non-TPG group (*P*=0.711).

Average preoperative kyphosis was 19.7°±6.2° (range 10°–31°): 18.7°±6.6° in the TPG group and 20.7°±5.9° in the non-TPG group (*P*=0.481). It was corrected to 1.9°±4.9° (range –6° to 16°): 2.3°±5.7° in the TPG group and 1.5°±4.4° in the non-TPG group (*P*=0.772) by the operation, and was observed at the final follow-up to have deteriorated to an average of 9.1°±6.4° (range 0°–23°): 7.9°±7.2° in the TPG group and 10.5°±5.4° in the non-TPG group (*P*=0.364). There were no significant differences between groups regarding the evolution of the sagittal plane deformity.

Table 1 Mean values (±SD) for age, follow-up and preoperative radiographic parameters (*TPG* transpedicular grafting performed, *NTPG* transpedicular grafting not performed, *FU* follow-up, *Preop SI* preoperative sagittal index, *Preop %ABC* preoperative percent anterior vertebral height compression, *LSC* load sharing classification)

	Age (year)	FU (month)	Preop SI (°)	Preop %ABC	**LSC**
TPG(*n*=11)	37±11	53±18	19±7	36±13	7±0,8
NTPG(*n*=10)	32± 9	44±18	21±6	40±14	7±1,1
P-value	0.316	0.345	0.481	0.462	0,384

Table 2 Distribution of the fractures according to level

	T11	T12	L1	L2	L3
TPG (*n*=11)	0	3	3	1	4
NTPG (*n*=10)	0	3	4	2	1

Table 3 Distribution of the fractures according to the Denis classification

Fracture type	A	B	C	D	E
TPG (*n*=11)	2	7	0	0	2
NTPG (*n*=10)	1	6	0	0	3

Table 4 The evolution of canal narrowing in the TPG and NTPG groups (mean±SD)

Canal narrowing	TPG	NTPG	*P*-value
Preoperative	40.5±16.9%	36.1±20.4%	0.601
Postoperative	24.2±20.6%	19.6±20.0%	0.648
Correction	**15.9±14.0%**	**18.5±14.3%**	**0.969**
Follow-up	0.4±10.9%	–5.4±21.3%	0.476
Remodeling	**27.8±20.3%**	**24.5±11.8%**	**0.109**

Spinal canal narrowing was 38.5±18.2% (range 10–72%) at presentation and 22.1±19.8% (range 0–72%) postoperatively; it further improved to –2.5±16.7% (range –35 to 41%) at final follow-up, similar for both groups (Table 4).

There were no operative complications; graft misplacement or subsequent displacement into the spinal canal was not observed in any of the patients. There were no apparent pseudoarthroses in either of the groups. There was one superficial infection, one deep vein thrombosis and two screw breakages (one in each group) during follow-up.

Discussion

This study evaluated the effects of transpedicular intracorporeal grafting on canal area restoration and remodeling in a group of patients with thoracolumbar burst fractures treated with short-segment posterior instrumentation. Our findings demonstrate that transpedicular intracorporeal grafting has no significant effect on canal restoration and remodeling.

Posterior short-segment instrumentation and fusion in the treatment of burst fractures offers the advantage of preserving more mobile spine segments when compared to longer constructs [10]. In addition to distractive forces, restoration of the physiological sagittal contours performed by manipulations on the sagittal positioning of the transpedicular screws in the global reference system may also be effective, to a lesser extent [14, 34]. These maneuvers (distraction and sagittal plane rotation) coupled together have been shown to contribute to a decompressive effect on the spinal canal [6, 20, 30, 34]. The amount of decompression has been reported to be variable, and is influenced by several factors, including the timing of surgery, fracture type, rupture of the posterior longitudinal ligament, and the presence of soft tissue attachments (especially anulus fibrosus) on the protruded bony fragments [14, 34]. The protruded major bone fragment(s) (posterosuperiorly located in type B fractures) appears to be rotated in the sagittal plane and pulled to a reduced position along with the superior intervertebral disc by the help of these attachments, with the exception of free bone fragments [14].

The concern about the safety and/or deleterious effects of transpedicular grafting on canal area restoration arises from the assumption that an increase in intervertebral pres-

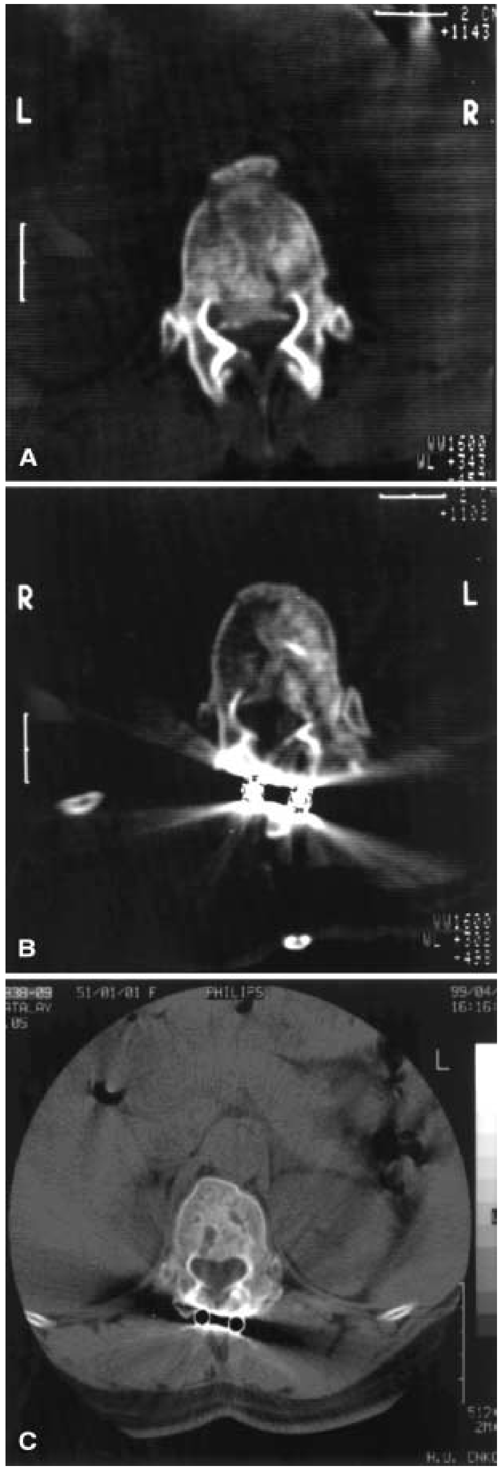

Fig. 1 **A** Preoperative computed tomographic (CT) scan of a patient with thoracolumbar burst fracture. The area of the spinal canal was measured as 2.2 cm^2, while the normal was estimated to be 3.1 cm^2. **B** Postoperative CT scan of the same patient showing the enlarged left pedicle and the intracorporeal grafts placed through this pedicle. The canal area was restored to 2.45 cm^2. **C** Follow-up CT scan showing a heart-shape canal remodeling with an area of 2.8 cm^2

sure during grafting may push the fracture fragments, and graft material, into the canal if the posterior soft tissues (posterior longitudinal ligament and/or annulus fibrosus) have been damaged. This study demonstrated that this problem does not occur, probably for two reasons. As indirect reduction of the retropulsed fragments is always performed before transpedicular grafting, grafts are almost always introduced after the repositioning of the posterior fragments, and presumably after any defects in the posterior wall have been closed or reduced in size. Secondly, transpedicular intracorporeal grafting performed by placing autologous cancellous bone chips into the intravertebral void probably never causes an increase in the intravertebral pressure, and does not, therefore, push the fracture fragments back into the canal. Accordingly, displacement of either fracture fragments or bone graft into the spinal canal is seemingly unlikely, but misplacement of graft during surgery remains a possibility [28].

Spontaneous remodeling of the spinal canal succeeding burst fractures of the spine has been recognised as an entity following the advent of three-dimensional imaging technologies [13]. Remodeling has been shown to occur regardless of the type of treatment, be it surgical or conservative [8, 16, 17, 24, 27, 29, 35], but the real clinical importance, or the influence on neurological recovery, is not yet clearly understood.

As has been mentioned above, indirect reduction of a burst fracture treated surgically is likely to cause a bone void within the fractured vertebral body. It might therefore be assumed that this very space, devoid of bone, may facilitate the subsequent clearance of the spinal canal, or conversely, that filling this space with bone grafts may hinder remodeling. The present study has demonstrated that such a detrimental effect does not take place, and the spinal canal at the level of grafted vertebral bodies do remodel as much as the non-grafted levels. The amount of remodeling in this group of patients is also comparable to the reported rates in the literature [24, 30, 35]. This finding implies that the mechanism of canal remodeling following burst fractures is resorption of the intracanal bone fragments, rather than subsequent changes in the position of those fragments, and that it is therefore not influenced by the structural integrity of the vertebral body. Moreover, the dilatation of the pedicle that is used as a route of entry into the vertebral body does not seem to affect the overall canal area or remodeling significantly either (Fig. 1).

There seems to be a tendency for better results regarding the kyphosis in the TPG group (6° of correction loss at the latest follow-up) as compared to the NTPG group (9° of correction loss at the latest follow-up), with no statistical significance. This may develop into significance in a larger series. However, Mumford and co-workers have shown that loss of correction in the sagittal plane had no significant effect on canal remodeling [24].

The major limitation of this study is the small number of patients in both groups, which may limit the statistical power. However, to our knowledge it is the only prospective randomized controlled study on the effect of transpedicular intracorporeal grafting on canal remodeling.

Finally, this study has evaluated canal restoration and remodeling in patients treated with a specific method of transpedicular grafting, which does not necessitate pressurisation of bone, in the form of paste, into the bony defect. The use of pressurisation might have an effect on the rate of canal area restoration as well as remodeling. Therefore, these findings should probably not be extrapolated to patients operated with other techniques.

As a conclusion, this randomized prospective study has demonstrated that intracorporeal transpedicular grafting associated with short-segment transpedicular fixation of thoracolumbar burst fractures does not have a detectable effect on the rate of canal area restoration by indirect reduction or subsequent remodeling of the spinal canal area.

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