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Distractible vertebral body replacement in patients with malignant vertebral destruction or osteoporotic burst fractures

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Abstract We studied prospectively the clinical and radiological course of 36 patients with localised spinal instability treated with vertebrectomy. A distractible titanium cage filled with polymethylmethacrylate (PMMA) in combination with transpedicular fixation was used to restore spinal stability. Mean follow-up was 16 (8–55) months. Average correction of the segmental kyphosis was 15.2° (-2 – 29°). During follow-up, a loss of correction of 0.9° (-2 – 15°) was seen. Segmental height was increased by 7.6 (0–14) mm on average with a mean loss of 1.6 (0–2) mm. Twenty-one patients without pre-operative neurological deficits were ambulatory without orthosis at discharge. Patients presenting with neurological deficits were unchanged ($n=3$) or improved ($n=12$).

Résumé Nous avons étudié prospectivement l'évolution clinique et radiologique de 36 malades avec une instabilité vertébrale localisée traitée par vertebrectomie. Une cage en titane distractible remplie de PMMA en combinaison avec une fixation transpédiculaire a été utilisée pour restaurer la stabilité vertébrale. Le suivi moyen était de 16 mois (8–55). La correction moyenne de la cyphose segmentaire était de $15,2^\circ$ (-2 – 29°). Pendant le suivi une perte de correction de $0,9^\circ$ (-2 – 15°) a été notée. La hauteur segmentaire a été augmentée à 7,6 (0–14) mm en moyenne avec une perte moyenne de 1,6 (0–2) mm. Vingt et un malades sans déficit neurologique préopératoire pouvaient marcher sans orthèse. Les malades qui présentaient un déficit neurologique étaient inchangés ($n=3$) ou améliorés ($n=12$).

Introduction

Bone destruction due to various causes (tumour, infection, trauma) may result in spinal instability. Consequently, patients suffer from pain, immobilisation, kyphotic deformity and neurological compromise. Re-stabilisation of the spinal column and eventually decompression of neural structures can achieve patients' re-mobilisation, pain relief and neurological improvement.

Sufficient surgical re-stabilisation depends on adequate anterior column reconstruction, and several methods of grafting are used in combination with different transpedicular fixation devices [3, 4]. Especially in patients with malignant diseases, vertebral-body replacement has to provide immediate stability. It is not important to achieve solid bony fusion, and there is a considerable risk of pseudarthrosis, implant settling and loosening [2].

We use a titanium mesh cage filled with polymethylmethacrylate (PMMA) in order to achieve maximum areas of support. The cage is designed for implantation in a vertical orientation between vertebral end-plates following corpectomy and resection of the adjacent discs. Mechanical stress distribution at the bone-graft-interface is equalised by posterior tension band fixation, as tilt moment loading is minimised [9]. Based on clinical application during 5 years, we present our results and experiences with the vertebral body replacement device (VBR, Ulrich, Ulm, Germany).

Patients and methods

From November 1996 to April 2002, a consecutive series of patients ($n=36$) treated by vertebral corpectomy and stabilisation using the VBR were prospectively followed. There were 18 men and 18 women. Mean age at operation was 64 (32–80) years. Pre-operative assessment included neurological examination, upright X-ray, magnetic resonance imaging (MRI) as well as arteriography and eventually embolisation at the tumour site.

Vertebral destruction had been caused by metastases in 27 patients and by unstable osteoporotic fractures in nine. All patients were bedridden. The primary diseases were plasmocytoma ($n=9$),

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Table 1 Post-operative complications in 36 patients with vertebral body replacement

Complications	Number
Superficial wound dehiscence (posterior procedures)	4
Monoparesis left leg	1
Pneumonia	2
Acute renal failure	1
Bedsore	3
Urinary tract infection	8
Ileus	2
Pulmonary embolism	1
Deep vein thrombosis	2
Nerve compression (nervus cutaneus femoris lateralis)	2
Implant migration	1
Total	27

Fig. 1 Localisation of vertebral body replacement

renal cell carcinoma ($n=7$), breast cancer ($n=4$), melanoma ($n=1$), and cancer of the rectum ($n=1$), thyroid gland ($n=1$), hypopharynx ($n=1$), prostate ($n=1$) and of unknown origin ($n=2$). All patients except two were treated by ventrodorsal ($n=27$) or dorsoventral ($n=7$) procedures. One patient refused the recommended dorsal instrumentation, and another patient suffered from a severe pulmonary embolism after vertebral body replacement before the posterior surgery was done. The implants used in addition to the VBR are shown (Table 1). In total 43 vertebral bodies were replaced. One single vertebral body was replaced in 29 patients and two adjacent segments in seven (Fig. 1).

The follow-up period was on average 16 (8–55) months. Clinical and radiographic examination was performed before discharge and after 1, 3, 6, 12 and 24 months. Segmental angulation (α) (Fig. 2) was measured between the endplates of the adjacent vertebral bodies, and segmental height (d) was estimated between the posterior corners of the adjacent vertebral bodies. The physiological segmental angulation served as reference [1]. Differences of estimated segmental angles, and reference angulation of the replaced segment(s), were compared. The statistical differences were analysed by performing *t*-tests.

Surgical procedures included anterior vertebral corporectomy after spinal decompression and decompression neural structure decompression. Anterior column reconstruction was performed using the VBR implant filled with methylmethacrylate. In addition, the neighbouring vertebral bodies were fixed by an anterior rodscrews construct (USIS, Ulrich, Ulm, Germany). In a second stage 7–14 days later, a posterior tension band fixation was added (Fig. 3 a–d). All procedures were performed by the senior author (JPG).

Fig. 2 Radiographic measurements (d =segmental height, α =segmental angle)

Results

Average correction of segmental kyphosis seen after surgery was 15.2° (-2 – 29°), and average segmental height was increased by 7.6 (0–14) mm. During the follow-up, a mean loss of correction of 0.9° (-2 – 15°) occurred. Mean loss of segmental height was 1.6 (0–2) mm. Neurological status improved in 12 patients (Fig. 4).

There were no intra-operative complications or peri-operative deaths. Unrelated to surgery, nine patients died from their primary malignancy during the follow-up period. Four surgical revisions were performed due to dorsal superficial wound dehiscence, local tumour progression and partial posterior implant removal due to soft-tissue irritation. Post-operative complications are listed in Table 1.

Mean duration of hospital stay was 49 (27–93) days. At discharge, 28 patients were without external orthosis. One patient remained wheelchair bound and two patients bedridden.

Discussion

Numerous pathological conditions can cause vertebral body destruction and thereby spinal instability. Restoration of spinal stability depends on the creation of a solid anterior column [6]. Several anterior, posterior and combined techniques are recommended [4, 7]. Anterior column reconstruction can be performed using fibula, rib or iliac crest autografts, allografts or heterologous materials [3]. In malignant spinal destruction, autograft and allograft present several problems, such as limited size,

Fig. 3 **a** A 68-year-old man. Metastatic destruction L3 by renal-cell carcinoma; preoperative lateral view. **b** Preoperative AP view. **c** CT-scan disclosed destruction of L3. **d** L3 corpectomy and

spinal reconstruction. Realignment and a solid anterior fusion mass are achieved (48 months follow-up)

morbidity at the donor site, possible disease transmission and delayed union following deficient properties of graft and host bone [5]. The use of bone grafts may require a supportive brace or even immobilisation, which favours the development of decubital ulcers, thromboembolism, pneumonia etc.

To overcome these problems, immediate stability should be achieved by appropriate instrumentation. In case of malignant destruction and limited life expectancy, incorporation of bone graft is not necessary. However, well-fitting spacers and equally distributed load transmission between spacers and the supporting vertebrae guarantee immediate stability. In addition, poor bone quality

(osteoporotic bone, progressive destruction of neighbouring vertebral bodies) will not compromise the mid-term results of surgery.

PMMA cylinders in vertebral replacement create an equal load transmission, but they bear a high risk of dislocation [3]. Harms cages filled with PMMA are favourable in achieving close contacts between graft and supporting bone, but proper cutting to shape is demanding. Furthermore, an anterior distraction before implant insertion is necessary, causing an unfavourable load change for the vertebral screws by the ultimate compression [4, 5].

	Frankel Stage of neurological deficit	Postoperative neurological status					Total
		A	B	C	D	E	
Pre	A						0
operative	B						0
neurologic	C			1			1
status	D				2	12	14
	E					21	21
	Total	0	0	1	2	33	36

Fig. 4 Improvement in Frankel grading

The VBR is a titanium cylinder, the length of which can be varied by twisting the central ring. In some cases, prior trans-pedicular fixation is useful so that a well-adjustable and distractible spacer is favourable afterwards. Tight fixation is achieved without prior anterior vertebral distraction.

In our series, we obtained an easy technical, and tight-fitting, implant application. Our clinical experiences were recently confirmed in laboratory tests [8]. Sufficient kyphotic deformity correction could be achieved. Loss of correction was not significant during the follow-up period, and sagittal alignment was maintained. Although a minimum follow-up of 8 months is short, we think it is adequate for these patients with a limited life expectancy.

In conclusion, we find that VBR is an improvement for correcting kyphotic deformity, providing immediate stability in metastatic and osteoporotic spinal destruction.

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