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ORIGINAL ARTICLE

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Another option to treat Kümmell's disease with cord compression

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Abstract The efficiency of short-segment fixation with transpedicle body augmenter (a titanium spacer with bone-ingrowth porous surface, TpBA) to treat Kümmell's disease with cord compression (stage III) was retrospectively evaluated. No laminectomy or instrumentation reduction was done. Inclusion criteria included Frankel CDE, single-level within T10–L2. FU rate was 88%, i.e. 21 cases were included. Frankel function classification was 6E9D6C. Mean age was 72 ± 8 years. F:M was 16:5. FU period was 48 M (range, 30–76 M). The hospitalization was 4.5 ± 2.2 days; operation time, 70.4 ± 17.2 min; blood loss, 150 ± 72 cc. Final Frankel class was 20E1D. Complications included two superficial infection and one pneumonia. Body height and kyphosis were all corrected significantly and well preserved at the final visit. No TpBA dislodgement or implant failure was noted; however, three cases developed new compression fractures. The clinical outcome showed 81% with P1 or P2 by Denis pain scale. This method can decompress spinal canal, maintain kyphosis correction and vertebral restoration, prevent implant failure, and attain good clinical results.

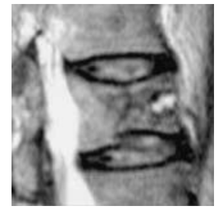
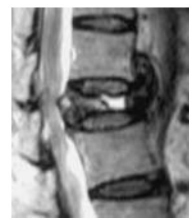
Keywords Kümmell's disease · Transpedicle body augmenter · Manual reduction · Osteoporosis · Compression fracture

Introduction

Kümmell's disease is defined as delayed post-traumatic vertebral collapse [1–3], which often occurs in an osteoporotic spine. Currently, it can be treated by vertebroplasty or kyphoplasty [4–6]. However, Kümmell's disease may have posterior cortex breakage with cord compression, i.e. stage III [7] (Table 1), which is a relative contraindication for cement usage. In such cases, it had been treated by posterior Egg-shell procedure [8, 9] with long segment fixation or anterior decompression and instrumentation [10]. The posterior Egg-shell procedure is technically demanding and highly risky. In addition, the long-segment fixation may limit spinal motion, increase adjacent segment disease, and cause complication rates reaching 70% [11]. The anterior approach usually involves a longer operation time and may injure the internal organs, in addition to the possibility of the prosthesis sinking into an osteoporotic spine [10]. As for burst fracture management, the posterior short-segment fixation is the most common and simple treatment [12, 13], but implant failure has been noted [14]. Therefore, the challenge lies in trying to increase the success rate of posterior short-segment fixation and prevent implant failure in the long term.

Manual reduction allowed safe reduction of the fractured vertebra and decompression of the spinal cord in acute non-osteoporotic burst fracture [15]. If manual

Table 1 Staging system of Kümmell's disease

Items	Criteria	Symptoms	Radiological Finding	MRI
Stage I	Body height loss < 20% No Adjacent DDD	Back pain or No symptom[a]		
Stage II	Body height loss > 20% usually with adjacent DDD Dynamic mobile fracture	Back pain with/without[b] radiculopathy		
Stage III	Posterior cortex breakage with cord compression	Back pain with/without cord injury[c]		

DDD Disc degenerative disease with disc space narrowing
[a]MRI for other reason with accidental finding of Stage I
[b]Stage II: back pain is the major complaint, sometimes with radiculopathy, especially in middle and low thoracic spine
[c]Stage III: even though MRI showed posterior cortex breakage with cord compression, the symptoms of cord injury sometimes are not significant. Probably due to the slow progression of Kümmell's disease in some cases, the spinal cord can adapt the changes to prevent significant cord injury

reduction can succeed in chronic osteoporotic stage III Kümmell's disease, subsequent decompression procedure and instrumentation reduction can be avoided. Transpedicle body augmenter (TpBA, a porous titanium spacer of various generations, Merries International Inc., Taipei, Taiwan) (Fig. 1) may reinforce the fractured vertebral body from a posterior approach with biomechanical advantages [16]. Therefore, TpBA and manual reduction may provide an answer to increase the success rate of posterior short-segment fixation for stage III Kümmell's disease. This report attempts to explore optimal management of stage III Kümmell's disease: manual reduction can succeed in restoring anatomic alignment and TpBA may maintain vertebral body restoration, prevent implant failure in osteoporotic spine, and improve clinical success.

Materials and methods

Between January 1999 and August 2003, 24 Kümmell's disease patients with posterior wall collapse and cord compression (stage III) [7] were treated with manual reduction, short-segment posterior fixation (one above, one below), and reinforcement with autologous bone

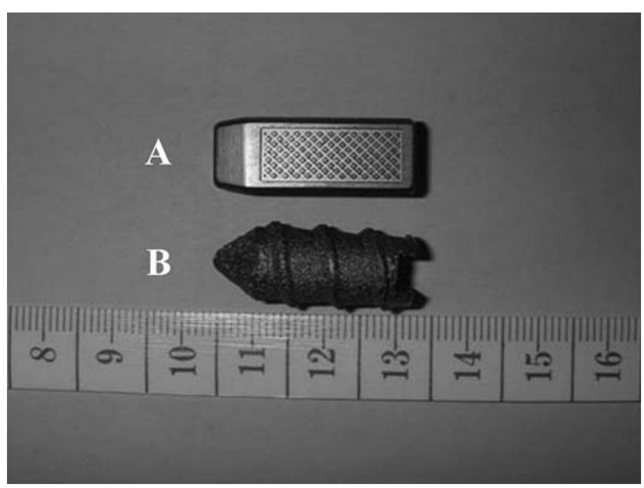


Fig. 1 The pictures showed the new (*A*) and old (*B*) generations of transpedicle body augmenters

graft cum TpBA of varying sizes (7×9×20 mm^3, 9×11×27 mm^3, 10×13×27 mm^3, etc.) Inclusion criteria required the following: function status limited to Frankel C, D, and E; single-level Kümmell's disease; limited disease T10–L2, and primary osteoporosis. Follow-up rate was 88%. One patient died of unrelated medical illness and two patients were lost to follow-up. These three patients were excluded from this retrospective study. The demographics of the 21 patients are in Table 2.

Kümmell's disease was diagnosed by intravertebral cleft sign on CT scan or osteonecrosis with fluid signal on MRI. Preoperative evaluation protocols included anteroposterior (AP) and neutral lateral thoracolumbar radiographs, computed tomography (CT) scans, and magnetic resonance imaging (MRI) scans to evaluate fracture sites and status of cord compression. The symptomatic segment was confirmed by matching clinical examination with MRI findings.

All the patients received manual reduction and short-segment fixation with posterior body reconstruction augmented by TpBA and bone graft (Fig. 2). Before anesthesia, myelogram was performed via L4/5 lumbar puncture using non-ionic contrast medium (Isovist-300, Schering AG, Berlin, Germany). If there was no allergic reaction after a 30-min observation, the patient received general anesthesia and was put in a prone position. There were no visible side effects of myelogram in this series. Then manual reduction was done: one anesthesiologist held the patient's head, two assistants held the patient's shoulders, one assistant held the patient's legs, and the surgeon compressed the fractured vertebra (Fig. 3). Traction and elevation of the trunk was initiated by the shoulder assistants, and pushing force over involved level was given by the surgeon simultaneously to counter the elevation force. The success of decompression of spinal canal was confirmed by C-arm myelogram. After manual reduction, short-segment fixation followed without laminectomy or instrumentation reduction. Pedicle screws were placed at the level above and below the fractured vertebrae (two levels, four screws) using the rod screw system (Reduction–Fixation Spinal Pedicle screw system) (Advanced Spine Technology Inc. Oakland, CA, USA; UP spine system, TiTec Medical Co., Ltd., Taipei, Taiwan, Merries spine system, Merries International Inc., Taipei, Taiwan).

Table 2 Patient demographics

Items	Parameters
Age (years)	72 ± 8 (61–91)
Female to male (ratio)	16:5
Etiology	15 mild injury, 6 no memorized accident
Sympton duration (weeks)	20 (4–100)
Follow-up (months)	48 (30–76)
Fracture location	1 T10, 2 T11, 8 T12, 7 L1, 3 L2
Frankel performance scale	6C, 9D, 6E
Denis pain scale	3 P4, 18 P5

Bilateral pedicle tunnels to the vertebral body were made by an awl, followed by a guide pin, which should be checked under C-arm fluoroscopy. Then the pedicle tunnels were enlarged by serial custom-made dilators to the matched size. The pedicle size, different among individuals and at different spine levels [17, 18], should be measured preoperatively on CT or plain AP and lateral views. Because the superior and lateral cortex can be violated with no danger of neurological sequelae, the safe zone is large enough to pass the TpBA. The pedicle in this series is so osteoporotic and soft that it can be easily dilated without brittle breakage. The bony defect in the fractured vertebral body was filled through bilateral pedicle tunnels [15], with autologous bone graft mixed with calcium sulfate (OSTEOSET®, Wright Medical Technology, Arlington, TN, USA) if the autograft from the posterior iliac crest was insufficient. Then TpBA was inserted into the vertebral body through the pedicle tunnel under C-arm fluoroscopy and finally, bone graft was used to fill up the pedicle tunnel space. The posterior interlaminar fusion was done over the fixed segments. The transpedicle discectomy and intercorporeal bone graft as described by Daniaux et al. [19] was excluded. Patients wore a thoracolumbar brace for 3 months. After discharge from hospital, patients were followed up regularly. Operation time, blood loss, hospitalization, and complications were documented.

In the radiographic analysis, the cross-section area of spinal canal, anterior and posterior vertebral height, lateral Cobb's angle, and wedge angle were measured. The cross-section area of spinal canal was measured at pre-operative and initial post-operative digital CT scan radiographs in the first 12 cases. Because the data showed highly significant differences, no more post-operative CT scan of the following patients was done. The lateral Cobb's angle was measured, as described by Kuklo et al. [20] from the superior endplate of the vertebral body above the fracture to the inferior endplate of the vertebral body below the fracture level. Wedge angle of the index vertebra was measured as described previously by Verlaan et al. [21]. The radiographic parameters were measured on neutral thoracolumbar radiographs before the operation, initial follow-up, and at the final follow-up. All digitization of the radiographic measurements was done by the same experienced research assistant in EBM-viewer software (EBM technologies Inc., Taipei, Taiwan) with an accuracy of ±0.1 mm. Repeat measurements of the same vertebral levels after a 10-day interval with the same observer demonstrated an error of ±0.13 cm^2 in cross-section area, 1.2 mm in height, 2.3° in lateral Cobb's kyphosis and 2.2°in wedge angle. The radiographs at the final visit were analyzed in detail and recorded if there should be implant loosening, migration or failure of posterior instrumentation or TpBA were

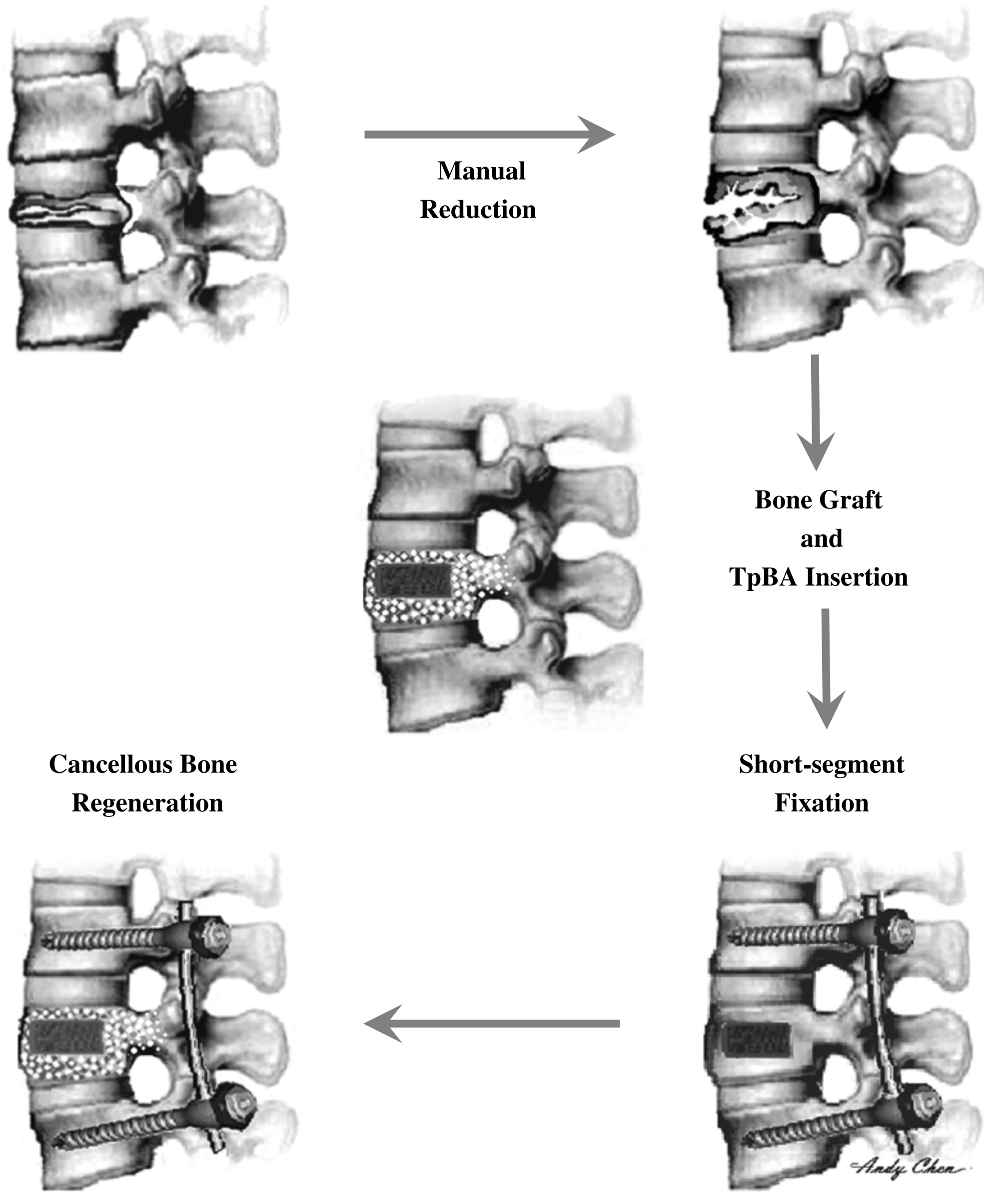


Fig. 2 The flow chart shows the procedures of manual reduction, TpBA insertion, bone graft, and short segment fixation

found. Clinical results were assessed by the Frankel Performance Scale (Grade A–E) [22] and Denis Pain Scale (Grade P1–P5) [23]. Denis Pain Scale shows results with P1 as no pain; P2, occasional, minimal pain with no need for medication; P3, moderate pain, occasional medications, no interruption in work or activities of daily living; P4, moderate to severe pain, occasional absence from work, significant change in activities of daily living; and P5, constant severe pain, chronic medications.

ANOVA was used for statistical analysis of lateral Cobb's and wedge angles, posterior and anterior vertebral height among the data of pre-operative, immediate, and final follow-up. Significant differences were further assessed using Duncan's multiple range tests. Paired *t*-test was done between the immediate and final corrections of lateral Cobb's angle, wedge angle, posterior and anterior vertebral height, and between preoperative and postoperative cross-section area of the spinal canal. Fisher's exact test was used to analyze Denis Pain Scale data. All the data presented in this paper has been mean ± standard deviation. The level of statistical significance was chosen at $P < 0.05$.

Results

Operation time and hospitalization were short and blood loss was limited. The hospitalization interval was 4.5 ± 2.2 days (range, 3–10 days), with operation time of 70.4 ± 17.2 min (range, 45–90 min). The blood loss was

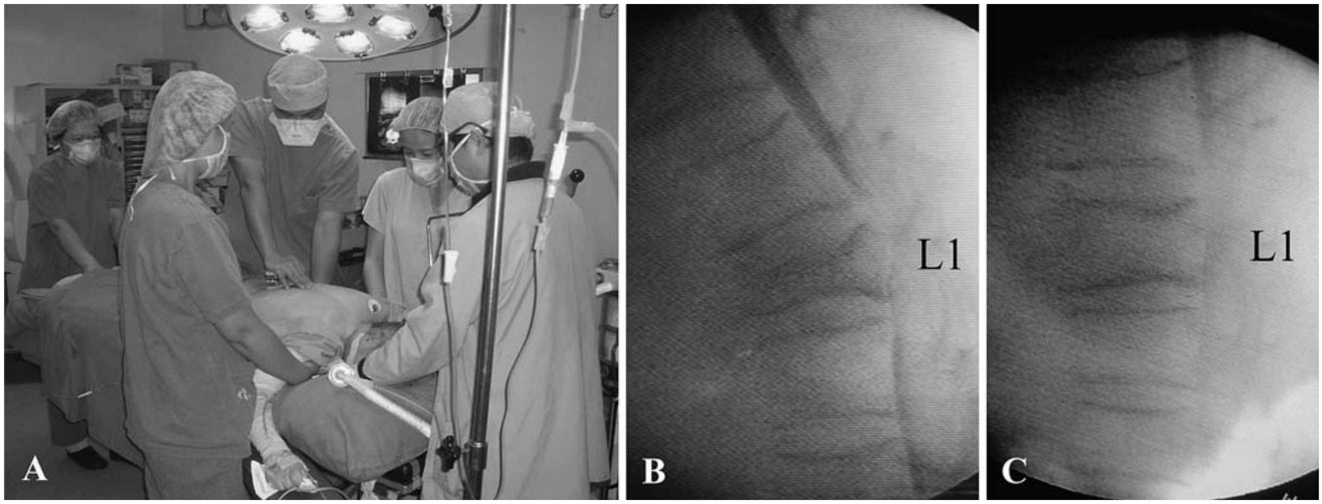


Fig. 3 The pictures showed the cooperation of five people to do manual reduction (**a**). The C-arm myelogram before manual reduction (**b**) showed body collapse with cord compression and post-procedure view (**c**) revealed the restoration of vertebral body and cord decompression

150 ± 72 cc (range, 100–450 cc). No neurological deterioration was found. The clinical outcome showed ten P1, seven P2, one P3, two P4, and one P5 by Denis pain scale. At the final visit, significantly more patients reported absence of pain, or had only minimal or occasional pain (Grade P1 or P2) compared to their preoperative status (81 vs. 0%, $P < 0.001$), and few had with severe or constant pain (Grade P4 and P5) (14 vs. 100%, $P < 0.001$). All the patients recovered to Frankel E except one patient with Frankel D due to untreated new compression fracture. The complications included one postoperative pneumonia and two superficial wound infection secondary to wound pressure sore. After medical care and debridment, all three cases recovered well. Cephalad rekyphosis detected by follow-up radiographs was noted in three cases due to adjacent compression fractures.

Anterior and posterior body heights and kyphotic deformity were all corrected and well preserved at the final visit (Table 3, Figs. 4, 5). The cross-section area at the involved spinal canal was 1.31 ± 0.43 cm^2 preoperatively and 2.53 ± 0.78 cm^2 postoperatively ($P < 0.001$). The final anterior and posterior body height corrections were 14.2 ± 7.2 and 5.5 ± 3.2 mm. The losses in anterior and posterior body height corrections at final visit were 2.3 ± 1.3 mm (13.8%) and 0.3 ± 0.1 mm (5.2%). The final correction was $18.4° \pm 6.9°$ in lateral Cobb's angle and $18.6° \pm 9.7°$ in wedge angle.

Indirect evidence showed that stability of the construct was maintained well. Fusion rate of posterior fusion after short segment fixation was not reported because there was no second look. Throughout the examination of all the final radiographs, neither TpBA dislodgement nor posterior implant failure or migration was noted. No holo lucency sign around the TpBA was noted in any case.

Discussion

Stage III Kümmell's disease was successfully treated via a posterior approach by manual reduction, short-segment fixation and body reconstruction with TpBA. Manual reduction and TpBA has been known to be successful in treating acute non-osteoporotic burst fractures [15]. In this study, manual reduction was successfully performed, and posterior body reinforcement with TpBA was applied to restore and maintain the vertebral height in chronic osteoporotic stage III

Table 3 Radiographic data and statistical comparisons

Item	Pre-operative	Initial follow-up	Final follow-up	Initial correction	Final correction	Loss correction
Anterior body height (mm)	12.3 ± 4.8^{ab}	28.9 ± 4.0^{ac}	26.5 ± 4.3^{bc}	16.6 ± 6.9	14.2 ± 7.2^{d}	2.3 ± 1.3
Posterior body height (mm)	24.8 ± 3.1^{ab}	30.6 ± 3.3^{a}	30.3 ± 3.2^{b}	5.8 ± 3.0	5.5 ± 3.2	0.3 ± 0.1
Lateral Cobb's angle	$28.6° \pm 9.9°^{ab}$	$5.0° \pm 3.0°^{ac}$	$10.1° \pm 7.9°^{bc}$	$23.6° \pm 8.5°$	$18.4° \pm 6.9°^{d}$	$5.1° \pm 5.5°$
Wedge angle	$22.6° \pm 6.8°^{ab}$	$3.1° \pm 4.1°^{a}$	$4.0 \pm 5.5°^{b}$	$19.5° \pm 8.8°$	$18.6° \pm 9.7°$	$0.8 \pm 2.0°$

Significant difference: [a]pre-operative vs. initial follow-up; [b]pre-operative vs. final follow-up; [c]initial follow-up vs. final follow-up[d]Significant difference between initial and final corrections

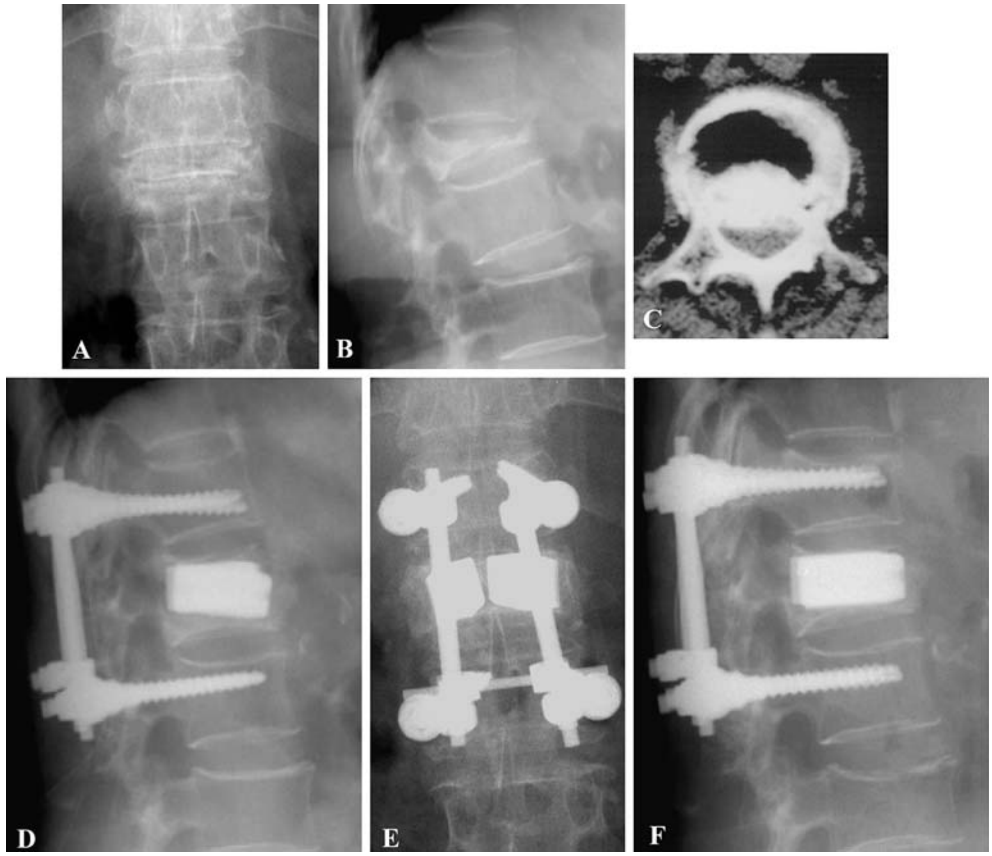


Fig. 4 A 71-year-old female with L1 stage III Kümmell's disease with Frankel C received manual reduction and TpBA with short segment posterior fixation. The preoperative plain anteroposterior (**a**) and lateral (**b**) views show L1 Kümmell's disease with kyphosis. The CT scan (**c**) shows canal encroachment. The **d** 1 month and **e**, **f** 24 months postoperative radiographs show good restoration. She was free of symptoms at the final visit with Frankel E

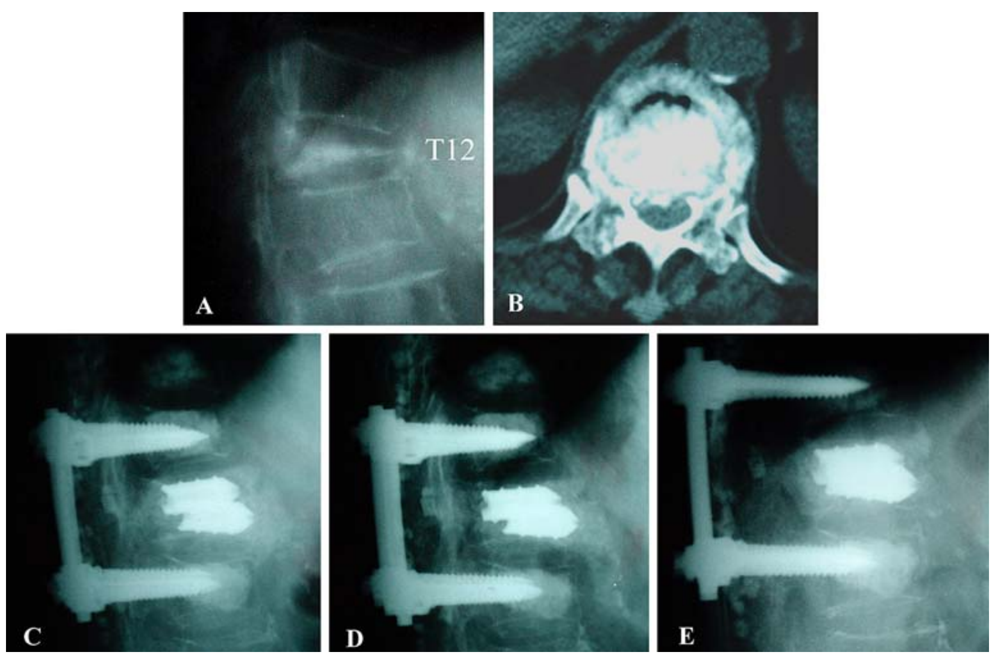


Fig. 5 A 83-year-old female with T12 stage III Kümmell's disease with Frankel C received manual reduction and TpBA with short segment posterior fixation. The preoperative plain lateral (**a**) and CT scan (**b**) views show T12 Kümmell's disease cord compression. The initial (**c**), 1 month (**d**) and 75 months (**e**) postoperative lateral radiographs show good restoration. She walked independently at the final visit with Frankel E

Kümmell's disease, and to prevent implant failure after short-segment fixation. Our series demonstrated a relatively low complication rate with no implant failures. Matched with 81% in P1–P2 group by Denis pain scale, the present method may be a new option to treat stage III Kümmell's disease.

Table 4 Comparisons among various operations for stage III Kümmell's disease

Author	Case no.	Operation procedures	Mean follow-up	Levels	OP time (min) Blood loss (cc)	Kyphosis (°) (pre-op → initial → final)	Function Evaluation (pre-op → final)
Shikata et al. [38]	7	PD + PI	24.7 M	T11–L4	??	33° → ? → 13°	Frankel: 2B5C → 2D5E
Kaneda et al. [10]	22	AD + AI	34 M	T12–L3	?387 cc	27.8° → 13.3° → 14.8°	?
Baba et al. [36]	27	7: AD + AI 20: PD + LSPF	44 M	T11–L5	AD + AI 270 min 530 cc PD + LSPF198 min 270 cc	AD + AI 23° → 13° → 20° PD + LSPF 24° → 9° → 13°	6: excellent 15: good 4: fair 2: poor
Mochida et al. [9]	22	9: AD+AI13: PD + PI	35 M	T7–L4	??	? → ? → ?	Frankel AD+AI 7C2D → 5D4E PD + PI? → 2C3D8E
Kim et al. [37]	14	PD + LSPF	36 M	T12–L1	217 min 682 cc	22.6° → 4.4° → 6.8°	Frankel: 7C11E → 7D2D
Nguyen et al. [11]	10	8: PD + LSF 1: AD + AI 1: AD + LSPF	16 M	T8–L3	??	28° → 11.9° → 19.9°	Frankel: 3C 7D → 1C6D3E
Matsuyama et al. [14]	5	PD + SSPF + CP	30 M	T10–L4	120 min 181 cc	? → ? → ?	JOA Score 17.8 → 26
Current authors	24	Current method	48 M	T10–L2	70 min 150 cc	28.6° → 5.0° → 10.1°	Frankel: 6C9D6E → 20E1D

AD Anterior decompression; *AI* anterior instrumentation; *CP* biodegradable calcium phosphate; *LSPF* long-segment posterior fixation; *PD* posterior decompression; *PI* posterior instrumentation; *SSPF* short-segment posterior fixation

Because this present study derives from a retrospective analysis, its limitations should be mentioned. Limited case number in stage III Kümmell's disease is the major reason not to do a prospective study and use a matched control group. Evaluation was not blinded in this study which would impart observer bias to the final report; however, since TpBA was clearly visible in radiograms, a completely blinded evaluation of radiographic parameters would be impossible. The clinical results were evaluated by the authors, which was not blinded.

After exclusion of case reports on just 1–4 patients and conference abstracts [24–35], studies in the English literature on surgical treatment of stage III Kümmell's disease [9–11, 14, 36–38] have been summarized in Table 4. Operations using various fixation methods and body reconstruction tended to improve neurological defects. However, the complication rates varied from being negligible to as high as 60% by Rhee et al. [32] and 70% by Nguyen et al. [11]. Compared with literature reports, the present study shares many similarities, e.g. insidious development of neurologic symptoms, frequent location in the thoracolumbar junction, and post-operative recovery of neural function. The unique technique of the present report includes manual reduction and posterior body reconstruction with TpBA and short-segment fixation. No laminectomy is needed; no hook is used and the operation time and blood loss is relatively short compared to other reports. All preoperative kyphosis and anterior body height loss were corrected and well maintained.

Kyphoplasty or open kyphoplasty were not tried by the authors. Because the surrounding vertebral cortex has already been compromised in stage III Kümmell's disease, inserted cement can easily leak out of the vertebral body, including maybe into the spinal canal, which is potentially very dangerous. That is more likely if collapsed vertebral body was reduced by manual reduction, as in Figs. 4, 5. That's why the authors hesitate to do kyphoplasty for stage III Kümmell's disease.

Long-term adjacent compression fracture rate was 14.3% after TpBA reconstruction and short-segment fixation, which is close to the natural course documented for an osteoporotic spine. It has been reported that the new compression fracture rate in the subsequent year was 12% in patients with one previous compression fracture, and 24% in those with two previous fractures [39]. When kyphoplasty is performed, there is conflicting data reported for the incidence of subsequent fractures, ranging from 3 to 29% [40, 41]. Kaneda et al. [10] reported 18% subsequent fractures after anterior procedures with a mean 34-month follow-up. Compared to results reported for other procedures in the literature, TpBA reinforcement with short-segment fixation did not overly increase adjacent compression fractures.

Short-segment fixation with manual reduction and reinforcement of TpBA was an effective and safe method to treat stage III Kümmell's disease. With an average 4-year follow-up, we showed that manual reduction could safely decompress the spinal canal and restore anatomic alignment and TpBA with short-segment fixation could ensure restoration of vertebral height, prevent implant failure, and lead to clinical success.

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