Use of Single Vertebral Body Screw-Plate Fixation Systems in the Treatment of Ventrally Located Lesions of the Middle or Lower Thoracic Spine

Orta veya Alt Torakal Omurganın Ventral Yerleşimli Lezyonlarının Tedavisinde Korpus Vertebra Tek Vida-Çubuk veya-Plak Fiksasyon Sistemlerinin Kullanımı

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Abstract: Most current anterior stabilization systems involve the placement of two screws in each vertebra, and connecting these using a rod or plate. In this study, we present findings from patients who were treated with single vertebral body screw (SVBS) - rod or - plate systems. Our aim was to determine whether these fixation systems adequately stabilize the thoracic spine. Over the past 4 years at our clinic, 13 patients (8 men and 5 women) of mean age 51 years (range 32-71 years), underwent stabilization of the thoracic spine with these fixation systems. The lesions were burst fractures (n=2), metastatic tumors (n=8), infections (n=2) and primary tumor (n=1). We achieved stabilization using a bone graft or methylmethacrylate, and applying screw-rod (n=7) or screw-plate (n=5) fixation. In one patient, both fixation devices were used together. The average follow-up period was 16 months. Ten patients experienced pain relief. Of 12 patients with preoperative neurological deficits, 7 (58 %) completely recovered, 4 (33 %) partially improved, and 1 (8 %) remained unchanged. Neither iatrogenic neurological damage, nor complications related to instrumentation were observed. Our results showed that, due to specific anatomical features of this region adequate stabilization of the middle and lower thoracic spine can be achieved using SVBS-rod or - plate fixation systems.

Key Words: Anterior surgical approach, spinal instrumentation, thoracic spine

Özet: Günümüzde anterior stabilizasyon sistemlerinin çoğu, her bir vertebraya yerleştirilmiş 2 vida ve bunları birbirlerine bağlayan plak veya çubuklardan oluşmaktadır. Bu çalışmada korpus vertebra tek vida (KVTV) - çubuk veya - plak sistemleri ile tedavi edilmiş olgular sunulmaktadır. Amacımız, bu fiksasyon sistemlerinin torakal omurgada yeterli stabilizasyonu sağlayıp sağlamadığını saptamaktır. Kliniğimizde son 4 yıl boyunca, yaş ortalaması 51 olan 8 erkek, 5 bayan 13 hastaya bu fiksasyon sistemleri ile torakal omurga stabilizasyonu uygulanmıştır. Lezyonlar, patlama kırığı (n=2), metastatik tümör (n=8), enfeksiyon (n=2) ve primer tümör (n=1)'dü. Stabilizasyon, kemik greft veya metil metakrilat kullanımına ek olarak vida-çubuk (n=7), veya vida-plak (n=5) fiksasyonu uygulanarak gerçekleştirildi. Sadece bir olguda bu iki sistem beraber kullanıldı. Ortalama takip süresi 16 aydı. On hasta ağrılarından kurtuldu. Preoperatif nörolojik defisiti olan 12 hastanın 7' si (% 58) tamamen, 4' ü (% 33) kısmen düzeldi, 1' inde (% 8) değişiklik olmadı. İatrojenik nörolojik defisit veya enstrümentasyona ait bir komplikasyon gözlenmedi. Bulgularımız, belirgin anatomik özellikleri nedeni ile orta ve alt torakal omurgada, KVTV - çubuk veya - plak fiksasyon sistemleri ile yeterli stabilizasyonun sağlanabileceğini göstermiştir.

Anahtar Kelimeler: Anterior cerrahi yaklaşım, spinal enstrümentasyon, torakal omurga

INTRODUCTION

Instability of the thoracic spine can result from various pathological lesions, including trauma, tumor, infection, or iatrogenic causes.The approach and fusion technique can be anterior, posterior, or a combination of both. Over the years, anterior approaches to the spine have been proved to be much more effective than laminectomy in improving neurological deficits as well as relieving pain caused by ventrally located lesions (7,14,19-21,25,29,32,38, 44,48).

The anterior approach is particularly important in the treatment of infections and metastatic tumors because more than 85% of such lesions occur anteriorly (11,16,23,24,38, 45-47,53). This approach is also indicated for managing traumatic lesions. Injuries occur mainly from flexion in the thoracic area, which usually produces an anatomical deformity ventral to the spinal cord (14,24). In such cases, the benefit of the anterior approach for adequate decompression and stabilization is clear.

Although Royle (40) was the first to describe anterior spinal cord decompression in 1928, the anterior approach did not start to become popular until the work of Hodgson and Stock was published. In 1956, these authors described the anterolateral transthoracic procedure for the treatment of tuberculosis spondylitis (22). In 1976, Richardson et al. (37) reported 22 patients with Pott's disease who were treated via this route.

In particular, the anterior approach was pioneered in the early 1980s by Harrington (19,20), Kaneda et al. (25), Sundaresan et al. (46,47), and Kostiuk (29). Over time, as the anterior approach to the spine has gained acceptance, a number of rigid distractive devices for the anterior spine have been developed (3,13,25,30,50).

Today, improved internal fixation devices have expanded our alternatives for stabilization of the thoracic spine, but there is still debate over what is the best instrumentation. At our clinic, we have been using anterior approaches to decompress and stabilize ventrally located lesions of the thecal sac since 1991. Over the past 4 years, we used single vertebral body screw (SVBS)-rod or -plate fixation to stabilize the middle or lower thoracic column. In this report, we present the clinical aspects and treatment results from a series 13 patients. Our major purpose was to determine whether these simple fixation devices could adequately stabilize the middle and lower thoracic spine.

MATERIALS and METHODS

Between the years 1994 and 1997, 13 patients with lesions involving the middle or lower thoracic vertebral bodies underwent decompression via the transthoracic anterolateral approach. SVBS-rod or -plate fixation was used to achieve stabilization in these cases. The patients' clinical details are summarized in Table I. Eight of the individuals were men, five were women, and patient age ranged from 32 to 71 years (mean 51.2 years). All the patients were evaluated preoperatively through history-taking, neurological examination, plain radiographs, computed tomography (CT), and magnetic resonance imaging (MRI). We obtained radiographic confirmation of anterior cord compromise in all 13 cases.

Back pain was the most common symptom in our patient group. According to narcotic requirements, this was graded as mild, moderate, or severe. Twelve patients had neurologic deficits and three of these individuals had urinary incontinence before surgery. Only one patient was completely paraplegic.

Eight patients had metastatic spine tumors, two had spinal infections, two had burst fractures, and one patient had a primary spine tumor. Only one vertebra was affected in nine patients, whereas two or more contiguous vertebrae were involved in the remaining four individuals. In all patients who had neurological deficits, high-dose corticosteroid treatment was started on admission to hospital (9,52).

Our indications for surgery were as follows: 1) severe back pain, or a neurological deficit that was clinically and radiographically attributable to compromise of the anterior spinal cord, 2) loss of spinal stability or impending stability loss. Following the induction of general anesthesia, the patients were placed in the lateral decubitis position. Selection of a right- or left-sided approach was dependent upon the underlying spinal pathology. Pressure points, and the lower axilla were padded. The lower thigh was flexed, and pillows were placed between the legs. Prophylactic antibiotics were started before surgery, and were given for 48 hrs postoperatively. We made a standart thoracotomy incision between the ribs of the affected vertebrae (or one to two levels rostral). A biluminal endotracheal tube was used, and the

Table I: Summary of clinical courses in the 13 patients in this series

Case No.	Age(yrs) Sex	Level of lesion	Type of lesion	Preoperative Status	Operation	Postoperative status	Follow-up status
1	58, F	T8-9	pyogenic abscess (S. aureus)	p+++ pp 3/5	bone graft, srf + spf	p - pp -	Walking independently 32 mo. postop
2	52, M	T4	burst fracture	p +++ pp 3/5	bone graft, srf	p+ pp 4/5	Returned to office work; no pain; no motor deficit 44 mo. postop
3	32, F	T 5	metastatic (breast)	p ++ pp 2/5	mm srf	p - pp 4/5	Progressive disease but still ambulatory 11 mo. postop
4	67, F	T 8-9	Pott's disease	p + paraplegia, urinary incontinence	bone graft, spf	p - paraplegia, urinary incontinence	No neurological recovery 11 mo. postop
5	42, M	T 9	osteosarcoma	p +++ pp 4/5	bone graft, spf	p + pp -	Returned to office work; no pain, no motor deficit 6 mo. postop
6	66, M	T 7-8-9	metastatic (prostate)	p ++ pp 1/5, urinary incontinence	mm, spf	p + pp 3/5	Regained urinary continence; walking with assistance 4 mo. postop
7	71, M	T 5	metastatic (unknown primary)	p ++ pp 3/5	mm, spf	p + pp -	Died of systemic disease 9 mo. postop; walked independently until the terminal stage
8	60, M	T 4-5	metastatic (lung)	p +++ pp 2/5	mm, srf	p + pp 3/5	Died of systemic disease 9 mo. postop; walked with assistance until the terminal stage
9	41, M	T 4	metastatic (lung)	p ++ pp 2/5, urinary incontinence	mm, srf	p + pp 4/5	Regained urinary continence; walked with assistance; died of systemic disease 7 mo. postop
10	42, F	T 7	metastatic (breast)	p ++ pp 2/5	mm, spf	p - pp 4/5	P +; progressive disease but still ambulatory 14 mo. postop
11	35, M	T 5	burst fracture	p +++ pp 4/5	bone graft, srf	p + pp -	Returned to office work; no paint; no motor deficit 38 mo. postop
12	47, F	T 4	metastatic (breast)	p ++ pp 3/5	mm, srf	p - pp -	Walked independently until the terminal stage; died of systemic disease 17 mo. postop.
13	53, M	T 6	metastatic (prostate)	p ++ pp -	mm, srf	p - pp -	Walked independently until the terminal stage; died of systemic disease 14 mo. postop

Abbrevations: p= pain; pp= paraparesis; srf= screw-rod fixation; spf= screw plate fixation; mm= methylmethacrylate; (+)= mild; (++)= moderate; (+++)= severe

lung on the operated side was deflated. After exposing the spinal column, we located the appropriate level. We excised the disc materials above and below the lesion, and removed the end plates of the vertebral bodies above and below the site. After decompression was completed, we stabilized the spine using a bone graft, or methylmethacrylate, and application of a screw-rod

fixation (SRF), or a screw-plate fixation (SPF) system. We performed interbody fusion with methylmethacrylate on eight patients who had a relatively limited life expectancy.In the remaining five patients, we used autogenous bone grafts that were harvested from the iliac crest.These were positioned as far anterior as possible to restore more effectively the load-bearing anterior column (24). The stabilization procedures included SRF (n=7), (Figure 1 a,b), SPF (n=5), (Figure 2), and combination of these devices (n=1), (Figure 3). Only three of them were MRI-compatible. Screws of appropriate-lenght were preselected on the basis of the CT characteristics of each particular vertebra. In each patient, screws were inserted into each of the vertebrae above and below the gap created by the corpectomy, until the screw tip reached the opposite side of bone cortex. When necessary, the distractor was placed between the screw heads to correct any angular deformity. The rod was selected and then connected to the screws. In cases with T 4 lesions, screw insertion into the T 3 vertebral body was difficult, depending on exposure. The screw could not be placed transversely across this vertebral body, thus, in these cases, the upper screws were placed at an angle of 30 to 40 degrees superior to the inferior end-plate of the T 2 vertebral body (Figure 4). In the SPF group, the spinal plates were positioned on the vertebra above and the vertebra below the gap. The screws were inserted through the spinal plates into the vertebral bodies. Initially, the screws were not completely inserted into the vertebral bodies, and this allowed the screws to be used as fixation points for a distraction device. Distraction was also applied by pressing on the back of the point. In all groups, after instrumentation was complete, the fixation was tested intraoperatively using the " push-pull " method. When instabilty was suspected, a rod or plate was fixed to additional vertebrae above or below the instrumented level. Two vertebrae were fixed in nine patients, three vertebrae were fixed in three patients, and four vertebrae were fixed in one patient. We inserted two chest drains, placing one anterosuperiorly, and the other posterobasally. The thoracotomy was then

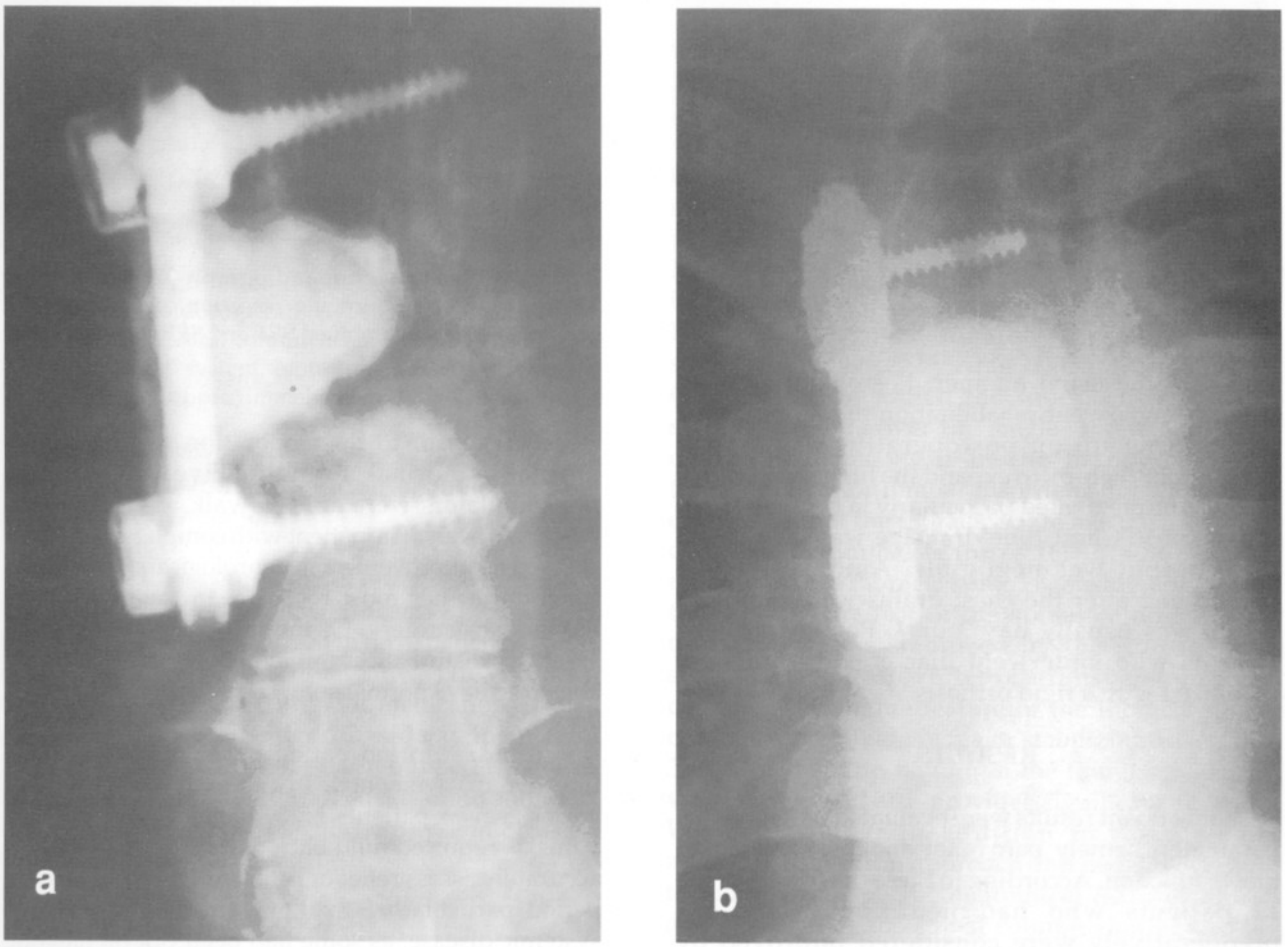

Figure 1. a) Postoperative anteroposterior radiograph demonstrating the methylmethacrylate-SRF construct, b) The FVM device was an another system used in this study as a SRF system.

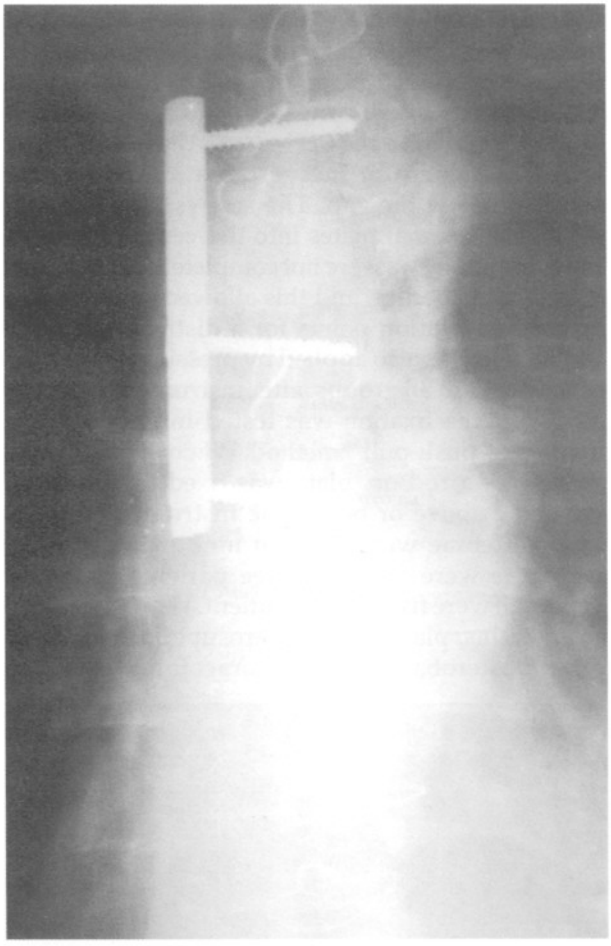

Figure 2: Anteroposterior x-ray film 9 months after surgery shows SVBS-plate fixation.

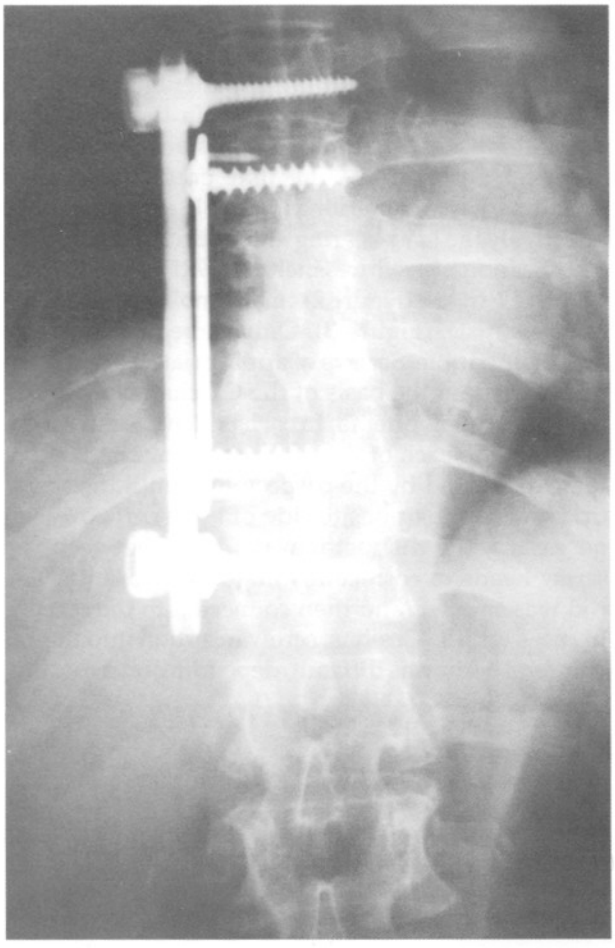

Figure 3: Anteroposterior radiograph 32 months after surgery. Following resection of two vertebral bodies, a combined SRF and SPF procedure was performed.

closed in the usual manner. Postoperatively, all patients underwent rehabilitation therapy, starting with sitting up on postoperative day 1 or 2. Respiratory therapy to expand the lungs is essential, and was implemented particularly in the first 2 days postsurgery. Chest tube drainage was maintained until output was negligible. Ambulation was encouraged after the chest drains were removed, which was usually day 3 or 4. Postoperatively, patients who underwent iliac crest fusion were mobilized with a rigid orthosis.

RESULTS

Treatment results were evaluated based on two parameters namely pain relief and improvement in motor function. According to these criteria, 11 of the 12 patients who had neurological deficits preoperatively were considered improved by surgery. No patient deteriorated neurologically due to their procedure. Those who could walk with assistance prior to their operation regained near-normal or normal strenght. Five preoperative nonambulators were able to walk with assistance postoperatively. The patient with complete paraplegia showed no improvement in neurological status (motor function) at her most recent exam, which was 11 months postsurgery. Of the three patients that had sphincter disturbances initially, two were eventually able to achieve normal sphincter function.

There were no patients whose pain did not improve or worsened. In the early postoperative period, seven patients had excellent relief of back pain, six reported mild back pain. It was difficult to accurately assess relief of back pain in the follow-up period, particularly for patients who had progressive systemic disease, as some had been put on narcotic medication for other painful sites. However, four of six patients who had mild back pain postoperatively

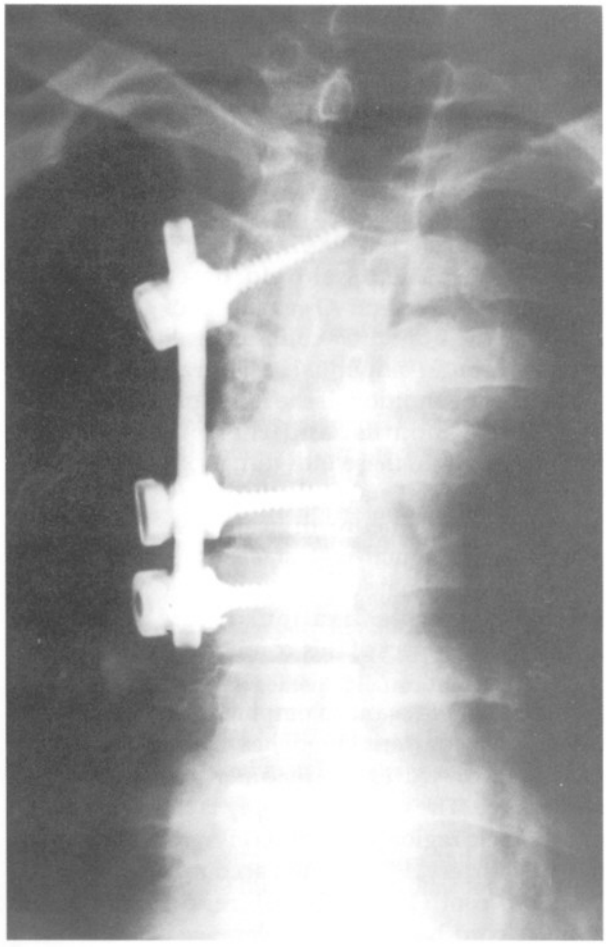

Figure 4: Anteroposterior roentgenogram obtained 44 months postoperatively, shows stabilization of the vertebral column achieved with s SVBS-rod fixation system. Note that the upper screw is angled approximately 40 degrees superiorly.

reported satisfactory resolution of their pain on subsequent examinations.

No vascular, neurologic, or other system injuries related to instrumentation were observed. However, minor complications occurred in three patients. These included superficial infection that was treated with a course of intravenous antibiotic medications in one patient, and prolonged graft-side pain in two patients. The follow-up period in our series ranged from 2 to 44 months, with a mean of 16 months. During follow-up, five patients with systemic cancer died, all as a result of metastasis.

DISCUSSION

Today, the transthoracic route is generally accepted as the treatment of choice for decompression and stabilization of lesions that affect vertebra in the middle or lower thoracic spine. Since anterior instrumentation has become very popular in the treatment of thoracic spinal disorders, numerous of fixation devices have been developed (7,13,15,19,20,25,30,34, 44,50). Although a variety of these devices are now available, there is no universal agreement on, or standardization of, any specific instrumentation system for internal fixation. No single system is clearly superior to the others, and each has its advantages and disadvantages. Most importantly, all of these so-called "universal" systems are difficult to use at or above T 3. Another disadvantage of these systems is their stainless steel construction, which interferes with CT and MRI. It is well known that radiological assessment for the presence of postraumatic syringomyelia, tumor recurrence, and adequacy of decompression postoperatively can be accomplished using of MRI or CT scans. We evaluated all the patients in our series postoperatively using conventional radiography, but were able to use CT or MRI in only three individuals. Clearly, there is a definite benefit to using MRI-compatible implants in these cases. Most of the current anterolateral fixation devices consist of two screws placed into each vertebra, which are then connected by rods or a plate (1,3,26,30,51). The stabilization devices used in this study consisted of a single vertebral body screw placed laterally and connected by a rod or a plate. In the follow-up period, we encountered no instrumentation failure in the SRF or SPF groups. However, biomechanical testing of anterior stabilization devices by Krag (31), and Shono et al. (43), has demonstrated the superiority of paired screws and rods over the single- screw and - rod design. This is valid in the management of thoracolumbar or lumbar disorders, but we wish to emphasize that the thoracic spine has the following distinct anatomical features (6,10,14,36): 1) the mobility of the thoracic spine is considerably lesser than that of the rest of the spinal column; 2) the thoracic spine is stabilized by the rib cage and sternum. The costovertebral-transverse process complex is a unique feature of the thoracic spinal column, and provides a major stabilizing affect; and 3) the ligamentum flavum in the thoracic region is very strong, and also provides significant support. We believe that in addition to focusing on appropriate surgical approach and instrumentation technique, the specific anatomical features of the affected level of the spinal column should also be considered when making surgical decisions.

One advantage in the SPF group was its low-

profile. However, reducing the kyphotic deformity (i.e., distraction) using this device was difficult. In the SRF group, an obvious advantage was that this system provided distraction and compression as needed. However, its high-profile is considered a disadvantage. Complications during and after surgery can be classified as those linked to the surgical approach and those associated with instrumentation. Potential postoperative complications that can accompany this type of surgical instrumentation include pleural effusion, pneumonia, atelectasis, empyema, cerebrospinal fluid-pleural fistula, neural damage, vascular injury, hydrothorax, pulmonary embolism, myocardial infarction, wound infection and instrumentation failure (4,13,20,24,32,42,48). Our series was small, we encountered no major complications. The choice of these simple systems depended on a number of factors, the most important of which is the rapidly progression of neurological deficits. Since the rate of recovery generally parallelled the preoperative neurological deficit (5,8,39,41), early decompression and stabilization of the compressive lesion is extremely important. Eight of our 13 operations were performed as emergency surgery under semielective conditions, and these types of devices were the only ones avilable. We did not have sufficient time to obtain the improved anterior internal fixation devices. However, there were no vascular or neurologic complications in our series.

Approximately 50 % of patients with systemic cancer develop skeletal metastases, with the spine being the most common site (17,18,53). Although medical advances have extended the life expectancy of cancer patients, the optimal treatment for vertebral metastasis is still under discussion (5,12,42,48,53). In such cases, prognosis is believed to be related to several factors, such as the natural history of the primary tumor (17), the type of treatment employed, and the histological type of the tumor (2,8). Some studies have shown that surgery offers only short-term benefits, and these authors have suggested that surgery should not be considered as a primary treatment modality (35,42,44). We disagree. First, accurately determining the survival time of these patients is difficult (33,49). During follow-up, five of our eight patients with systemic cancer died. The average survival time was 10 months, which is comparable to results obtained by others (2,27,28,42). Second, the positive impact of the surgical treatment on quality of their life should not be forgotten. It is well known that, early mobilization and ambulation prevents many of the complications related to bed rest. We believe that the most important aspect of this kind of surgical intervention is to improve the quality of life for these patients until they reach the terminal stage. In our series, all eight patients with cancer were considered to have benefitted from surgery because they received significant pain relief and their neurological state improved. Our results support the concept that de novo surgery should be considered in selected patients with spinal metastases (48). These patients should be considered as candidates for surgery regardless of the primary nature of the tumor. Of course, this decision needs to be made on an individual basis, in accordance with the patient's condition. If the life expectancy is more than a few months, and there is no medical contraindication, these individuals should undergo surgery for spinal stabilization and fusion. We also believe that early neurosurgical consultation for all patients with spinal metastases to allow time for planning of optimal surgical treatment and to obtain the best possible fixation device is another considerable aspect of this condition.

Finally, we want to emphasize that variations of the thoracic arterial branches of the aorta and the presence of watershed zones are of surgical importance. The vascular supply is tenuous and the midthoracic region usually receives only one major radicular artery, which often accompanies the T4 or T5 nerve root (10,14). Therefore, the compressed thoracic cord has minimal tolerance capacity. As a result of the poor afferent blood supply and the presence of watershed zones, the alterations in the systemic blood pressure can have devastating effects. Since these operations are often long, hypotensive anesthesia techniques to minimize blood loss should be used with caution or avoided, due to the risk of end-organ failure.

CONCLUSION

If complete decompression and adequate stabilization are the treatment goals for ventral lesions of the middle and lower thoracic spine, the transthoracic transpleural anterolateral approach should be the surgeon's first choice. Our experience has shown that use of the single vertebral body screw fixation system does achieve adequate stabilization of these regions. However, it is not our intent to present these systems as preferred substitutes for other well-designed anterior fixation devices. We only want to emphasize that in emergency situations these simple fixation devices can be used safely in the middle or lower thoracic spine when the other alternatives are not available.

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