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Functional Outcome Following Synthetic Vertebral Body Implantation in the Management of Spinal Disorders

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Abstract

OBJECTIVE: Synthetic vertebral body replacement has been widely used recently to treat different spinal conditions affecting the anterior column. They arrange from trauma, infections, and even tumor conditions. In this study, we assess the functional outcome of this modality in different spinal conditions.

PATIENTS AND METHODS: Thirty-six cases operated from October 2010 to December 2017. Twelve patients had spinal type A3 fractures, 11 cases with spinal tuberculosis (TB), and 13 cases with spinal tumors. They were followed clinically for a mean period of 2.4 years.

RESULTS: All the cases were approached anteriorly. Seven cases had a post-operative infection. No neurological worsening reported. We had dramatic neurological improvement in all spinal TB cases. Mortality recorded in only 4 cases with metastatic spinal tumor during the mean period of follow-up. Karnofsky performance status scale showed statistically significant change for spinal TB, and tumor cases during the follow-up period, but there was no significant change in cases of spinal type A3 fractures.

CONCLUSION: The positive outcome of this surgery makes it recommended for properly selected patients, especially with spinal TB and tumors.

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Introduction

Anterior manipulation of the spine is defined as a surgery in which a device applied on the anterior column of the vertebral body to provide stabilization according to the two-column concept that was firstly described by Holdsworth [1].

The surgical approach is usually anterior. However, many new approaches described, especially for the lumbar spine such as posterior lumbar interbody fusion (PLIF) or transforaminal approaches (transforaminal lumbar interbody fusion) [2].

The technique of interbody fusion was first reported for the lumbar spine to manage spinal deformity and Pott's disease by Hibbs and Albee in 1911 [3], [4]. Burns in 1933 used the same technique to stabilize a case of spondylolisthesis [5]. Smith and Robertson in 1955 used it in the cervical spines [6].

Cages first used by Bagby and Kuslich in the late 1980s; they were initially spiral cylinders filled with milled bone graft. Nowadays, a variety of cages of different materials and shapes are available for use by either anterior or posterior approaches [7], [8].

The replacement of the vertebral body with a synthetic one was relatively new technique which appeared in late 1990s [9], [10], [11]. It replaced the traditional method with autograft because it provides more fixation and immobilization of the affected segment and hence this will result in earlier mobilization and recovery of the patient [12].

In this study, we assess the functional outcome of this modality in different spinal conditions.

Patient and Methods

This study is a prospective clinical study. The inclusion criteria were any patient diagnosed radiologically (computed tomography and magnetic resonance imaging [MRI]) to have fracture vertebrae type A3, tuberculosis (TB) spine, and primary or metastatic spinal tumors with neurological deficit. We performed the procedure for 36 cases from October 2010 to December 2017. The exclusion criteria were if there was a previous surgical intervention at the

same site, if the patient was without neurological deficit, was responding well to conservative treatment (as in cases of TB spine responding to anti-TB drugs or spinal metastatic tumors responding to chemotherapy and or radiotherapy), and if the vertebral fracture was stable. The surgeries were performed in The Neurosciences Hospital (24 cases), Nursing House Hospital (5 cases), Al-Amal Hospital (2 cases), Al-Kafeel Hospital (1 case), and Ibn Sina Hospital (4 cases). The patients had fractured vertebrae type A3 (12 cases), primary spinal tumor (5 cases), spinal metastases (8 cases), and spinal TB (11 cases). Karnofsky performance status scale was measured preoperatively and compared with the rate at the end of the follow-up period (mean = 2.4 years).

The surgery was done under general anesthesia with anterior cervical approach, thoracotomy, or thoracoabdominal approaches. The affected vertebrae were removed using electrical drill and CO₂ laser. The synthetic vertebral body was implanted and fixed with anterior screws, rods, or plates (see illustrative case 1).

The study protocol was approved by our institutional review board and conformed to the principles of the Declaration of Helsinki. All patients provided written informed consent for the use of their data.

Statistical analysis

Descriptive analysis in the form of percentages was calculated using Excel and presented in the relevant tables shown below.

Statistical Package for the Social Sciences version 17 was used in implementing Student's t-test for statistical comparisons ($p < 0.05$ was considered an indicator of significant association).

Results

Thirty-six patients were operated (22 males, 14 females), age range 16–65 years (average = 37.5 years). All the cases were approached anteriorly, we had cervical (5 cases), dorsal (15 cases), dorsolumbar (10 cases), and lumbar (6 cases) (Figure 1).

We managed 12 cases with spinal fractures type A3, 13 patients with spinal tumors, and 11 cases with spinal TB. The pathology, according to the site, is clarified in Figure 2.

All the cases had next day mobilization with physiotherapy. The mean follow-up was 2.4 years.

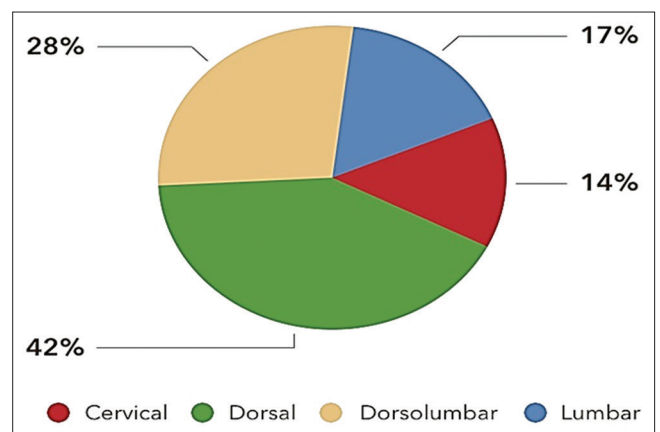


Figure 1: Site of implant of the synthetic vertebral body presented in percentages. The sites are: cervical, dorsal, dorsolumbar and lumbar

Postoperatively wound infection reported in 5 cases treated conservatively. No mechanical graft failure reported in our series. Neither neurological deficit nor worsening of existing neurological condition reported in our cases.

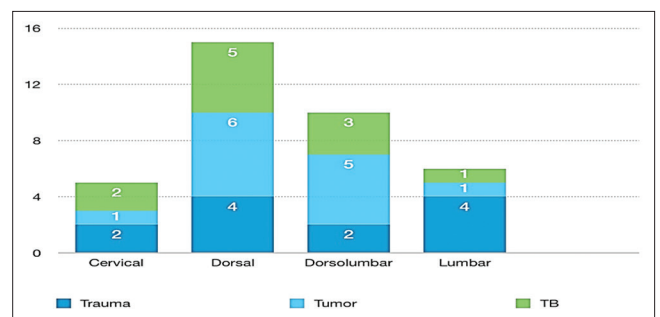


Figure 2: The type of pathology frequency according to the site of the involved vertebrae. The pathologies included: Trauma, tumor, and tuberculosis

Neurological functional improvement with improvement in the Karnofsky performance status scale was recorded with all the TB cases and 3 of 5 cases of primary spinal tumor and 4 of 8 cases of patients with metastatic spine tumors. During the period of follow-up, mortality reported in only three cases, all of them were having metastatic spinal tumors. No neurological improvement reported in type A3 spinal fracture cases (Figure 3).

Illustrative case 1

A 52-year-old male presented with chest pain and progressive paraparesis. MRI revealed T3 and T4 invasions (Figure 4a) with tumor extending to the adjacent ribs (Figure 4b).

Thoracotomy was done, three ribs removed with ligation of the azygos vein (Figure 5a). CO₂ laser used to remove the affected vertebrae (Figure 5b).

Titanium cylinder implanted with the demineralized bone matrix. Adjacent vertebrae were fixed with screws and rods (Figure 6).

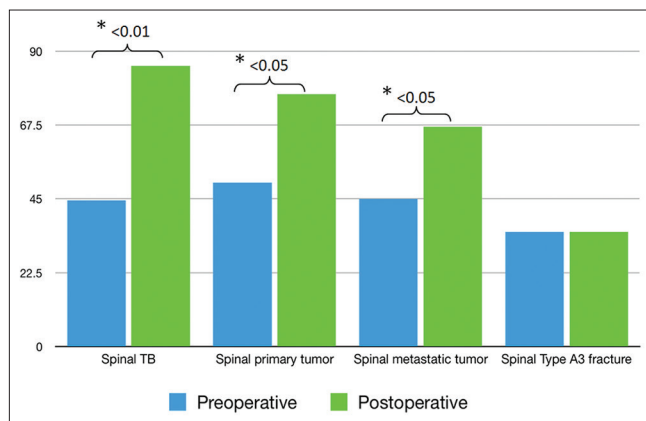


Figure 3: Karnofsky performance status scale average values comparing pre and postoperatively in different spinal pathologies. The statistical difference for each group of patients, as calculated by Student's t-test, is shown. Spinal tuberculosis $p < 0.01$, spinal primary tumors $p < 0.05$, spinal metastatic tumors $p < 0.05$, and spinal type A3 fractures, there was no significant change. There is a statistical difference between pre-operative and post-operative values as calculated by Student's t-test which is $p = 0.01$

Discussion

A great debate still presents on the best indications for anterior spinal fusion with instrumentation. Although spondylitis and vertebral burst fractures are well-accepted indications, no agreement attained for other pathologies.

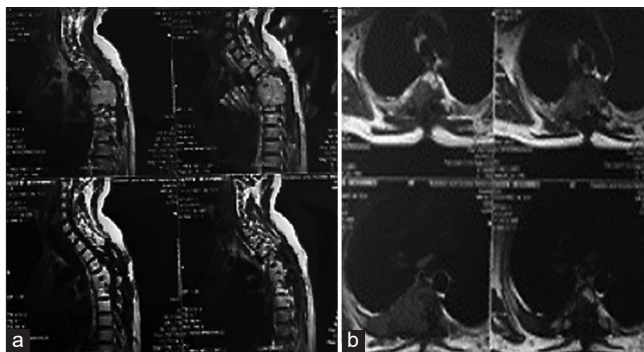


Figure 4: 52-year-old male presented with chest pain and progressive paraparesis. (a) Magnetic resonance imaging (MRI) sagittal views showing the T3 and T4 tumor invasions, (b) MRI axial views showing invading of the tumor into the adjacent ribs

Biomechanical aspects

It has been proved that the complete discectomy including the removal of the anterior longitudinal ligament will make the spine dangerously unstable for all loading stresses. In lateral bending and flexion, the interbody devices can maintain stability remarkably. However, the drawback of these implants, whatever the approach (PLIF or anterior lumbar interbody fusion) is the unattained control of both rotation and extension [13].

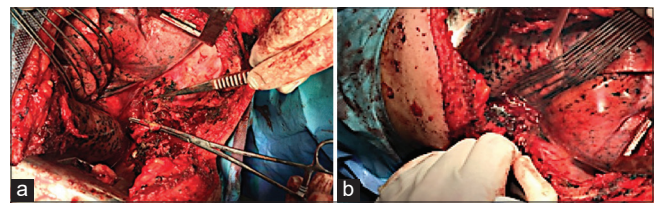


Figure 5: (a) Thoracotomy, with ligation of the azygos vein. (b) The use of CO₂ laser to remove the tumor

The multi-level vertebrectomy is a defiance issue to return spinal stability. It is indicated in chronic spondylitis, tumor growth, myelopathy, and severe compound fracture cases. However, the resulting instability, and thus the need of implantations, depends mainly on the number of affected vertebrae with the preserved and functioning stabilizers. Pure bi-segmental spinal stability after single-level corpectomy in the lumbar spine can theoretically be restored by pedicle screw systems [14].

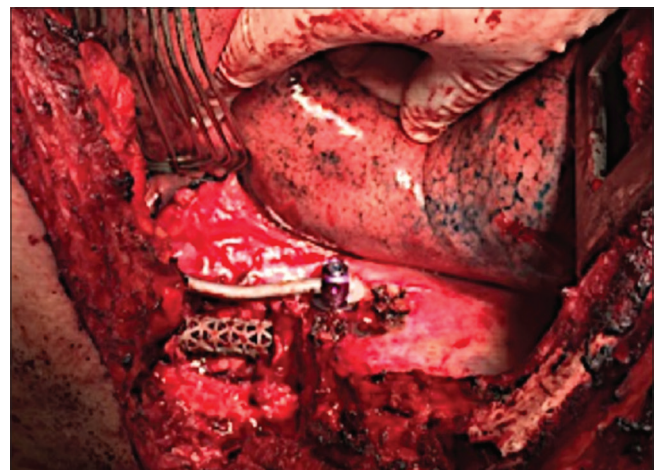


Figure 6: The synthetic vertebral body replaced the tumor mass and fixation applied using screws and rod

However, in the absence of anterior column integrity, the posterior bridge construct bears 100% of the load and will most likely fail even in the presence of a posterior spondylosis. This phenomenon reported in cases with unstable burst fractures lacking anterior support [15]. Biomechanical tests revealed that corpectomy with cages implantation alone or with an anterior angle-stable plate fixation is not able to restore the physiological segmental stability. To ensure solid bony fusion, it is commonly accepted that normal spinal physiological stability must be exceeded.

Corpectomy in the cervical vertebrae is used for different spinal pathologies: Cervical myelopathy, cervical spine trauma, and tumor. The stability following single-level corpectomy with cage implantation is almost similar to the range of motion of the intact vertebrae in all the six degrees of freedom [16]. Additional instrumentation must be applied. Anterior plating adds remarkable stability, especially in rotation, which is only exceeded by posterior systems.

Vertebral body replacement in trauma

With the advancement in spinal instrumentation techniques, different modalities of vertebral replacement prostheses were developed, mainly from either peek or titanium material [17]. The anterior approach remained the main modality for managing spinal fractures with anterior compression especially the avulsion type [18]. However, the neurological recovery following such trauma still is disappointing. In our series, although this sort of technique enabled us for early mobilization and rehabilitation, only three (33%) of our series were able to walk with sticks following 6 months of physiotherapy.

Vertebral body replacement in TB

Spinal TB still recognized as a difficult disease to manage, not because of the technical expertise or the time required to treat it, but more because of the decisions involved to treat it [19]. The worst neurological complications in TB spine occur in the active stage of the disease by inflammatory changes, instability, and mechanical compression [20]. In all our cases, there was severe dorsal vertebral collapse with the paraspinal abscess. All the cases managed by anterior approach to evacuate the abscess and remove damaged vertebrae with synthetic replacement. All the cases had dramatic functional recovery which arranged from immediate to 12 months of rehabilitation. Although many centers may advocate the posterior approach for managing such cases [21], with severe vertebral collapse and anterior compression, we still recommend the anterior approach if the general condition of the patient is fit for that. In conclusion, surgery has a key role in relieving pain, correcting deformities, prevents neurological impairment, and may restore function [22].

Vertebral body replacement in spinal tumors

This is the most important and rewarding indication for vertebral body replacement. Survival showed to be improved for both single metastatic and primary spinal tumors when removed radically [23], [24], [25]. In our series, we had two cases of plasmacytoma, four cases with metastatic breast carcinoma, 1 lung tumor, 1 prostate carcinoma, and two with adenocarcinoma of unknown origin. We had three mortalities in our mean duration of follow-up.

Conclusion

This type of surgical technique, although it is difficult, of long duration, and technically demanding, its

outcome is excellent, especially for patients with spinal TB and tumors.

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