Introduction

Anterior manipulation of the spine is defined as a surgery in which a device is placed 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 were 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 vertebral 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 vertebral 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 CO\textsubscript{2} 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.

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.

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). CO\textsubscript{2} 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).
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].

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.

Biomechanical aspects

It has been proved that the complete diskectomy 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].
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 ranged 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.

References

1. Holdsworth FW. Fractures and dislocations of the lower thoracic and lumbar spines, with and without neurological involvement. Curr Pract Orthop Surg. 1964;23:61-83. PMid:14282216
2. Mumaneni PV, Rodts GE Jr. The mini-open transformal lumbar interbody fusion. Neurosurgery. 2005;57 Suppl 4:256-61. https://doi.org/10.1097/01.neu.0000176408.95304.f3 PMid:16234672
3. Albee FH. Transplantation of a portion of the tibia into the spine for pott’s disease: A preliminary report 1911. Clin Orthop Relat Res. 2007;460:14-6. https://doi.org/10.1097/blo.0b013e3180686a0f PMid:17620806
4. The classic: The original paper appeared in the New York medical journal 93:1013, 1911. I. An operation for progressive spinal deformities: A preliminary report of three cases from the service of the orthopaedic hospital. Clin Orthop Relat Res. 1964;35:4-8. PMid:4874801
5. Burns BH. An operation for spondylolisthesis. Lancet. 1933;221:1233.
6. Smith GW, Robinson RA. The treatment of certain cervical-spine disorders by anterior removal of the intervertebral disc and interbody fusion. J Bone Joint Surg Am. 1958;40-A(3):607- 24. https://doi.org/10.2106/00004623-195840030-00009 PMid:13539086
7. Tsantrizos A, Andreou A, Aebi M, Steffen T. Biomechanical stability of five stand-alone anterior lumbar interbody fusion constructs. Eur Spine J. 2000;9(1):14-22. https://doi.org/10.1007/s005860050003 PMid:10766072
8. Tsantrizos A, Baramki HG, Zeidman S, Steffen T. Segmental stability and compressive strength of posterior lumbar interbody fusion implants. Spine (Phila Pa 1976). 2000;25(15):1899-907. https://doi.org/10.1097/00007632-200008010-00007 PMid:10908932
9. Epari DR, Kandziora F, Duda GN. Stress shielding in box and cylinder cervical interbody fusion cage designs. Spine (Phila Pa 1976). 2005;30(8):908-14. https://doi.org/10.1097/01.brs.0000158971.74152.b6 PMid:15834335
10. Jost B, Cripton PA, Lund T, Oxland TR, Lippuner K, Jaeger P, et al. Compressive strength of interbody cages in the lumbar spine: The effect of cage shape, posterior instrumentation and bone density. Eur Spine J. 1998;7(2):132-41. https://doi. org/10.1007/s005860050043 PMid:9629937
11. Oxland TR, Grant JP, Dvorak MF, Fisher CG. Effects of endplate removal on the structural properties of the lower lumbar vertebral bodies. Spine (Phila Pa 1976). 2003;28(8):771-7. https://doi. org/10.1097/01.brs.0000060259.94427.11 PMid:12698119
12. Salas N, Prébet R, Guenoun B, Gayet LE, Pries P. Vertebral body cage use in thoracolumbar fractures: Outcomes in a prospective series of 23 cases at 2 years’ follow-up. Orthop Traumatol Surg Res. 2011;97(6):602-7. https://doi.org/10.1016/j.orth201008.011.
13. Nibu K, Panjabi MM, Oxlund T, Cholewicki J. Multidirectional stabilizing potential of BAK interbody spinal fusion system for anterior surgery. J Spinal Disord. 1997;10(4):357-62. https://doi.org/10.1097/00002517-199708000-00012
PMid:9278922

14. Arand M, Wilke HJ, Schultheiss M, Hartwig E, Kinzl L, Claes L. Comparative stability of the “internal fixator” and the “universal spine system” and the effect of crosslinking transfixating systems. A biomechanical in vitro study. Biomed Tech (Berl). 2000;45(11):311-6. https://doi.org/10.1515/bmte.2000.45.11.311
PMid:11155532

15. McLain RF, Sparling E, Benson DR. Early failure of short-segment pedicle instrumentation for thoracolumbar fractures. A preliminary report. J Bone Joint Surg Am. 1993;75(2):162-7. https://doi.org/10.2106/00004623-199302000-00002
PMid:8423176

16. Schmidt R, Wilke HJ, Claes L, Puhl W, Richter M. Effect of constrained posterior screw and rod systems for primary stability: Biomechanical in vitro comparison of various instrumentations in a single-level corpectomy model. Eur Spine J. 2005;14(4):372-80. https://doi.org/10.1007/s00586-004-0763-8
PMid:1524055

17. Raslan F, Koehler S, Berg F, Rueckriegel S, Ernestus RI, Meinhardt M, et al. Vertebral body replacement with PEEK-cages after anterior corpectomy in multilevel cervical spinal stenosis: A clinical and radiological evaluation. Arch Orthop Trauma Surg. 2014;134(5):611-8. https://doi.org/10.1007/s00402-013-1721-1
PMid:24676649

18. Reinhold M, Knop C, Beisse R, Audigé L, Kandziora F, Pizantis A, et al. Operative treatment of 733 patients with acute thoracolumbar spinal injuries: Comprehensive results from the second, prospective, internet-based multicenter study of the Spine study group of the German association of trauma surgery. Eur Spine J. 2010;19(10):1657-76. https://doi.org/10.1007/j.spinee.2010.11.026

19. Mak KC, Cheung KM. Surgical treatment of acute TB spondylitis: Indications and outcomes. Eur Spine J. 2013;22 Suppl 4:603-11. https://doi.org/10.1007/s00586-012-2455-0
PMid:22695736

20. Jain AK, Kumar J. Tuberculosis of spine: Neurological deficit. Eur Spine J. 2013;22 Suppl 4:624-33. https://doi.org/10.1007/s00586-012-2335-7
PMid:22565802

21. Liu J, Wan L, Long X, Huang S, Dai M, Liu Z. Efficacy and safety of posterior versus combined posterior and anterior approach for the treatment of spinal tuberculosis: A meta-analysis. World Neurosurg. 2015;83(3):1157-65. https://doi.org/10.1016/j.wneu.2015.01.041
PMid:25698521

22. Trecarichi EM, Di Meco E, Mazzotta V, Fantoni M. Tuberculous spondylodiscitis: Epidemiology, clinical features, treatment, and outcome. Eur Rev Med Pharmacol Sci. 2012;16 Suppl 2:58-72. https://doi.org/10.1016/j.eun.2012.07.015
PMid:22655484

23. Yang Q, Li JM, Yang ZP, Li X, Li ZF, Yan J. Treatment of thoracolumbar tumors with total en bloc spondylectomy and the results of spinal stability reconstruction. Zhonghua Zhong Liu Za Zhi. 2013;35(3):225-30. https://doi.org/10.3863/zhzh.2013.03.03-03
PMid:23880006

24. Waschke A, Walter J, Duenisch P, Kalff R, Ewald C. Anterior cervical intercorporal fusion in patients with osteoporotic or tumorous fractures using a cement augmented cervical plate system: First results of a prospective single-center study. J Spinal Disord Tech. 2013;26(3):E112-7. https://doi.org/10.1097/bsd.0b013e3182764b37
PMid:23073150

25. Viswanathan A, Abd-El-Barr MM, Doppenberg E, Suki D, Gokaslan Z, Mendel E, et al. Initial experience with the use of an expandable titanium cage as a vertebral body replacement in patients with tumors of the spinal column: A report of 95 patients. Eur Spine J. 2012;21(1):84-92. https://doi.org/10.1007/s00586-011-1882-7
PMid:2168163