Journal on Surgery

www.journalonsurgery.org

*Research Article*

*Open Access, Volume 2*

# One Year Experience with the use of a New Expendable Cage and Large Endplates for Thoracolumbar Vertebral Body Replacement

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**Abstract**

**Introduction:** Subsidence is the most common complication following thoracolumbar vertebral body replacement (VBR) with expandable cages. Implants with large endplates are now being used in order to reduce the rate of subsidence. However, these require more elaborate preparations of the vertebral endplates, which may lead to higher surgical morbidity. Herein we present the 30-Day morbidity results following VBR with these devices.

**Method and material:** We retrospectively reviewed medical records of all patients who underwent corpectomy and implantation of an expendable cage with large endplates (Posidon, Fa. Signus) between June 2018 and September 2019. We included cases with one level of trauma, which were operated without additional platting and excluded infectious and tumorous cases. Demographics (age, sex, primary diagnosis), operative data (length of surgery, blood loss), surgical level, preoperative and postoperative neurologic status, perioperative complications, length of stay after surgery and measurement of footplate-to-vertebral body endplate ratio were analyzed.

**Results:** The study included 20 consecutive patients who were treated with a vertebral body replacement in Th 11 n=2, Th 12 n=4, L1 n=7, L2 n=3 and L3 n=4. Findings included a mean age of 60.6 years (32 to 72 years), mean surgical time of 140 min (90 to 190 min), mean blood loss of 560ml (250 ml to 900ml) and average length of stay of 13 days (5 to 34 days). All cases showed a footplate-to-vertebral body endplate ratio greater than 0.78. There were no surgical complications (e.g. neurological deterioration, vascular or pulmonary injuries).

**Conclusion:** Using of a large endplate for thoracolumbar vertebral body replacement in expandable cages is safe and not associated with a higher surgical morbidity. Nevertheless, long term results for clinical and radiographic follow up with focus on subsidence is desirable.

**Keywords:** Corpectomy; Large endplate; Footplate-to-vertebral body endplate ratio; Experience; Vertebral body replacement.

**Manuscript Information:** *Received: Nov 23, 2022; Accepted: Dec 14, 2022; Published: Dec 21, 2022*

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**Citation:** *Reinke A, Magudya B, Schmid G, Stemmer B, Kraus M, et al. One Year Experience with the use of a New Expendable Cage and Large Endplates for Thoracolumbar Vertebral Body Replacement. J Surgery. 2022; 2(2): 1070.*

## Introduction

Vertebral Body Replacement (VBR) is often performed in the lumbar and thoracolumbar spine. Reasons for this procedure include trauma, infection, degenerative changes, deformity and tumor pathologies. It is well known that subsidence is the most common complication following thoracolumbar vertebral body replacement (VBR) with expandable cages. It is more often seen with expandable implants than in cases with non-expandable, static Vertebral Body Implants (VBI) [1-3]. Failure rates are seen in cases up to 50% [4]. Subsidence often ends in reoperation because of pseudarthrosis, instability, secondary kyphosis or even because of new neurological symptoms [5]. Expandable cages with large endplates are now being used in order to reduce the subsidence rates. However, these require more elaborate preparations of the vertebral endplates which may lead to higher surgical morbidity [6]. For the traditional VBI morbidity rates of 14% to 29% are described [6,7]. A secured anti-subsidence capability, because of a stress distribution on the two endplates interfacing the VBI, is a large contact area on the bone graft [8]. In using techniques which allow the implantation of intervertebral cages with a large footprint (Extreme Lateral Interbody Fusion (XLIF)) the rate of subsidence is 7.5% less than in procedures with smaller footprints cages (transforaminal lumbar interbody fusion (TLIF)) [9]. Herein we present our experience in the first year with these new devices and the 30-Day morbidity following vertebral body replacement.

## Method and material

### Device

We retrospectively reviewed medical records of all patients who underwent a corpectomy and implantation of an expandable cage (Posidon®, Signus Medical LLC , Alzenau, Germany).

### Patients

For a distinct interpretability we focused only on cases with one level of trauma which were operated without additional plating in the lumbar and thoracolumbar spine. Supplemental dorsal stabilization was done in all cases. We excluded infectious and tumorous cases as well as those with deformity and degenerative changes.

### Data

Demographic data (age, sex), primary diagnosis, operative data (length of surgery, blood loss), surgical level, preoperative and postoperative neurologic status, perioperative complications, length of stay after surgery and measurement of footplate-to-vertebral body endplate ratio were analyzed.

### Procedure

An extreme lateral mini-open approach for vertebral body replacement was preformed [10]. The patients were positioned on their right side for this standard procedure. After a small incision (5 to 7 cm) above the fluoroscopic marked index segment a blunt dissection through all muscle layers (external oblique muscle, internal oblique muscle and transverse abdominal muscle) was performed. The retroperitoneal fat was then retracted anteriorly and the psoas muscle bluntly dissected or mobilized dorsally. Where necessary the diaphragm had to be transected. After verifying the level, the adjacent intervertebral discs to the index vertebral body were completely removed after contralateral annulotomy. Afterwards the VB was resected and the endplates as well as the distance between the adjacent VB were measured and the device with the maximum possible surface of footplates was implanted. Bony autograft was then attached to the VBI.

### Footplate-to-vertebral body ratio

Calculation of footplate-to-vertebral body endplate ratio was done on the basis of the standard preoperative CT-Scan. Endplate surfaces from the adjacent segments of the index level were measured and calculated (Figure 1). Alternatively surface from the intraoperative chosen footplates for the expandable cage was calculated and ratio of both was generated.

## Results

Between June 2018 and September 2019 the study included 20 consecutive patients who were treated with a vertebral body replacement. Twelve women and eight men with a mean age of 60.6 years (32 to 72 years) were included. Two female cases had osteoporosis which was under medical therapy. None of the cases had neurological deficits preoperatively.

All operations were due to a burst or a split fracture (Type A2 or A4) in the thoracolumbar and lumbar spine. Affected vertebral bodies were Th 11 (n=2), Th 12 (n=3), L1 (n=9), L2 (n=3) and L 3 (n=4) (Figure 2). All cases underwent an additional dorsal pedicle screw instrumentation in a separated procedure [11].

Implanted sizes of the footplates of VBI were 2.2 cm x 5.1 cm (11.22 $cm^2$) in 6 cases, 2.2cm x 4.3 cm (9.46 $cm^2$) in 10 cases and 2.2 cm x 3.5 cm (7.7 $cm^2$) in 4 cases. Mean surface of the footplates was 9.66 $cm^2$. Mean surface of adjacent segment endplates was 12.05 $cm^2$ (range from 10.5 $cm^2$ to 13.4 $cm^2$). Therefore mean footplate-to-vertebral body endplate ratio was 0.81 (range 0.78 to 0.89). So all cases showed a footplate-to-vertebral body endplate ratio greater than 0.78 (Figures 3,4).

Our data shows a stable surgical time during the first year. The mean surgical time was 140.8 min (range 90 to 190 min), the median time was 145.5 min with a normal Gaussian distribution (Figure 5). Mean blood loss was 560 ml (250 ml to 900 ml) (Figure 6) and the average length of stay was 13 days (5 to 34 days). There were no surgical complications (e.g. neurological deterioration, vascular or pulmonary injuries, impaired wound healing).

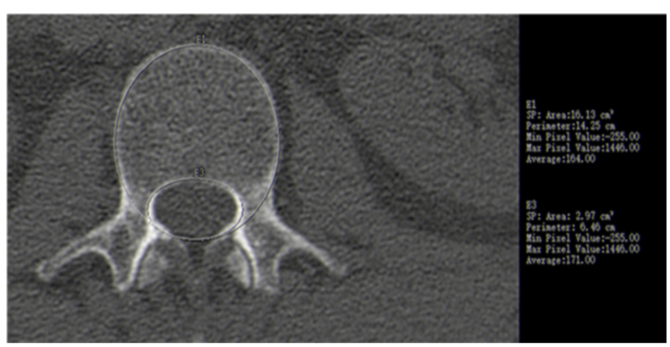


**Figure 1:** Slice (computer tomography) with marked boundary of the surface from the vertebral body. Surface of the great ring (E1) minus surface of the small ring (E3) results in the total surface of the endplate.

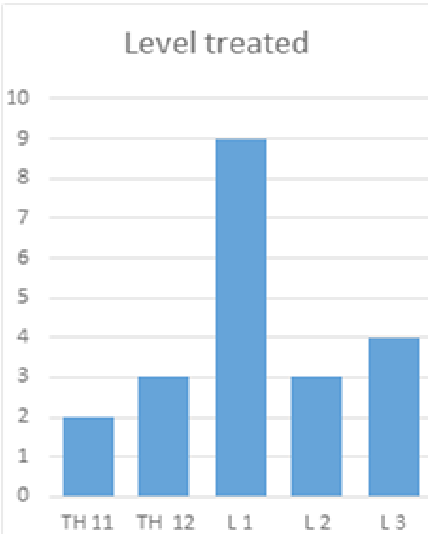


**Figure 2:** Graph shows distribution of levels treated from all 20 patients.

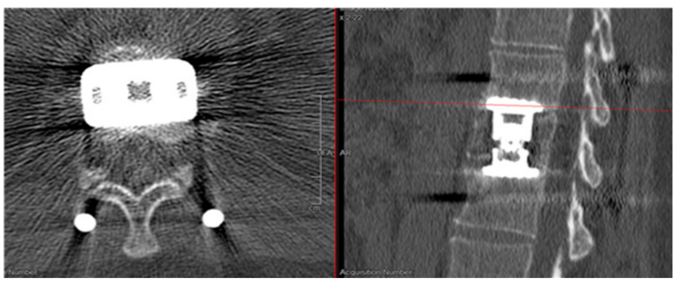

**Figure 3:** Postoperative computer tomography in axial (left) and sagittal (right) view after VBR (Posidon, Signus, Germany) and dorsal stabilization with a screw rod system. Footplate-to-vertebral body ratio is more than 0.78.

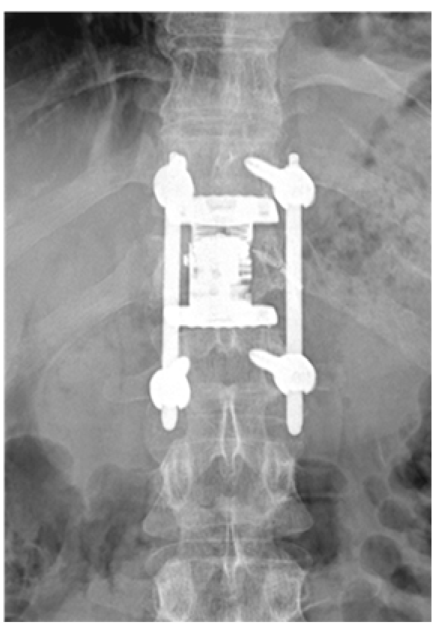

**Figure 4:** AP X-ray after VBR of Th12 and dorsal screw rod system implantation. Large endplates with a footplate-to-vertebral body ratio more than 0.78.

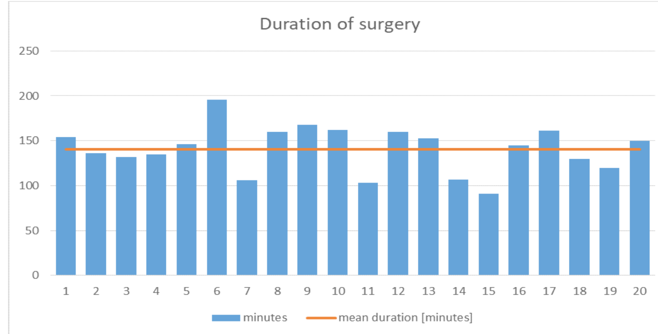


**Figure 5:** Time from cut to closure ("Duration of surgery") of all cases (n=20) treated with VBR. During the total period of one year a constant surgery time could be measured. Average surgery time is 140.8 minutes.

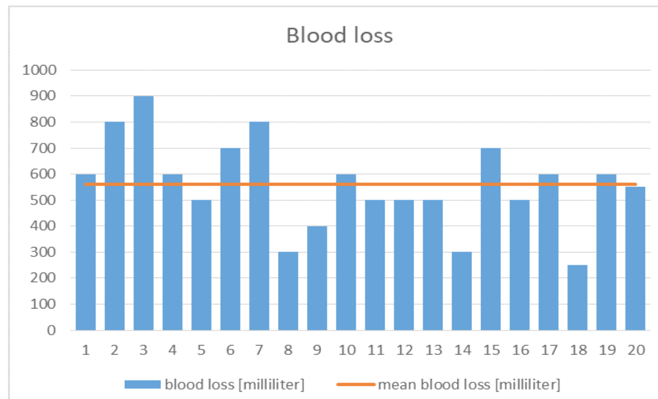


**Figure 6:** Blood loss of each case is demonstrated. Mean blood loss is 560 ml.

## Discussion

Nowadays Vertebral Body Replacement (VBR) after corpectomy is a standard procedure in spinal surgery. Over the last 50 years surgeons have used materials such as bone grafts, titanium, glass-ceramics, polymethyl methacrylate and wollastonite [12-14]. Likewise the surgical techniques and approaches evolved into new techniques with posterior placement of expendable cages in the lumbar spine [15,16]. Even patient specific three-dimensional-printed polymers are an innovative future trend [17]. Expandable devices are replacing static vertebral body cages these days [3], but there is the risk of higher rates of subsidence in expendable cages [1]. For optimizing biomechanical stability larger endplates for the implant were developed. One of the first VB implant with large footplates was the Posidon® (Signus Medical LLC, Alzenau, Germany).

## Patients

Our cohort included 20 consecutive patients who underwent a two stage thoracolumbar instrumentation. After initial dorsal pedicle screw instrumentation (short construct) an anterior erection and fixation was done using a one level vertebral body replacement with large endplates in a second operation. The reason in all cases was an unstable fracture. None of the twelve women and eight men had neurological symptoms prior to or after surgery. No complications like wound- or deep infection, cerebrospinal fluid leakage, implant failure or dislocation, pneumothorax or hemothorax occurred. Demographics and spreading of affected segments showed a typical spreading [18].

**Blood loss**

When performing a more complex VBR, especially with preparation of the endplates of the adjacent vertebral body, you may expect a greater loss of blood. It may be indispensable to place the VBI with large endplates.

The present finding reveals an average blood loss of 560 ml (250 ml to 900 ml) for the VBR itself (Figure 3). That is in keeping with normal ranges described in literature. There you can find a loss of blood for VBR in the lumbar spine for tumor surgery with an average of 1272 ml [19] and for VBR in fracture cases with a mean loss of 596.4 ml. Collected data for an update and meta-analysis of anterior spine surgery of recent fractures of the thoracolumbar spine could demonstrate volumes of blood loss between 600 ml up to 2500 ml [20]. Consequently the use of and VBI with lager endplates and the necessity of an enlarged preparation does not determine an increased loss of blood.

**Learning curve/duration**

To establish the use of a new implant or a new technique you can expect a learning curve for all users. Especially for a surgical method which requires more elaborate preparation than the familiar practice. An important point is not to overshoot preparation of endplates which may result in the reduced cortical consistency of adjacent segments and an elevated risk of subsidence.

Our data shows a consistent time of surgery during the learning stages of performing the new technique. A mean time of 140.8 min, a median time of 145.5 min and a normal Gaussian distribution (Figure 3) was documented in the first 20 cases.

Cut-to-closure time, which can be found in the available literature for VBR of thoracolumbar spine, ranges from 180 min up to 330 min [19-22]. So in total, the use of the above described new VBI does not result in a prolonged surgery time and does not need extensive practice to get familiar with it.

**Endplate**

A large surface between the VBI and the endplates of the adjacent vertebral body is supposed to decrease the stress to the endplates and the rate of subsidence. Three-dimensional patient specific vertebral body replacement with anatomical interfacing design shows 75% less stress in a finite element analysis to the endplates than a design with flat plates [8].

In 2014 Holland et al advocated a footplate-to-vertebral body ratio greater than 0.5 and an optimal expansion of the expandable cages in the thoracic spine. They could not evaluate an increased subsidence rate in the use of expendable cages compared to static cages [1,23-25]. But in their retrospective analyzed cohort they found a greater footplate-to-vertebral body ratio for static cages (0.71) than after implanting an expendable cage (0.63). There were no significant differences between the two groups in rates of subsidence (33% expandable cages, 40% static cage).

In our series the mean footplate-to- vertebral body ratio is 0.81. The smallest ratio in our cohort is 0.78. Therefore, all cases have a contact surface at least of three-fourths to the adjacent segment endplates. This value exceeds the amount which is recommended in the literature so far.

Nevertheless we do not know if a great footplate-to-vertebral body ratio shows a benefit. Essential issues include subsidence, consolidation, fusion, loosening and pseudarthrosis. These assessments require further analysis with a long term follow up, a prospective and randomized study design.

## Conclusion

Based on the results of this study, VBR with the new expandable implant for a large bearing surface for anterior stabilization in the lumbar and thoracolumbar spine after burst fracture is safe and not associated with a higher surgical morbidity. Particularly with regard to the necessity of a more elaborate preparation. There is a good technical possibility to achieve an extensive footplate-to-vertebral body ratio. Nevertheless, long term results for clinical and radiographic follow up with focus on subsidence as well as fusion is desirable.

## Declarations

**Acknowledgments:** None

**Formatting of funding sources:** This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Abbreviations:** MRI: Magnetic Resonance Imaging; VBL: Vertebral Body; VBI: Vertebral Body Implant; VBR: Vertebral Body Replacement; XLIF: Extreme Lateral Interbody Fusion; Cm: Centimeter.

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