Restoration of Endplate Integrity in A Type Thoracic and Lumbar Vertebral Fractures

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Abstract

Introduction: Posterior reduction probably reduces only the periphery of the endplate with its strong annular attachments while the central area remains depressed. After removal of the internal fixation (without fusion), the disc settles in this depressed area causing narrowing of the disc space and amplifying the residual kyphosis.

Aim of the Work: To study the restoration of endplate integrity in a type thoracic and lumbar vertebral fractures using a transpedicular approach.

Patients and Methods: The study was performed on 20 vertebrae in 20 patients with burst fractures for whom transpedicular spongioplasty was performed.

Results: By using transpedicular spongioplasty success was detected by immediate and follow-up of cobb's angle.

Conclusion: Transpedicular restoration of endplate integrity is an effective method to prevent later collapse.

Key Words: Restoration – Endplate – Transpedicular – Burst.

Introduction

SPINAL column injuries represent approximately 3% of all trauma cases [1] and 90% of these injuries involve the thoraco-lumbar region [2]. The thoraco-lumbar segment of spine (D 10 to L2) is an unstable zone between fixed dorsal and mobile lumbar spine.

Most often, damage occurs from a combination of different forces. Pure axial loads, or compressive forces, have been shown to result in end plate fractures as under compression the discs are always stronger than the endplate and that compression forces create a fracture of the endplate before damage to the intervertebral disc [3].

Recurrent kyphosis after posterior reduction was commonly seen with posterior instrumentation and appears to be a result of creeping of the nucleus pulposus back into the depressed central area although it can be argued that eventually discs adjacent to fractures will degenerate, such as are seen in degenerative disc disease, but the degree of kyphosis observed after longer follow-up does not seem to be greater than that at two years [4].

Posterior reduction probably reduces only the periphery of the endplate with its strong annular attachments while the central area remains depressed. After removal of the internal fixation (without fusion), the disc settles in this depressed area causing narrowing of the disc space and amplifying the residual kyphosis.

Anterior approach or combined anterior and posterior can allow better control of kyphosis, but higher morbidities with anterior approach.

Transpedicular spongioplasty may restore depression of the endplate and prevent creeping of the disc [5]. Most of the central depressions occur in the posterior half [4-6].

Patients and Methods

This is prospective study included twenty patients with thoracic and lumbar burst fractures that presented to Kasr Al-Einy Hospital managed over the past two years 2013-2014 using restoration of endplate integrity followed by augmentation.

The procedure possible complications, benefits, risks and other alternative interventions were all explained to the patients and an informed consent was obtained.

Methodology:

Clinical assessment through history taking and clinical examination was done for all the patients.
including: Age, gender, occupation and mode of trauma.

Investigation were done in the form of: Routine laboratory tests: Complete blood picture, kidney and liver function tests, coagulation profile.

Radiological assessment using X-ray, CT scan and MRI.

Selection criteria for this study:

Inclusion criteria:
1- Thoracic or lumbar spine fractures.
2- Cases with burst spine fracture.
3- Cases with intact neurology.
4- Age between 15 and 60 years.
5- Type A (according to AO classification).

Exclusion criteria:
1- Cases with type B or C.
2- Wedge fractures.
3- Neurologically affected.
4- Bleeding disorders.
5- Patients with pre-existing spinal deformity.
6- Patients with previous spinal surgery.

Technique:

The standard posterior approach till reaching the pedicle screw entry point, fixation was done one level above and below the fractured vertebra, distraction using the rod from one side (helping restoration) while trans-pedicular restoration of endplate from the other side, in five cases rods used for distraction on both sides at same time while using poly-axial screws that allow moving the rod medial and lateral helping the trans-pedicular axis.

After screws insertion and under image intensifier control, end plate restoration was done by three different methods either uni-pedicular or bi-pedicular:

A- Balloon: A 2-mm diameter trocars inserted into both pedicles of the fractured vertebra, the position of the cannula was continuously controlled in both planes, and then enlarged with the use of an access cannula with a trocar and gentle reaming.

Once the cannula reached the middle third of the fractured vertebral body, the void was reamed and kyphoplasty balloon carefully inserted and inflated by 20ml under continuous fluoroscopic monitoring.

B- Instrumented assisted endplate reduction: To elevate the endplate instead of the balloon, example arcuplasty tool or opening of disc punch with temporary K-wire inserted trying to fix the reduced endplate till cement injection.

C- Stentoplasty: Transpedicular entry into the vertebral body was used via Jamshidi needles and guide wires. The wires are very important in predicting the subsequent position of the stents.

Once the working cannula was in place, a bone drill created the tunnel for the stents.

Selected stent size is connected to its handle and inserted over the guide wire stopping a few millimeters posterior to the anterior cortex, guided by the image intensifier, then the handle is unlocked to allow the stent expansion gradually guided by image intensifier.

Stent is ideally placed under the collapsed endplate on the lateral projection, leaving enough bone to be evenly reduced by the net of the stent. Therefore care was taken to direct the guide wires in the optimal position.

Following elevation of endplate (whatever the method used) a radio opaque dye can be injected into disc space (discography) to check the efficiency of endplate elevation.

The elevated endplate is then supported by injection of calcium phosphate in eighteen cases or Polymethylmethacrylate (PMMA) in two cases transpedicular, into the cavity created.

Radiological assessment:

This includes Cobb’s angle, Vertebral Wedge Angle (VWA), recovery of vertebral height was measured on the sagittal reconstructions, by comparing the height of the anterior face of the fractured vertebral body with that of the adjacent body (caudal) both pre-and post-operatively, as described by Acosta [7] and by comparing to posterior body height in same vertebra.

But we have to detect a method to assess the efficiency of endplate reduction postoperative, and since the central portion is often more prominent to be fractured because of the hydrostatic pressure in the nucleus that is built up during the traumatic impact so we have to concentrate on middle part of vertebral endplate in middle sagittal CT cuts.

We compared the mid-vertebral body height in the mid sagittal CT scan of the fractured vertebra to that of the adjacent vertebra below both before and after restoration.
Also as a method of restoration assessment we compared the shortest body height (lowest point) in sagittal CT (any sagittal cut) preoperative to height of caudal vertebra in same area and same cut and then compare that to shortest body height in sagittal CT (whatever the sagittal cut) postoperative to height of caudal vertebra in same area and same cut.

**Results**

Cobb’s angle preoperative and post operative were compared statistically and it was found that there is significant difference between preoperative (15.3) and post-operative (0.75) Cobb’s angle (p-value <0.001) meaning that significant improvement in fracture deformity.

Mean value of Cobb’s angle immediate postoperative was $0.75 \pm 5.15$ and at latest follow-up became $4.15 \pm 7.59$ with p-value 0.105 considered no significant change.

Percentage of anterior height restoration in sagittal CT preoperative and post operative were compared statistically and it was found that there is significant difference between preoperative and post-operative ($p$-value <0.0002).

Mid-vertebral body height preoperative and postoperative was significantly corrected in mid-sagittal CT from $66.95 \pm 9.46\%$ to $88.1 \pm 5.57\%$ with $p$-value significant less than 0.0001.

By examining all the sagittal cuts the lowest point mean was $63.34 \pm 11.02\%$ (when compared to adjacent caudal vertebra) and was corrected to $85.22 \pm 6.46\%$ with $p$-value 0.0001 which is very significant.

**Discussion**

The vertebral endplate consists of a strong cortical periphery for attachment of the annulus fibrosus fibers, and a much thinner and weaker central part adjacent to the nucleus pulposus. Following a burst-type injury, both the central and peripheral parts of the endplate usually fracture, although the injury in the central portion is often more prominent because of the hydrostatic pressure in the nucleus that is built up during the traumatic impact. Indirect reduction of a fractured endplate by traction on the annular fibers will easily restore the cortical periphery, giving the impression of a good restoration of the vertebral body on anteroposterior and lateral radiographs. However, the central endplate portion cannot be reduced this way, leading to a distorted disc space morphology. The nucleus can subsequently herniate through the fractured endplate and cause anterior column insufficiency.

Transpedicular spongioplasty has been used to augment the fractured body but has not been consistently successful because of the inability to correct the endplate deformity well.

Mermelstein et al., [8] provided biomechanical evidence that short-segment posterior instrumentation combined with a transpedicular reconstruction of the anterior column with injectable calcium phosphate cement decreases pedicle screw bending moments in comparison with those seen in association with posterior instrumentation alone (using cadaveric L 1 fracture). Specifically, screw bending moments were decreased by 59% in flexion and 38% in extension. Moreover, the overall stiffness of the construct was increased by 40%. This decrease in screw bending moments and increased stiffness of the construct after anterior column reconstruction may explain the lower prevalence of screw breakage and progressive kyphosis demonstrated in the current series.

We studied the effect of endplate restoration using different methods on twenty patients with thoracic or lumbar fractures presented to Kasr Al-Ainy causalities, followed by augmentation using calcium phosphate in eighteen cases or PMMA in two cases.

Age of patients ranging from 15 to 51 years with mean $29.3 \pm 11.27$ years avoiding the osteoporotic fractures where endplates would be very fragile to be elevated, also avoiding the degenerated discs that are more common with old age, twelve of patients were females and eight males, no age or sex significant difference in selection of reduction method.

All cases were classified preoperative as type A (A3.1, A3.2, A3.3) compression fracture according to AO classification avoiding both type B distractive and C rotational injury that may require additional fusion, A3.2 was the most common representing 65%.

Verlaan et al., [9] conducted a study on twenty neurologically intact patients with thoracolumbar burst fractures where endplate restoration was done using balloon (BAER) applied bilaterally transpedicular followed by calcium phosphate introduction for augmentation. All patients recovered uneventfully, and the neurologic examination revealed no deficits. The postoperative radiographs and magnetic resonance images demonstrated a good fracture reduction and filling of the bone defect.
without unwarranted bone displacement, Verlaan et al. [9] stated that average Cobb's angle was corrected from 1 1º (±9.2º) before surgery to – 1. 6º (±9.5º) after surgery, to 3.0º (±11.4º) after instrumentation removal.

Since the depression usually involves the central part of superior endplate so measuring the mid-vertebral body height in mid-sagittal CT was very important with its comparison to next caudal vertebra, our results showed that mid-vertebral body height was significantly corrected in mid-sagittal CT from 66.95±9.46% to 88.1±5.57% with p-value significant less than 0.0001, also with no significant difference between balloon and instrumented assisted reduction methods in mid-vertebral body height preoperative with p-value 0.67 or postoperative correction with p-value 0.11.

In the trial performed by Verlaan et al. [9], average central body height increased from 66% (±10.7%) before surgery to 81% (±10.4%) after surgery, to 80% (±12.0%) of the estimated intact height after instrumentation removal.

Although restoration of the vertebral body height and kyphosis seemed to be easier with balloon kyphoplasty, it became clear that some of the correction achieved by the balloon is lost once it was deflated. Vertebral body stent was developed to eliminate this phenomenon.

Conclusion and recommendations:

Restoration of end plate integrity in type A thoracic and lumbar spine fractures is an effective method to prevent disc creeping in the broken endplate so preventing recollapse after correction of body height and cobb's angle, however longer term follow-up is needed to reassess the morphological changes in the disc following this method comparing it to traditional posterior fixation only, and further study of the chemical changes in disc following endplate fracture.

Restoring endplate would prevent early post-traumatic disc degeneration, which requires longer term follow-up for serial MRI disc assessment [10,11].

References


