



Surgical Outcomes of Bone Cement Augmented Screw Fixation, Cannulated Screws and Vertebroplasty in Osteoporotic Spine

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: osteoporosis is a common morbidity characterized by a systemic impairment of bone mass and microarchitecture that results in bone fragility fractures leading to decreased quality of life.

Methods: This study was conducted upon 30 adult patients with osteoporotic spine subjected to bone cement augmentation in the department of Neurosurgery, Tanta University Hospitals between January 2020 and January 2021.

Results: Oswestry Disability Index (ODI) ranged from 64-85 with mean 78 ± 18.8 before surgery and 21-44 after surgery with mean 33 ± 15.6 . Visual Analog Scale for Pain (VAS) ranged from 7-9 pre-operatively with a mean value 8.2 ± 1.8 and from 1-3 post-operatively with a mean value 2.3 ± 1.6 .

Keywords: Vertebroplasty; cannulated screws; osteoporotic; cement augmented pedicle screw.

1. INTRODUCTION

Osteoporosis is a skeletal condition characterized by decreased density of normally mineralized bone; it leads to decreased bone mechanical strength, thus making the skeleton more liable to fracture. The loss of bone occurs silently and progressively. Often there are no symptoms until the first fracture occurs. Osteoporosis risk increases by age, family history, some races as white or Asian, post-menopausal females, smoking, alcohol and certain medications as steroids. Vertebral fractures are the most common among osteoporotic fractures [1,2].

Loss of trabecular architecture weakens the bone and decreases the mechanical hold of the pedicle screws, compromising the strength and hastening osteolysis around the screws. Multiple cyclic loading leads to clear zone formation around the screws preventing osseous integration at screws bone interface resulting in screw loosening and screw pullout in osteoporotic spine [3].

The majority of complications of vertebroplasty are mild and transient. Potential complications include allergy, local trauma to nerve roots or spinal cord, fracture of the lamina, pedicle, or ribs, hemorrhage, infection, spinal stenosis, pulmonary emboli, paravertebral leakage, venous leakage, or leakage into the spinal canal and inter vertebral foramen could occur [4].

2. PATIENTS AND METHODS

This study was conducted upon 30 adult patients with osteoporotic spine subjected to bone cement augmentation in the department of Neurosurgery, Tanta University Hospitals between January 2020 and January 2021.

2.1 Preoperative Protocol

All patients are evaluated and subjected to clinical history, general and neurological examination, and routine laboratory investigations. Preoperative clinical examination is carefully done and muscle strength of the lower limbs for each patient is carefully graded according to the motor power grading system from 0 to 5.

2.2 Imaging

Plain radiographs: Anteroposterior and lateral views. Dynamic views shows: presence or absence of instability.

CT spine: Evaluatatoin of the integrity of the posterior wall of the vertebral body to avoid the risk of cement leakage into the spinal canal during injection.

MRI spine with or without contrast: Show vertebral body edema which is an especially sensitive sign of an active fracture, Visualization of soft tissue, neural structures, lumbar canal stenosis and disc prolapsed and shows if there is a benign or malignant lesion.

DEXA (Dual energy X-ray absorpitometry) scan: used to measure bone density in spine to detect osteoporosis.

Conservative Treatment: Prior surgery trial of conservative treatment was done first for stable patients who had no neurological deficit as bed rest, anti-inflammatory drugs, physiotherapy, lumbar bracing, vitamin D and calcium supplement.

2.3 Surgical Technique

Anesthesia, Patient Positioning, and Imaging:A general anesthetic was applied and the patient was positioned in prone position on the operating table.

In Cases of Transpedicular Cannulated Screw Fixation: The first step in insertion of pedicle screws was to identify pedicle landmarks. The bone cement metallic injection cannulas were first inserted empty into the polyaxial fenestrated screw heads to check the proper fit and entry trajectory sealed to avoid cement emersion into the screw heads, which could preclude rod insertion Fig. (1).

▪ The PMMA cement was prepared

Cement preparation and mixing: the container of the powder was set on flat surface and the cap was opened .The vial of the liquid was opened and mixed with the powder into the powder container. The container was closed and manually shaken for one minute until a liquid and homogeneous mass was achieved.

Loading the spine gun and application of extension tube then filling the extension tube then connecting the metallic injection cannulas to extension tube supplying cement by turning the handle clockwise under continuous monitoring of filling of the vertebra using C arm Figs (2,3).



Fig. 1. showing a cement metallic injection cannula and a cannulated screw



Fig. 2. showing the mixing of the liquid and the powder into the powder container



Fig. 3. showing application of extension tube to the gun



Fig. 4. showing application of transpedicular two bone biopsy needles for bone cement injection



Fig. 5. showing injection of the bone cement



Fig. 6. showing fluoroscopic image during bone cement injection



Fig. 7. Post operative X-ray dorsolumbar spine after D10-D11-L1-L2 fixation with traditional screws and bone cement



Fig. 8. Post operative CT lumbosacral spine after L3-L4-L5 fixation with traditional screws and bone cement and L2 vertebroplasty



Fig. 9. Post operative X-ray lumbosacral spine after L4-L5 fixation with cannulated screws and bone cement

Then filling is done into the injection cannulas, which can hold 1.5mL of cement. Injection was performed with a tooth-paste like consistency of the cement. Per screw, approximately 2 mL of cement was injected in the lumbar spine and 1.5 mL of cement in the thoracic spine. For every 0.3–0.5 mL of cement injection, cement distribution was checked with fluoroscopic images in lateral projection. In case of evidence of epidural, intradiscal, or prevertebral/intravenous cement extravasation, the injection of cement was stopped.

2.4 In cases of Bone Cement Augmented Screw Fixation

Tapping was performed under the fluoroscopic guidance taking the location in which the bone

cement would be injected. A bone biopsy needle was inserted into the tapping site, located in the anterior third of the vertebral body Fig. (4).

Bone cement was injected under the C-arm guide, through a bone biopsy needle, and it was allowed to be maximally localized in the vertebral body area. The bone biopsy needle contained approximately 1.5-2.5 cc of bone cement, and therefore vertebra was injected. Permanent transpedicular screws were inserted as soon as possible after the injection of bone cement under the C-arm guide and the track for the screw can be also injected with bone cement using insulin syringe Figs. (5,6).

Bone cement augmented transpedicular screwing was performed in adjacent vertebra

using the same method. It took anywhere from a few minutes to 10 minutes for the bone cement to become completely hardened, and therefore the rod was connected after at least 10 minutes.

2.5 Operative Technique of Vertebroplasty

A spinal needle was positioned, as a guide, with its tip in the center of the pedicle. A small skin incision (5 mm) was made. The needle tip was positioned along the line drawn through the middle of the pedicle then advanced carefully, under the fluoroscopy guidance. About 0.3- to 0.5-mL of the PMMA mix is repeatedly injected with immediate checks of fluoroscopy Fig. (6).

After final needle removal, the puncture sites were cleaned, sutured and dressed with sterile dressing and betadine ointment. Most patients are able to return to their home the same day of the procedure.

2.6 Follow Up

Clinical outcome: All patients are evaluated in the outpatient clinic at a regular period after 2 weeks from the operation then after 3 and 6 months. Oswestry Disability Index (ODI): was used for pre and postoperative disability assessment in all cases. The 10 factors which constitute the [ODI] criteria for assessing patient functional impairment are pain intensity, ease of personal care, lifting, working, sitting, standing, sleeping, sex life, social life and travelling. **Also pain before and after surgery was compared with [VAS] scale:** VAS is a straight horizontal line of fixed length usually 100 mm. The ends are defined as the lower limits of the parameter to be measured oriented from the left (the best) to right (worst).

Radiological follow up: Approximately one day after surgery, CT scan was done to ensure that instrumentation was in good position and efficacy of injection and exclusion of leakage and other complications Fig. (8).

At 3 and 6 months after surgery plain x-rays were done to assess pedicle screw, and fusion Figs. (7,9).

If patient complain reoccured new images were done to discover the cause of the new back pain. The flexion-extension lateral radiographs were done to all patients to assess the fusion and stability during the follow-up visits by ensuring if

there was evidence of lucency developed around the screws.

3. RESULTS

Postoperative hospitalization ranged from 2-3 days with a mean value 2.17 ± 0.83 days in patients with cannulated screws, ranged from 2-4 days with a mean value 3 ± 1 days in patients with usual augmented screws and ranged from 0-2 days with a mean value 1 ± 1 days in patients with Vertebroplasty Table (1).

As regard to motor deficit improvement according to MRC muscle power scale in which motor power is divided into 6 grades from G0 which refers to no muscle contraction to G5 which refers to normal motor power 20 (66.7%) patients were improved, 7 patients (23.3%) was moderately improved and 3 (10%) patients were not improved Table (2).

ODI ranged from 64-85 with mean 78 ± 18.8 before surgery and 21-44 after surgery with mean 33 ± 15.6 Table (3).

Pain was evaluated using a 11 point Visual Analog Scale for Pain (VAS Pain) Scale from 0 (no pain) to 10 (worst experienced pain) before and after the procedure. It was ranged from 7-9 pre-operatively with a mean value 8.2 ± 1.8 and from 1-3 post-operatively with a mean value 2.3 ± 1.6 Table (4).

As regards to complications, Infection was found in 2 (6.7%) patients, cement leakage was found in three patients (10%) and screw loosening was found in 2 (6.7%) patients of fixation Table (5).

4. DISCUSSION

In this study, thirty patients with osteoporotic spine were admitted and operated in The Department of Neurosurgery, Tanta University Hospitals in the period between January 2020 to January 2021. Fixation was done to twenty of them; eight patients were with cannulated screws and twelve patients were with augmented usual screws. Vertebroplasty was done to ten patients.

In our study PMMA was used in all patients because it is the cement of choice for screw augmentation as it has properties like biocompatibility with fewer allergies. It is mechanically strong and if Barium or Strontium is added then it has good radio-opacity [5]. Wuisman et al. [6] used calcium apatite cement in their study in seven patients with a progressive

Table 1. Postoperative hospitalization of all studied patients

		Patients (n = 30)
Postoperative hospitalization (days) in cannulated screws	Mean ± SD	2.17 ± 0.83
	Range	2-3
Postoperative hospitalization (days) in usual augmented screws	Mean ± SD	3 ± 1
	Range	2-4
Postoperative hospitalization (days) in vertebroplasty	Mean ± SD	1 ± 1
	Range	0-2

Table 2. Motor deficit improvement of all studied patients according to MRC muscle power scale

		Patients (n = 5)
Motor deficit improvement	Improved	20 (66.7%)
	Moderately improved	7 (23.3%)
	Not improved	3 (10%)

Table 3. Clinical outcome based on the Oswestry Disability Index (ODI) in all studied patients before and after surgery

Result	Patients(n = 30)	
	Preopertaive	Postopertaive
Range	64-85	21-44
Mean	78±18.8	33±15.6

Table 4. Clinical outcome based on the Visual Analogue Scale (VAS) in all studied patients before and after surgery

Result	Patients(n = 30)	
	Preopertaive	Postopertaive
Range	7-9	1-3
Mean	8.2±1.8	2.3±1.6

Table 5. Complications of all studied patients

		Patients (n = 30)
Complications	Superfascial Wound Infection	2 (6.7%)
	Cement Leakage	3 (10%)
	Screw loosening	2 (6.7%)
	No	23 (76.6%)

osteoporotic spinal deformity. Thirty-nine spinal segments (64 screws) were augmented. Screw augmentation failure occurred in only one patient. However, it may get integrated with the surrounding bone and get resorbed with time. Eventually, resorption of the cement matrix around the screws may loosen the purchase in bone and may lead to pull-out.

Fusion procedure was done in nine studies over the patients with non-malignant affection of vertebra. Most common of procedure to be

performed was posterolateral fusion [7-9]. Interbody fusion was done in cases with neurological impairment and severe vertebral height loss. Cho et al. [10] performed corpectomy with interbody fusion in all cases of Kummell's disease. Sawakami et al. [11] in their comparative study has found better fusion rates in cemented group as compared to the non-cemented group.

In our study Infection was found in 2 (6.7%) patients and leakage was found in three patients

(10%) of type (B) and type (S) leakage. There was low rate of infection due to prophylactic antibiotic and complete sterilization and the only 2 cases with superfascial wound infection were diabetics.

In our study postoperative hospitalization ranged from 2-4 days in cases of fixation with a mean value 2.17 ± 0.83 days and amount of cement injected ranged from 2-10 cc with a mean value 6.27 ± 2.48 cc.

In accordance with our data Huang YS et al. [12] the mean volume of cement was 9.8 ml (8.5–11.5), and the mean hospital stay was 7.9 days (6-11).

In accordance with our data Pesenti S et al. [13] Mean length of stay was 6.4 days (ranging from 4 to 14 days). All patients used grade III analgesics before the surgical procedure.

In this study, Pain was evaluated using a 11-point Visual Analog Scale for Pain (VAS Pain) Scale from 0 (no pain) to 10 (worst experienced pain) before and after the procedure. It was ranged from 7-9 pre-operatively with a mean value 8.2 ± 1.8 and from 1-3 post-operatively with a mean value 2.3 ± 1.6 .

ODI ranged from 64-85 with mean 78 ± 18.8 before surgery and 21-44 after surgery with mean 33 ± 15.6 . As regard to deficit improvement, 19 (63.3%) patients were improved, one patient (3.3%) was moderately improved and 10 (33.3%) patients were not improved.

In accordance with our data Mo GY et al. [14]. The preoperative VAS and ODI of the PSA group were 7.75 ± 0.75 and 36.61 ± 2.17 , respectively, and they were higher than the postoperative. Similarly, the preoperative VAS and ODI of TPS group were 7.64 ± 0.91 and 37.14 ± 2.17 , respectively, which were higher than the post-operative. They were statistically significant. There was no significant difference between the two groups.

In accordance with our data Seo JH et al. [15]. The mean VAS improved from 9.0 before the surgery to 1.8 after the surgery, and the mean Oswestry disability questionnaire scale changed from 79.1% to 39.2% in osteoporotic spine fractures or idiopathic scoliosis. The VAS improved from 7.9 to 1.9 for the patients with various spinal diseases, and the mean Oswestry disability questionnaire scale improved 74.5% before the surgery to 40.2. In both groups, a

significant improvement in VAS and Oswestry disability questionnaire was achieved ($p < 0.01$). 146 patients out of 157 patients were graded as having excellent.

In our review, cement augmentation provided improved anchorage for the pedicle screws in the osteoporotic vertebral body. Improvement in pain parameters were maintained after surgery. Cement augmentation provided desired resilience to the vertebra to withstand corrective forces for deformity correction.

System stability in our study was 100% in all cases of fixation and only 2% screw loosening but not affect stability of the patient after follow up at least 6 months and also in Wang HS et al. [16] there was no appreciable screw loosening or pullout at final follow-up and all patients achieved successful bone fusion but in Mo GY et al. [14] 2/172 screws loosening and 1/56 segment non-union occurred using PMMA cement augmented traditional screws and in Klingler JH et al. [17] One screw loosening was noted (0.6%) after a mean follow-up of 12.8 months using cannulated screws.

In regular follow up 3 cases developed new back pain one at three months, two at six month. After new imaging done new vertebral compressed fracture discovered this level also injected so this was not recurrence understanding of how vertebroplasty affects the risk of future fractures, two issues are particularly important to patient care.

As regards to complications cement leakage (CL) is the most common complication, which may progress in pulmonary cement embolism [18].

Janssen I et al. [19] and Martí'n-Ferna'ndez et al. [20] in their large studies, have reported that CL rates of 66.7% and 62.3%, respectively. Although, majority of CL were asymptomatic requiring no further treatment, morbidity and mortality associated with cement usage were significant.

Strategies have been suggested to reduce the incidence of CL. Fenestrated screws have been preferred choice for cement augmentation [21,22]. A total of 8 studies used fenestrated screws and their use has been more frequent in studies reported after year 2010. Pilot hole preparation into the pedicle followed by cement injection and screw placement was done in numerous studies. Sawakami et al. [11] performed augmentation by manually covering

thescrews with PMMA cement before placing it into the pedicles. Chang MC et al. [23] suggested inserting the cement cannula 5 mm short of the selected screw length to avoid anterior cement breach.

Additional vertebroplasty was done using PMMA cement in few studies. Aydog˘an et al. [24] performed vertebroplasty in all cases along with cement placement adjacent to the instrumented levels. Chang et al. [23] used additional laminal hooks at levels adjacent to CAPS. Amount of cement per screw ranged from 1 to 3 cm. Frequency of CL were higher in cases where multiple vertebrae have been instrumented rather than the amount f the cement used. Hu et al. [25] suggested that rate of CL was higher with lower BMD and was not dependent on amount of cement injected per vertebra. Consistency of cement at the time of injection was not widely studied. However, few studies did recommend using tooth-paste like consistency to avoid extravasation.

5. CONCLUSION

Vertebroplasty is a successful, safe, effective, rapid image guided therapy for painful vertebral lesions regardless its duration and may be the only solution for generally unfit patient. Cement augmented pedicle screw technique is effective and safe in the osteoporotic spine with lumbar degenerative diseases, with better fusion rates and less screw loosening incidence if used carefully and properly, it can be a safe and effective treatment in patients who need spinal fixation accompanying severe osteoporosis. The cannulated screws are safer with lower risk of cement leakage and less blood loss with lower duration of surgery but more expensive than augmented usual pedicle screws.

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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