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Analysis of the Results of Percutaneous Vertebroplasty of Compression Fractures of Bodies of Chest and Lumbar Vertebrae on the Background of Osteoporosis

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It is well known that the most frequent complication of osteoporosis is compression fractures of vertebral bodies. In addition to brittleness of the bones and mechanical stress, more and more evidence approving that compression fractures of vertebral bodies are related to many risk factors, such as aging, sex, concomitant morbidities of cardiovascular and cerebrovascular diseases and lifestyle (chronic smoking and alcohol consumption) are collected. Objective. Analyzing the condition of spines of the patients suffering from compression fractures of vertebral bodies on the background of osteoporosis after the performed Percutaneous vertebroplasty (PV). Methods. 553 patients who underwent hospital treatment at the spine pathology clinic of the Sytenko Institute of Spine and Joint Pathology (2005–2022) and underwent PV were examined. Results. The patients were divided into three groups depending on the number of damaged vertebrae. The 1st group included the patients with compression fractures of one vertebra (185 — 33.4 %); the 2nd group included the patients having 2 or 3 deformed vertebrae (216 — 39 %); and the 3rd group included the patients with 4–5 damaged vertebrae (152 — 27.4 %). Stages of compression of vertebral bodies during the X-ray morphometry was as follows before the surgery: I — 349 (24 %) vertebrae; II — 494 (34 %); III — 552 (38 %); and IV — 58 (4 %). We achieved the reduction of the level of compression of vertebral bodies as a result of PV in 20 % of cases (patients who noticed the manifestation of the pain syndrome within 2 weeks mostly suffered from these deformations). Conclusions. The results of analysis of PV of 553 patients with composite material and bone cement in the near and far future provide us an opportunity to state that this surgical treatment is an efficient and safe treatment method (despite the materials used). 40 (24 %) patients out of 165 patients of the group I, 52 (33 %) patients out of 157 patients of the group II and 54 (44 %) patients our of 133 patients of the group III were diagnosed with repeated compression fractures. Summarizing all the above, we should note that the more compression fractures the patient has, the higher the risk of further augmentation of other deformations of vertebral bodies is.

Як відомо, найчастішим важким ускладненням остеопорозу є компресійні переломи тіл хребців. На додаток до крихкості кісток і механічного стресу, накопичуються докази того, що компресійний перелом тіла хребця пов'язаний з багатьма чинниками ризику: старіння, стать, супутні патології серцево-судинних і цереброваскулярних захворювань, стиль життя (хронічне куріння, вживання алкоголю). Мета. Проаналізувати стан хребта в пацієнтів із компресійними переломами тіл хребців на фоні остеопорозу після проведеної пункційної вертебропластики. Методи. Досліджено 553 хворих, які перебували на стаціонарному лікуванні в клініці патології хребта ДУ «ІПХС ім. проф. М. І. Ситенка НАМН України» за період 2005–2022 рр., яким проводилася черезшкірна пункційна вертебропластика. Результати. Пацієнти були розподілені на три групи за кількістю ушкоджених хребців. У першу групу входили хворі з компресійним переломом одного хребця (185 — 33,4 %), другу групу становили особи, які мають від 2-х до 3-х деформованих хребців (216 — 39,0 %), третя група включала 4–5 ушкоджених хребців (152 — 27,4 %). Ступінь компресії тіл хребців під час рентгенометричної морфометрії становив до операції: I — 349 (24 %) хребців, II — 494 (34 %), III — 552 (38 %), IV — 58 (4 %). Зменшення ступеня компресії тіла хребця під час пункційної вертебропластики ми досягли у 20 % випадків (більшість цих деформацій були в пацієнтів, які відзначили виникнення больового синдрому протягом 2 тижнів). Висновки. Результати аналізу пункційної вертебропластики 553 пацієнтів із використанням композитного матеріалу та кісткового цементу, у найближчому та віддаленому періоді, дають підстави говорити про те, що це оперативне втручання є ефективним і безпечним методом лікування (незважаючи на використаний матеріал). Повторні компресійні переломи діагностовано в 40 (24 %) пацієнтів із 165 в I групі, 52 (33 %) з 157 в II групі, 54 (44 %) з 133 в III групі. Підсумовуючи результати цього дослідження, зазначимо, що чим більше в пацієнта компресійних переломів, тим вищий ризик у подальшому наростання інших деформацій тіл хребців. Ключові слова. Компресійний перелом, остеопороз, композитний матеріал, пункційна вертебропластика.

Keywords. Compression fracture, osteoporosis, composite material, Percutaneous vertebroplasty

Introduction

Compression fractures of the vertebral bodies are known to be the most frequent serious complications of osteoporosis [1]. The peculiarities of their manifestation are the multiplicity of lesions and severity of structural deformations of the vertebral bodies with preservation of the function of the vertebral-motor segment. This leads to the development of varying degrees of clinical signs of the disease due to the developing deformation of the vertebral body. In addition to bone fragility and mechanical stress, evidence is accumulating that compression fracture of the vertebral body is associated with many risk factors, ranging from aging, gender, comorbidity of cardiovascular and cerebrovascular diseases, to lifestyle — chronic smoking and alcohol consumption [2–5]. Treatment of patients with such disorders requires original surgical interventions aimed, for the most part, at stabilizing the anterior support complex. One of the most promising directions in restoring the support function of the front support complex is puncture vertebroplasty.

Puncture vertebroplasty (PVP) (percutaneous cementoplasty, percutaneous vertebroplasty, transpedicular vertebroplasty) is a minimally invasive technique for stabilizing vertebral body injuries using bone cements. It is an effective and safe minimally invasive intervention for improving life and immediate pain relief in patients with compression fractures of the vertebral bodies [6–8].

Results of treatment of compression fractures of the vertebrae by puncture replacement of the defect with composite materials and bone cements have been studied at the State Establishment Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Sciences of Ukraine since 2000.

Purpose: to analyze the condition of the spine in patients with compression fractures of the vertebral bodies secondary to osteoporosis after puncture vertebroplasty.

Material and methods

The study was conducted at the clinic of spine disorders of the State Establishment Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Sciences of Ukraine. The work plan was discussed and approved at the meeting of the Bioethics Committee of the Institute (Protocol No. 236 dated 13 November 2023).

The medical records of 553 subjects who were undergoing inpatient treatment at the clinic of spine disorders of the State Establishment Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Sciences of Ukraine. The patients were aged from 46 to 88 years (89 % of them were women and 11% were men; for the period 2005–2022) and underwent percutaneous puncture vertebroplasty using composite material and bone cements. The composite material included: bone cement (80 %) and bioactive ceramic (20 %), consisting of 2 parts of hydroxyapatite ceramic (HAP) and 8 parts of tricalcium phosphate ceramic (TCP). The main component of polymethyl methacrylate bone cement is an acrylic mixture that hardens by itself and consists of powder and liquid. The powder contains benzoyl peroxide, barium sulfate, etc. The liquid component is mainly methyl methacrylate monomer, NN-dimethyl methacrylate base, p-toluidine and hydroquinone [9].

Examination was carried out using clinical, radiological, radiometric methods. The diagnosis of osteoporosis was confirmed densitometrically (dual-energy X-ray absorptiometry). CT studies were performed to determine the tactics of operative treatment.

During the X-ray examination, 1,453 compression fractures of the vertebral bodies of the thoracic and lumbar spine were detected in 553 patients (Table). Of these, 578 injuries occurred in the thoracic and 891 in the lumbar regions of the spine.

On the basis of the X-ray examination data, X-ray morphometry was performed according to the Bilosilsky method.

In order to prevent the progression of deformations of the vertebral bodies, we have developed a method and device for the surgical treatment of compression fractures of the vertebral bodies (percutaneous puncture vertebroplasty) [10].

Puncture vertebroplasty was performed on 1,453 vertebrae. Composite material was used to treat 377 (68.1 %) patients, and bone cement was used in 176 (31.9 %) patients. In the thoracic spine, the trocar was inserted extrapedicularly through the transverse process and the costovertebral articulation into the vertebral body at an angle of 15°–20° to the horizontal plane. In the lumbar spine during transpedicular insertion, the main landmark is the intersection of the line drawn through the center of the transverse process in the frontal plane and the line drawn

Table

Fracture frequency distribution in patients

Patient	Number of fractures				
	1	2	3	4	5+
Number	185	141	75	88	64

through the base of the upper articular process in the sagittal plane.

Then composite material or bone cement was injected in a volume of 1.5 to 3.5 ml, depending on the degree of compression of the vertebral body.

Operative intervention was performed under local + intravenous anesthesia. The introduction of the trocar was monitored using an electronic-optical transducer.

During the PVP in 5 (0.90 %) patients, migration of material occurred under the posterior longitudinal ligament with spread for 1 or 2 segments up or down, 14 (2.53 %) patients were found to have a migration of material beyond the front parts of the vertebra body, in 8 (1.45 %) cases there was leakage of material into the higher/lower interbody spaces and in 2 (0.36 %) — leakage of bone cement into the paravertebral venous plexus. Only 2 (6.90 %) patients had complications that were manifested by root symptoms. After the foraminal blockades, the pain syndrome regressed in one patient, and the pain syndrome disappeared in the second patient over the next 4 months.

Results

Patients were divided into three groups according to the number of damaged vertebrae. The first group included patients with a compression fracture of one vertebra (185 — 33.5 %), the second group consisted of persons with 2 to 3 deformed vertebrae (216 — 40.0 %), the third — 4–5 damaged vertebrae (152 — 27.5 %).

In the postoperative period, on the 3rd day, the time course of the pain syndrome were evaluated according to the VAS, as well as the functional state of the vertebral column. The results in the first group in 163 (88 %) patients can be assessed as good, in 22 (12 %) as satisfactory. In the second group, 154 (71.2 %) patients had a good result, 62 (28.8 %) had a satisfactory result.

The third group was the most difficult category, which in all cases has somatic problems due to endocrine diseases. The result was good in 80 (52.6 %) cases, satisfactory in 72 (47.4 %) cases.

The percentage ratio of satisfactory results in the second and third groups increased due to a violation of the biomechanics of the spine as a result of a decrease in lumbar lordosis and an increase in thoracic kyphosis resulting in a redistribution of the load on the rear support complex along with the development of spondyloarthralgia. Articular blocks with corticosteroids were performed in this category of patients. Twenty-three patients subsequently underwent denervation of the arcuate joints and the results were rated as good.

Clinical example No. 1

A 78-year-old patient R. presented with pain in the lumbar region of the spine for 13 years. During the examination, a diagnosis was established: compression fracture of L_I, L_{II}, L_{III}, L_{IV}, L_V vertebrae secondary to osteoporosis. One-stage puncture vertebroplasty of deformed vertebral bodies with composite material was performed. In the postoperative period, the patient noted positive time course in the form of an increase in the range of motion in the spine, a decrease in the intensity of the pain syndrome from 8 to 3 points according to VAS.

The degree of compression of the vertebral bodies according to radiometric morphometry was before the operation: 1st — 349 (24%) vertebrae, 2nd — 494 (34 %), 3rd — 552 (38 %), 4th — 58 (4 %). We achieved a reduction in the degree of compression of the vertebral body during puncture vertebroplasty in 20 %

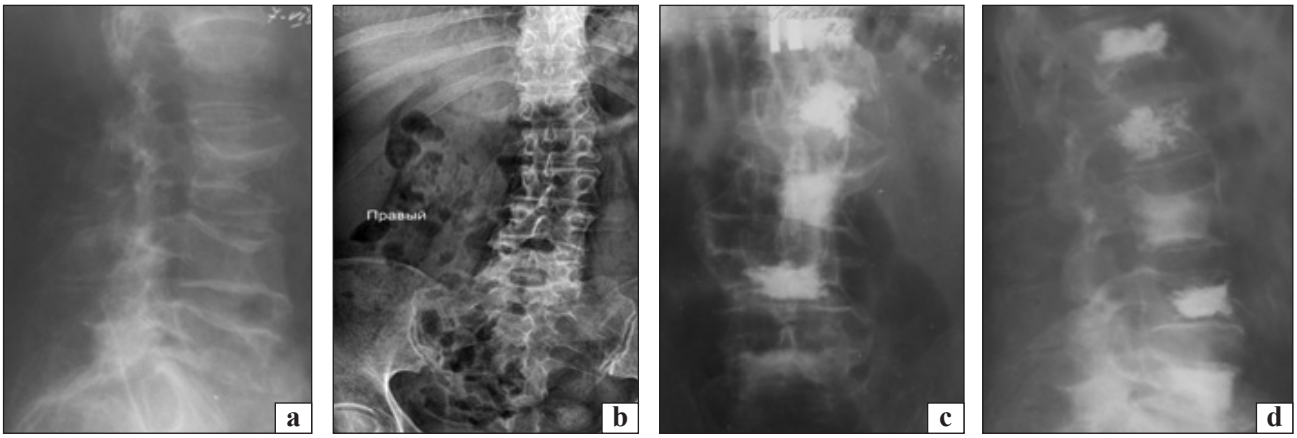

Fig. 1. Photographs of radiographs of a 78-year-old patient R. Diagnosis: compression fracture of L_I–L_{II}–L_{III}–L_{IV}–L_V vertebrae secondary to osteoporosis (before (a, b) and after (c, d) surgical treatment)

of cases (most of these deformations were in patients with pain syndrome within 2 weeks).

All patients subsequently received drug therapy aimed at blocking the resorption process and stimulating bone tissue regeneration.

Follow-up medical histories of operated patients: clinical and X-ray results were evaluated at intervals of 1 month, 3 months, 6 months and one year. 80 % of subjects were re-examined. In the 1st group, 165 (89 %) patients were examined, 66 (40 %) of them were found to have a deterioration of the local status: development of pain syndrome in the spine, partial impairment of its function. X-ray examination showed that 40 (24 %) patients had new deformations of the vertebral bodies.

Clinical example No. 2

A 69-year-old patient K. underwent puncture vertebroplasty of the L_I vertebra. During the year, the patient received therapy with zoledronic acid 5 mg intravenously, as well as calcium agents. A year later,

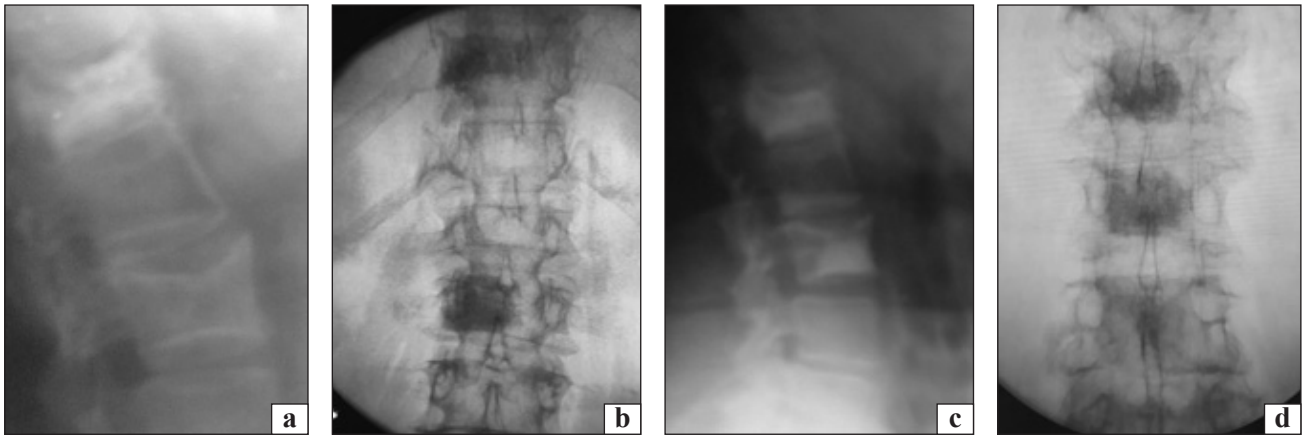

Fig. 2. Photographs of radiographs of a 69-year-old patient K.. Diagnosis: compression fracture of the L_{III} vertebra secondary to osteoporosis. Condition after puncture vertebroplasty of the L_I vertebra (before surgery (a, b), after surgery (c, d))

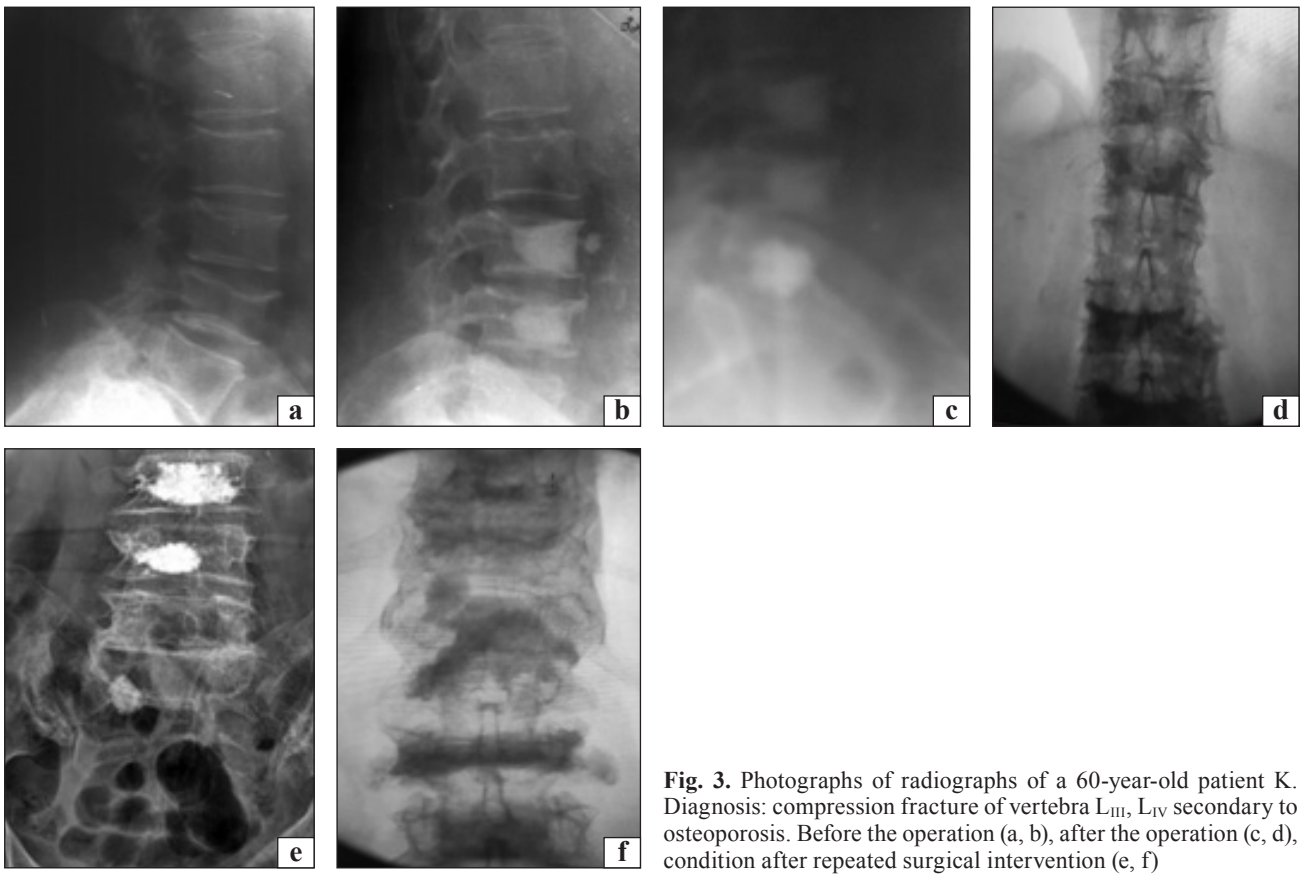

Fig. 3. Photographs of radiographs of a 60-year-old patient K. Diagnosis: compression fracture of vertebra L_{III}, L_{IV} secondary to osteoporosis. Before the operation (a, b), after the operation (c, d), condition after repeated surgical intervention (e, f)

pain developed in the lumbar region of the spine, X-ray examination showed 2nd degree compression fracture of the L_{III} vertebra due to osteoporosis.

A puncture vertebroplasty of the L_{III} vertebra was performed.

Control examination of Group II involved examination of 157 (73 %) patients. During the examination, new deformations of other vertebral bodies were detected in 52 (33 %) patients.

Clinical example No. 3

A 60-year-old patient K. underwent inpatient treatment with a diagnosis of compression fractures of L_{III}, L_{IV} vertebral bodies secondary to osteoporosis. Puncture vertebroplasty of L_{III}, L_{IV} vertebrae was performed. During 6 months he received medication, control examination after 6 months revealed a compression fracture of the L_V vertebra. Vertebroplasty was performed.

After a control examination of Group III patients (122 (80 %) subjects), an increase in pain syndrome in the lumbar spine was found in 72 (59 %) patients. During the examination, 54 (44 %) new compression fractures were recorded in the adjacent vertebrae. Pain syndrome in the rest developed, in our opinion, due to degenerative-dystrophic diseases of the spine.

Discussion

X-ray examination of deformed vertebrae after vertebroplasty showed no increase in the degree of compression of the vertebral bodies. The main pathogenic and morphological feature of compression fractures of the vertebral bodies due to osteoporosis is the deformation of the vertebral body due to its compression splitting. Such injuries are, for the most part, stable, but the impact of the locking plates can lead to a rapid progression of the degenerative process in the vertebral-motor segment with the development of clinical symptoms, and over time, an increase in the deformation of the vertebral bodies, and, as a result, changes in the biomechanics of the spine. We observe the following pattern: the more compression fractures in one patient, the more severe the symptoms and rehabilitation, which is carried out against the background of pronounced degenerative changes of the spine. Early detection of osteoporosis and initial deformations of the vertebral bodies is one of the good prognostic factors that affect the outcome of treatment. Yang et al. [11] suggested that PVP within 30 days after fracture reduces the subsequent risk of new vertebral compression fractures in the thoracolumbar spine. He B. et al. [12] also showed that the incidence of new vertebral compression fractures was significantly lower in the early PVP group (21 days) compared to the late PVP group during a 4–6-year follow-up period. Most often, compression fractures are found in the thoracolumbar section of the Th_{XI}–L_{II} spine [13]. In 75 % of cases, this is due to the peculiarity of the thoraco-lumbar transition, during which the increase in axial loads on the Th_{XI}–Th_{XII}–L_I–L_{II} POC determines the severity of the clinical manifestations of the disease. All patients in the early stages after puncture vertebroplasty noted positive dynamics — a decrease in pain syndrome, an increase in the range of motion in the spine.

Conclusions

Outcomes of puncture vertebroplasty of 553 patients with compression fractures of the vertebral bodies of the thoracic and lumbar regions of the spine using composite material and bone cement, in the near and distant period, give grounds to say that such surgical intervention is an effective and safe method of treatment (despite the applied material). The use of the developed method of vertebroplasty, device and composite material proves their clinical effectiveness. Pain disappears or is significantly reduced immediately after percutaneous puncture vertebroplasty. Early verticalization of the patient on the next day after the intervention contributes to the prevention of complications and improves the quality of rehabilitation of patients. New compression fractures were recorded in 40 (24 %) patients out of 165 in Group I, 52 (33 %) out of 157 in Group II, 54 (44 %) out of 133 in Group III. Summarizing, we note that the more compression fractures a patient has, the higher the risk of further growth of other deformations of the vertebral bodies, most of which occur in adjacent vertebrae. We associate new compression fractures with a change in the biomechanics of the spine and a redistribution of the load on the higher/lower segments after vertebroplasty. Today, this issue is relevant and needs further investigation studies predicting new compression fractures in patients with osteoporosis after vertebroplasty.

Conflict of interest. The authors declare no conflict of interest.

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ANALYSIS OF THE RESULTS OF PERCUTANEOUS VERTEBROPLASTY OF COMPRESSION FRACTURES OF BODIES OF CHEST AND LUMBAR VERTEBRAE ON THE BACKGROUND OF OSTEOPOROSIS

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