

**A.T. Stashkevych,
A.V. Shevchuk,
D.V. Uleshchenko,
V.G. Martynenko,
V.I. Melenko**

DYNAMICS OF PAIN SYNDROME AND QUALITY OF LIFE IN THE APPLICATION OF VERTEBROPLASTY IN PATIENTS WITH VERTEBRAL FRACTURES AGAINST OSTEOPOROSIS

*SI "Institute of traumatology and orthopedics of National academy of medical sciences of Ukraine"
Department of spinal surgery with spinal (neurosurgical) center
Bulvarno-Kudriavska str., 27, Kyiv, 01601, Ukraine
ДУ «Інститут травматології та ортопедії Національної академії медичних наук України»
відділ хірургії хребта з спінальним (нейрохірургічним) центром
(зав. – д. мед. н., проф. А.Т. Сташкевич)
вул. Бульварно-Кудрявська, 27, Київ, 01601, Україна
e-mail: fasti@i.ua*

Цитування: *Медичні перспективи. 2021. Т. 26, № 1. С. 169-175*

Cited: *Medicni perspektivi. 2021;26(1):169-175*

Key words: *osteoporosis, vertebrae, vertebroplasty, fracture*

Ключові слова: *остеопороз, хребець, вертебропластика, перелом*

Ключевые слова: *остеопороз, позвонок, вертебропластика, перелом*

Abstract. *Dynamics of pain syndrome and quality of life in the application of vertebroplasty in patients with vertebral fractures against osteoporosis. Stashkevych A.T., Shevchuk A.V., Uleshchenko D.V., Martynenko V.G., Melenko V.I. Currently, insufficient attention is being paid to an issue of the necessary anti-osteoporotic therapy after percutaneous vertebroplasty for vertebral fractures associated with osteoporosis, which leads to premature termination of medical treatment and worsening of the treatment results in this group of patients. An objective of the research is to study the results of treatment of patients with vertebral fractures associated with osteoporosis, depending on the use of anti-osteoporotic therapy. The results of percutaneous vertebroplasty of 91 postmenopausal women aged 50-90 years, depending on the use of anti-osteoporotic therapy during the postoperative period were analysed. An assessment was made according to the dynamics of pain syndrome using the Visual Analogue Scale (VAS), the Quality of Life Scale by J.R. Gaughen to estimate the patient's mobility and a need for pain medication. The results of the treatment were assessed 3 and 6 months after the percutaneous vertebroplasty. Bone mineral density was measured using Dual-energy X-ray absorptiometry 6 month after the treatment. Anti-osteoporosis therapy, which was prescribed for all patients comprised calcium supplements, antiresorbents and in D-hypovitaminosis – alfacalcidol or cholecalciferol. Only half of the patients followed the recommendations – 46 (50.6%), while the rest of the patients stopped the therapy in 2-3 months due to the improvement of their condition. In the main group of patients, where necessary anti-osteoporotic therapy was administered, significant reduction of pain syndrome and increase in quality of life during 3 and 6 months' observation period were revealed. In the group of patients where prescribed anti-osteoporotic therapy was not adhered, significant reduction of pain syndrome and increase in quality of life in the observation period 3 months was revealed but deterioration in the form of pain syndrome increase and decrease in quality of life in the observation period of 6 months occurred. Effectiveness of anti-osteoporosis therapy, with regard to measuring bone mineral density can be reliably confirmed only in the main group. Intraoperative and postoperative complications occurred up to 5.5%, and generally did not require further treatment and did not affect the overall treatment result. Thus, it was revealed that to ensure a stable effect after the surgery, long-term prescription of anti-osteoporosis therapy is needed.*

Реферат. *Динамика болевого синдрома и качества жизни при применении вертебропластики у пациентов с переломами позвонков на фоне остеопороза. Сташкевич А.Т., Шевчук А.В., Улещенко Д.В., Мартыненко В.Г., Меленко В.И. В настоящее время в вопросе необходимости антиостеопорозной терапии после проведения пункционной вертебропластики по поводу остеопоротических переломов позвонков уделяется недостаточно внимания, что приводит к преждевременному прекращению лечения и ухудшению результатов лечения у этой группы пациентов. Целью исследования было изучение результатов лечения больных с переломами тел позвонков на фоне остеопороза в зависимости от применения антиостеопорозной терапии. Проанализированы результаты пункционной вертебропластики 91 женщины в постменопаузе в возрасте от 50 до 90 лет в зависимости от применения антиостеопорозной терапии в послеоперационном периоде. Оценку проводили по динамике болевого синдрома по визуальной аналоговой шкале (VAS), шкале качества жизни J.R. Gaughen, по которой оценивались двигательная активность больного и необходимость применения*

обезболивающих препаратов. Результаты лечения оценивали через 3 и через 6 месяцев после пункционной вертебропластики. Минеральную плотность костной ткани оценивали с помощью двухэнергетической рентгеновской абсорбциометрии через 6 месяцев после лечения. Всем пациентам была назначена антиостеопорозная терапия в виде препаратов кальция, антирезорбентов и, при D-гиповитаминозе, альфакальцидол или холекальциферол. Рекомендаций придерживалась только половина пациентов – 46 (50,6%), остальная часть пациентов прекращала терапию в течение 2-3 месяцев после назначения в связи с улучшением состояния. В основной группе больных, где проведена необходимая антиостеопорозная терапия, отмечено достоверное снижение болевого синдрома и повышение качества жизни в срок наблюдения 3 и 6 месяцев. В группе больных, которые не придерживались назначенного лечения, отмечено достоверное снижение болевого синдрома и повышение качества жизни в срок наблюдения 3 месяца, с ухудшением состояния в виде нарастания болевого синдрома и ухудшения качества жизни в срок наблюдения 6 месяцев. Эффективность антиостеопорозной терапии по определению минеральной плотности костной ткани достоверно подтверждена только для основной группы. Интраоперационные и послеоперационные осложнения встречались до 5,5%, в целом не требовали дальнейшего лечения и не влияли на общий результат лечения. Таким образом установлено, что для обеспечения устойчивого эффекта после оперативного вмешательства необходимо долгосрочное назначение антиостеопорозной терапии.

Osteoporosis is one of the most common diseases, which, together with myocardial infarction and oncological pathology, occupies a leading place in the structure of morbidity and mortality. The social significance of osteoporosis is determined by its consequences and complications – fractures of vertebral bodies, long bones, which cause a high level of disability and mortality among the elderly and, accordingly, high material costs for health care.

Among all fractures in the elderly on the background of osteoporosis, vertebral body fractures range from 20 to 30%. Moreover, osteoporotic vertebral deformities are more common in postmenopausal women and are determined in 69.0-73.2% of cases. During this period there is a hormonal adjustment with the development of estrogen deficiency, which actively affects bone mineralization.

Functional treatment of vertebral body fractures in the elderly on the background of osteoporosis is largely difficult due to the risk of hypodynamic complications, the use of fixative corsets and orthoses in such patients is significantly limited due to their intolerance and risk of exacerbation of heart and lung failure [8].

Traditional surgical methods of treatment of vertebral body fractures are associated with significant trauma and blood loss, which can be fatal for the elderly.

Among the methods of surgical treatment of uncomplicated fractures of vertebral bodies in osteoporosis, our attention was drawn to the method of puncture percutaneous vertebroplasty, developed and applied in France in 1984. The principle of the method is to puncture bone cement into the vertebral body during its fracture [6].

At the same time there is a "reinforcement" of a vertebral body, basic function is restored, the pain syndrome considerably decreases. The results were

evaluated as positive, as 80-90% of patients experienced regression of pain and muscle-tonic syndromes, more than 90% of patients after surgery did not require systemic analgesics [9].

In addition to surgical treatment, sufficient attention should be paid to the conservative treatment of osteoporosis. It is known that without the use of adequate antiosteoporosis therapy there is a further progression of the disease and new deformations and compression fractures of the vertebral bodies may occur [12, 13].

Thus, indications for vertebroplasty: traumatic uncomplicated compression fractures of the vertebral bodies of primary or secondary osteoporosis without displacement of fragments into the lumen of the spinal canal, i.e. without compression of the neurovascular structures of the spinal canal [4, 11]. Although the problem of multiple vertebral fractures and the threat of new fractures remains [5].

Recently, more and more published studies show the return of pain as early as 3 months after surgery (until there is no difference in the level of pain between the groups of surgery and control). This is due in particular to the lack of attention to antiosteoporosis therapy after surgery.

The aim of the study was to study the results of treatment of patients with vertebral body fractures on the background of osteoporosis depending on the use of anti-osteoporosis therapy.

MATERIALS AND METHODS OF RESEARCH

We observed 91 women with vertebral fractures on the background of osteoporosis aged 50 to 90 years, who were hospitalized in the spinal surgery department with a spinal (neurosurgical) center in the period of 2014-2019.

For vertebroplasty a device for the introduction of cement "Stryker" was used transpedicularly. The surgery was performed under local anesthesia in

combination with the introduction of central anesthetics [1].

Vertebroplasty at one level was performed in 57 patients (62.7%), at 2 or more levels – in 34 (37.3%).

Pain regression and motor activity were assessed using a visual analog scale (VAS) of pain in 10 days, 3 and 6 months after surgery (formalized forms were completed by patients). The VAS visual analog scale makes it possible to assess the patient's subjective pain sensations during a 10-point study. VAS criteria: 1-2 points – minimal pain, 3-4 points – moderate pain, 5-6 points – severe pain, 7-8 points – very severe pain, 9-10 points – excruciating pain [7].

Evaluation of the effectiveness of treatment was performed on a scale of quality of life developed by J.R. Gaughen et al. [10]. Mobility was assessed on a five-point scale as follows: 0 indicated that the patient was walking without assistance; 1 – walking with help; 2 – wheelchair; 3 – limited to sitting in bed; and 4 – limited to lying in bed.

Bone mineral density was assessed by dual-energy X-ray absorptiometry (DEXA) before and 6 months after surgery. T-standard deviations (SD) were evaluated [3].

The distribution of patients by age and duration of fractures are presented in Table 1.

Table 1

The distribution of patients by age and duration of fractures

Months	Age, yeras							
	before 55		55-70		over 70		Total	
	abs.	%	abs.	%	abs.	%	Abs.	%
Up to 1	6	6.6	20	22.0	18	19.7	44	48.3
1-3	4	4.4	5	5.5	7	7.7	16	17.6
3-12	2	2.2	8	8.8	10	11.0	20	22.0
More than 12	-	-	6	6.6	5	5.5	11	12.1
Total	12	13.2	39	42.9	40	43.9	91	100

Preoperative examination.

Despite the relative simplicity of surgical intervention, the attitude to preoperative preparation should be quite responsible. Most of these patients have a complicated history due to old age, comorbidities, cancer and so on.

Preoperative examination included: general clinical, biochemical blood and urine tests. Necessarily, in addition to X-ray examination, computed tomography was performed to determine the condition of the posterior cortical plate, X-ray densitometry, examination by a physician.

Contraindications to vertebroplastic surgery:

- compression unstable fractures with displacement of bone fragments in the lumen of the spinal canal;
- coagulopathies of different genesis;
- complicated fractures, which are accompanied by post-traumatic herniated discs;

- complete compression destruction of the vertebral body - flat vertebra.

Statistical processing of the material was performed using the statistical software package Statistica 13.3 (StatSoft Inc., Serial No. ZZ999000009906307) and Microsoft Office Professional 2016. To describe the groups descriptive statistics – calculated the mean, error, and standard deviation was used. A non-parametric chi-square test for qualitative variables was used to determine the probability of discrepancy between the two samples. The difference in parameters was considered statistically significant at $p < 0.05$ [2].

RESULTS AND DISCUSSION

Osteoporosis was previously diagnosed in 44 patients, accounting for 48.4% of cases. And only in 23 (25.3%) patients this diagnosis was established three months before going to the clinic. The

maximum follow-up period was 48 months, the mean follow-up period was 6.2 ± 1.3 months.

Even among patients diagnosed with osteoporosis and vertebral fractures, only 30.8% of patients followed the treatment recommendations. The other 69.2% stopped therapy within 2-3 months after appointment. Among them, the vast majority considered further use of drugs inappropriate and did not seek medical attention.

All operated patients were prescribed anti-osteoporosis therapy in the form of calcium preparations, anti-resorbents and, in case of D-hypovitaminosis – alfacalcidol or cholecalciferol. Only half of the patients followed the recommendations – 46 (50.6%), the main group of observations. In this group of patients, anti-osteoporosis therapy was performed with various drugs. We did not evaluate the effects of the various drugs, but risendronate or denosumab in combination with calcium and vitamin D3 (alfacalcidol and cholecalciferol) predominated in the treatment of our patients.

Despite the prescribed anti-osteoporosis therapy, 45 patients (49.4%) did not follow the recommendations and, in fact, in this group of patients, anti-osteoporosis therapy was not performed, these patients are in the control group. The main reasons for refusing further treatment were financial costs against the background of a significant reduction in pain.

Pain syndrome in the main group in 3 months decreased from 4.6 ± 1.7 on average to 3.2 ± 1.4 by VAS; in 6 months we observed not only the absence of an increase in the pain syndrome, but also its decrease (up to 3.0 ± 1.3).

Among patients who did not follow the recommendations for anti-osteoporosis therapy (control group), the pain in 3 months decreased from 4.8 ± 1.8 on average to 3.8 ± 1.5 by VAS, but in 6 months we observed a significant increase in pain to 5.1 ± 2.4 according to VAS, the probability of difference in chi-square was $p=0.029$.

The quality of life of patients and the effectiveness of transcatheter vertebroplasty were evaluated 3 and 6 months after vertebroplasty. Improving the quality of life in patients of the main group persisted within the observed period. Patients without adequate antiosteoporosis therapy obtained similar results in the dynamics of the pain syndrome, but if the quality of life up to 3 months significantly increased, then up to 6 months reached almost baseline, preoperative level, the probability of chi-square difference was $p=0.021$ (table. 2).

Also, positive dynamics was observed in patients of the main group according to the assessment of bone mineral density (BMD) by the DEXA method at the level of the lumbar spine (L1-L4). 6 months

after surgery, the level of BMD on the T-index significantly increased from the average in the group – 3.3 ± 2.1 SD to – 2.4 ± 1.7 SD for 6 months of therapy (the difference is significant within $p < 0.05$). Accordingly, in patients who did not receive adequate anti-osteoporosis therapy, an increase in BMD was not expected ($p > 0.05$).

Errors and complications

Options for the spread of cement: in the intervertebral disc, vessels and ligaments, we did not regard as a complication in the absence of clinical manifestations.

Complications that require surgery – the spread of cement in the epidural space with compression of its contents occur in 1-3% [8]. Among our observations, this was only in one patient, which was 1.09%.

There are also a number of complications that do not require surgical treatment, the consequences of which are eliminated by medical correction. These are complications associated with the spread of cement beyond the vertebrae: the spread of cement through the vessel, the spread of cement into the intervertebral disc (cranial or caudal), the spread of cement under the posterior longitudinal ligament.

Intraoperative complications:

- transient hypotension during the introduction of bone cement (3 patients – 2.73%);

- hemorrhage. It occurs in patients with coagulopathy. Given this circumstance, coagulopathy should be medically adjusted before vertebroplasty (2 patients – 1.82%);

- fracture of the rib, articular process, transverse process, vertebral arch, pleural injury (5 patients – 4.55%);

- spinal cord compression, non-cement, is a rare complication (1 patient – 0.91%). It occurs more often with metastatic vertebral lesions. In most cases, open surgery is required;

- pulmonary embolism (1 patient – 0.91% – in mild form). It can be triggered by the use of excessive amounts of bone cement, for example, during the cementation of a large number of vertebrae and/or the penetration of cement into the paravertebral veins;

- lethal outcome (was not among our observations). The literature describes cases of deaths that were associated with a large number of vertebrae that have undergone cementation. It is common for no more than three vertebrae during one procedure.

Postoperative complications:

- transient increase in pain and fever (6 patients – 5.46%). It occurs infrequently and is more associated with manipulation during the procedure;

- radiculopathy (2 patients – 1.82%). It is associated with the outflow of bone cement into the

radicular vein or intervertebral foramen. In most cases, radiculopathy regresses with oral non-steroidal anti-inflammatory drugs. Rarely, surgery is required, including removal of the cement and decompression of the root;

- spondylitis as a manifestation of infectious complications after puncture vertebroplasty (among our observations were not). The above-mentioned complication is quite rare, as a rule, in patients with immunodeficiency.

Table 2

Dynamics of quality of life of patients with adequate anti-osteoporosis therapy (main group)

Dynamics of quality of life	Main group		Control group	
	in 3 months*	in 6 months **	in 3 months *	in 6 months **
Motor activity, points	0	24	23	17
	1	12	11	16
	2	10	11	12
Antalgic therapy usage, points	1	3	9	18
	2	18	16	14
	3	13	14	17
	4	12	6	6

Notes: * – differences between the groups are unreliable for the term of observation of 3 months ($p > 0.05$); ** – differences between the groups are reliable for the term of observation of 6 months ($p < 0.05$).

CONCLUSIONS

1. Vertebroplasty surgery is indicated for uncomplicated compression fractures of the thoracic and lumbar vertebrae with pain that occurs and is exacerbated by static and dynamic loads, regardless of the age of spinal cord injury and with proper training can be performed in elderly and senile patients with difficulty.

2. Vertebroplasty surgery in uncomplicated vertebral fractures allows to reduce a pain syndrome and to increase a motor activity of patients, has a low

percentage of complications, most of which do not require further treatment and do not affect the outcome of treatment.

3. To ensure a lasting effect after surgery, a long-term appointment of anti-osteoporosis therapy is required, which should be aimed at increasing the mineral density of bone tissue.

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

REFERENCES

1. Garmish AR. [Technical features and anatomical background of choice of Percutaneous vertebroplasty for aggressive vertebral hemangiomas]. *Ukrainskyi nei-*

rokhirurhichnyi zhurnal. 2003;2:78-82. Russian. Available from: http://nbuv.gov.ua/UJRN/Unkhj_2003_2_15

2. Petrie A, Sabin C. [Visual Medical Statistics: A Study Guide]. Leonov VP, editor. GEOTAR-Media; 2015. p. 216. Russian.
3. Rudenko JeV. [Dual-energy X-ray absorptiometry – a method for the quantitative diagnosis of osteoporosis]. *Novosti luchevoi diagnostiki*. 1998;3:16-17. Russian. Available from: <http://www.nld.by/398/stat7.htm>
4. Francisco Aparisi. Vertebroplasty and kyphoplasty in vertebral osteoporotic fractures. *Semin Musculoskelet Radiol*. 2016;20(4):382-91. doi: <https://doi.org/10.1055/s-0036-1592431>
5. Hui Zhang, Caiyuan Xu, Tongxing Zhang, Zhongyu Gao, Tao Zhang. Does percutaneous vertebroplasty or balloon kyphoplasty for osteoporotic vertebral compression fractures increase the incidence of new vertebral fractures? A meta-analysis. *Pain Physician*. 2017;20(1):13-28. doi: <https://doi.org/10.36076/ppj.2017.1.E13>
6. Kim Y-C, Bok DH, Chang H-G, Kim SW, Park MS, Oh JK, Kim J, Kim T-H. Increased sagittal vertical axis is associated with less effective control of acute pain following vertebroplasty. *Bone Joint Res*. 2016;11:544-51. doi: <https://doi.org/10.1302/2046-3758.511>
7. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care & Research*. 2011;63(11):240-52. doi: <https://doi.org/10.1002/acr.20543>
8. Martikos K, Gregg T, Faldini C, Vommaro F, Scapale A. Osteoporotic thoracolumbar compression fractures: long-term retrospective comparison between vertebroplasty and conservative treatment. *Eur Spine J*. 2018;27(2):244-7. doi: <https://doi.org/10.1007/s00586-018-5605-1>
9. Buchbinder R, Johnston RV, Rischin KJ, Homik J, Jones CA, Golmohammadi K, Kallmes DF. Percutaneous vertebroplasty for osteoporotic vertebral compression fracture. *Cochrane Database Syst Rev*. 2018;6(11). doi: <https://doi.org/10.1002/14651858.CD006349.pub3>
10. Gaughen JR, Jensen ME, Schweickert PA, Kaufmann TJ, Marx WF, Kallmes DF. Relevance of antecedent venography in percutaneous vertebroplasty for the treatment of osteoporotic compression fractures. *American Journal of Neuroradiology*. 2002;23(4):594-600. Available from: <http://www.ajnr.org/content/23/4/594.long>
11. Zhan Yi, Jiang Jianzhong, Liao Haifen, Tan Haitao, Yang Keqin. Risk factors for cement leakage after vertebroplasty or kyphoplasty: A meta-analysis of published evidence. *World Neurosurgery*. 2017;101:633-42. doi: <https://doi.org/10.1016/j.wneu.2017.01.124>
12. Sakae Tanaka. Molecular understanding of pharmacological treatment of osteoporosis. *Efort Open Rev*. 2019;4:158-64. doi: <https://doi.org/10.1302/2058-5241.4.180018>
13. Wang G, Sui L, Gai P, Li G, Qi X, Jiang X. The efficacy and safety of vertebral fracture prevention therapies in postmenopausal osteoporosis treatment. *Bone Joint Res*. 2017;6:452-63. doi: <https://doi.org/10.1302/2046-3758.67>

СПИСОК ЛІТЕРАТУРИ

1. Гармиш А. Р. Особенности техники и анатомическое обоснование выбора пункционных доступов при лечении агрессивных гемангиом позвоночника методом пункционной вертебропластики. *Укр. нейрохірургічний журнал*. 2003. № 2. С. 78-82.
URL: http://nbuv.gov.ua/UJRN/Unkhj_2003_2_15
2. Петри А., Сэбин К. Наглядная медицинская статистика : учеб. пособие / пер. с англ. под ред. В. П. Леонова. Изд. 3-е, перераб. и доп. Москва: ГЭОТАР-Медиа, 2015. 216 с.
3. Руденко Э. В. Двухэнергетическая рентгеновская абсорбциометрия – метод количественной диагностики остеопороза. *Новости лучевой диагностики*. 1998. № 3. С. 16-17.
URL: <http://www.nld.by/398/stat7.htm>
4. Aparisi F. Vertebroplasty and kyphoplasty in vertebral osteoporotic fractures. *Semin Musculoskelet Radiol*. 2016. Vol. 20, No. 4. P. 382-391. DOI: <https://doi.org/10.1055/s-0036-1592431>
5. Does percutaneous vertebroplasty or balloon kyphoplasty for osteoporotic vertebral compression fractures increase the incidence of new vertebral fractures? A meta-analysis / Z. Hui et al. *Pain Physician*. 2017. Vol. 20, No. 1. P. 13-28. DOI: <https://doi.org/10.36076/ppj.2017.1.E13>
6. Increased sagittal vertical axis is associated with less effective control of acute pain following vertebroplasty / Y. Kim et al. *Bone Joint Res*. 2016. Vol. 11. P. 544-551. DOI: <https://doi.org/10.1302/2046-3758.511>
7. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP) / G. A. Hawker et al. *Arthritis Care & Research*. 2011. Vol. 63. P. 240-252. DOI: <https://doi.org/10.1002/acr.20543>
8. Osteoporotic thoracolumbar compression fractures: long-term retrospective comparison between vertebroplasty and conservative treatment / K. Martikos et al. *Eur Spine J*. 2018. Vol. 27, No. 2. P. 244-247. DOI: <https://doi.org/10.1007/s00586-018-5605-1>
9. Percutaneous vertebroplasty for osteoporotic vertebral compression fracture / R. Buchbinder et al. *Cochrane: Cochrane Database Syst Rev*. 2018. 11 p. DOI: <https://doi.org/10.1002/14651858.CD006349.pub3>

10. Relevance of antecedent venography in percutaneous vertebroplasty for the treatment of osteoporotic compression fractures / J. R. Gaughen et al. *American Journal of Neuroradiology*. 2002. Vol. 23, No. 4. P. 594-600. URL: <http://www.ajnr.org/content/23/4/594.long>

11. Risk factors for cement leakage after vertebroplasty or kyphoplasty: A meta-analysis of published evidence / Y. Zhan et al. *World Neurosurgery*. 2017. Vol. 101. P. 633-642.

DOI: <https://doi.org/10.1016/j.wneu.2017.01.124>

12. Tanaka S. Molecular understanding of pharmacological treatment of osteoporosis. *Efort Open Rev*. 2019. Vol. 4. P. 158-164.

DOI: <https://doi.org/10.1302/2058-5241.4.180018>

13. The efficacy and safety of vertebral fracture prevention therapies in postmenopausal osteoporosis treatment / G. Wang et al. *Bone Joint Res*. 2017. Vol. 6. P. 452-463.

DOI: <https://doi.org/10.1302/2046-3758.67.BJR-2016-0292.R1>

The article was received
2020.07.16

