The osteoporosis is a global problem with significant health, social and financial consequences. According to the International Osteoporosis Foundation (IOF) from 2010, it affects more than 22 million women and 5.5 million men between the ages of 50 and 85 in the European Union. Due to the increase in the average age, this number is expected to reach about 34 million patients by 2025. In 2010, more than 3 million new bone fractures due to reduced bone mineral density were presented – 620,000 fractures of the femur, 520,000 vertebral fractures and 1,800,000 others. It is estimated that they have led directly or indirectly to at least 43,000 deaths, with the total number of lost so-called Quality-Adjusted Life Years (QUALYs) is estimated at 1,180,000 [1]. In well-developed countries such as Switzerland, hospital stays for new osteoporotic fractures exceed those associated with acute myocardial infarction, stroke and breast cancer each year, and represent a relatively superior financial problem [2].

The osteoporosis precipitates the occurrence of compression vertebral fractures, even in daily activities and low-energy traumatic accidents. In world statistics, about 3 new osteoporotic vertebral compression fractures (OVCF) occur every minute in men and women over the age of 50 years [3]. The total cumulative risk of developing a new fracture in women over this age is 16%, in men about 5% [3]. Women over 65 with available OVCF have a 25% risk of developing a new one in the next 5 years [4], as well as a significantly increased risk of fractures of other bones [5-10]. On the other hand, more than half of patients hospitalized for femoral fracture have evidence of previous OVCF [11].

In practice, the timely diagnosis of OVCF is often missed, as the pain is interpreted as a consequence of another disease of the musculoskeletal and nervous system – radiculitis, plexus irritation, disc disease and others. As a consequence, about 70% of OVCFs remain clinically unexamined and, correspondingly, incorrectly or incompletely treated [12].

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**FEATURES AND ALGORITHM OF SURGICAL BEHAVIOR IN OSTEOPOROTIC VERTEBRAL FRACTURES**

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**Abstract.** *The aim of the current study is to present the possibilities for minimally invasive percutaneous procedures for surgical treatment of osteoporotic compression fractures of the vertebrae (OVCF), expressed in vertebroplasty and balloon kyphoplasty. We compare their therapeutic effect with that of conservative treatment and present conclusions from the world literature regarding the safety of these procedures. Material and methods: We used data from our surgical experience for the last 10 years. We took into account the relevant literature from the global PubMed database and Google Scholar to present randomized clinical trials and meta-analyses comparing OVCF treatment methods. We analyzed those who assessed the quality of life, pain, and complications of treatment. Results: The world experience shows an excellent result in the short term from the minimally invasive percutaneous procedures. In the long term some authors note a significant overlap of the results with the conservative methods. All studies show a low risk profile in the surgical treatment, as well as comparable results between the two main procedures – vertebroplasty and balloon kyphoplasty. Conclusion: Both vertebroplasty and balloon kyphoplasty have a statistically significant advantage in terms of final clinical indicators compared to conservative treatment at low and clinically justified risks. No statistically significant differences were found between the surgical techniques on most of the studied criteria, which would justify the significantly higher cost of kyphoplasty.*

**Key words:** vertebroplasty, balloon kyphoplasty, osteoporotic vertebral fractures

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**CLINICAL CHARACTERISTICS**

The most common clinical presentation of OVCF is axial pain syndrome – pain along the spine, spasm of paravertebral muscles and forced analgesic posture. Typical for this type of pain is its intensification when changing the position of the body – from lying or sitting to standing, as well as the relative improvement of symptoms at rest and stationary or supported body position. The clinical picture may be accompanied by excitatory and deficient neurological manifestations depending on whether fragments of the fractured vertebral body compress on nerve structures. With the
accumulation of multiple osteoporotic fractures with progressive reduction of the height of the spine and the subsequent kyphotic deformity, significantly more serious and difficult to treat problems appear, such as sagittal imbalance, reduction of vital lung capacity and additional cardiovascular system load.

Despite its occult clinical course in a high-risk patient with existing axial pain symptoms and no other etiopathogenetic mechanism, OVCS should be suspected.

**IMAGING DIAGNOSTICS**

Many different methods for assessing vertebral fractures and measuring bone mineral density (BMD) are known in practice, but to date the three main imaging studies in these patients remain: radiography, computed tomography and magnetic resonance imaging.

**Radiographs**

Lateral radiographs, which are the imaging tool used most recently in practice (Fig. 1 and 2), have diagnostic value with over 20% reduction in the height of the vertebral body [13]. It decreases significantly when there is more than one osteoporotic fracture in the studied segment, which makes the assessment of acute versus chronic fracture very difficult and in many cases impossible [4]. In practice other methods are available to assess existing osteoporotic fractures based on radiographic images – dual-energy X-ray absorptiometry (DXA) and morphometric x-ray absorptiometry (MXA), but their additional study shows their lower diagnostic accuracy and specificity than that of simple lateral radiography [14].

Fast to perform, easily accessible and with minimal radiation load, this tool should be the first line of the diagnostic process. It should be noted that lateral radiographs make it difficult to fully image the vertebrae of the upper segment of the thoracic spine, due to the overlap of other structures of the shoulder girdle and the greater density of the costal arches. However, this rarely interferes with the diagnostic process, as the bulk of OVCFs occur below the Th6 level.

In the presence of low-grade fractures or multiple adjacent OVCFs (cascades of fractured vertebrae), it becomes significantly more difficult to assess the source of the patient's pain symptoms on the basis of a single radiograph. With such an X-ray image, it is practically impossible to determine with...
certainty which of the fractured vertebrae is the main generator of pain in the patient (Fig. 3). It is possible that most of the fractures depicted are in a chronic stage of consolidation and do not require additional therapeutic attention and follow-up.

**Computed tomography**

Computed tomography (CT) provides significantly more information on the morphology of the fracture compared to the two-dimensional image presented by radiographs, but even this much more modern study suffers from the same shortcomings in differentiating between chronic asymptomatic fractures and those generating pain symptoms, especially when observed multiple neighboring OVCFs [15]. On the other hand, this modality is of direct importance in preoperative planning in complex cases.

**Magnetic resonance imaging (MRI)**

Despite its significantly higher cost and the time required to perform magnetic resonance imaging (MRI), it remains the most informative of the three main modalities for examining patients with suspected OVCF. On the basis of a well-conducted examination of the relevant segment of the spine, the presence of a low-grade but symptomatic vertebral fracture can be determined with great accuracy, as well as the etiology of the fracture – osteoporotic or pathological. In this way, fractures can be sifted out in chronic stages, which are not the cause of new axial pain. An illustrative case is shown in Fig. 4.

Using the various protocols used in magnetic resonance imaging, we can very accurately distinguish the chronic from acute fractures based on changes in signal intensity, as well as to assess the available pathological changes in the joint-ligament and disc apparatus between the individual vertebrae, which can impose a significant change in the therapeutic plan and in particular in the surgical approach.

**Surgical treatment**

Treatment of osteoporosis as the underlying disease reduces the risk of new vertebral fractures in 30-70% of those studied [16, 17]. In the presence of clinically manifested OVCF, it can be both conservative, which is beyond the interest of the current review, and through minimally invasive surgical techniques – vertebroplasty and kyphoplasty, which we focus on here.

**Vertebroplasty**

Vertebroplasty (VPL) was introduced in practice in 1980, initially for the treatment of pathological fractures and local control of cancer. For the last 40 years, the tools for performing the surgical intervention and the physicochemical characteristics of the bone cements have undergone significant development, which improves the safety profile of this procedure.

The surgical procedure is performed under fluoroscopic control, locating the pedicle of the affected vertebra. A cannula is inserted into the latter, which is inserted at a depth of about 2/3 of the vertebral body, after which „bone cement“ is introduced under high pressure, the main ingredient of which is...
polymethyl methacrylate. There are products with different viscosity and rate of hardening depending on the needs and largely on the preferences of the surgeon.

**Kyphoplasty**

Kyphoplasty (KPL) is similar to the previous procedure with one main difference – the use of a balloon, which on the principle of a hydraulic cushion is inflated in the vertebral body in order to lift the lowered end plates and restore the sagittal size of the vertebral body.

Surgical technique involves cannulating the pedicles of the vertebrae in the same way. A balloon is inserted into the vertebral body through the needle, which is inflated to the desired volume with the help of a hydraulic device in order to correct the cranio-caudal size of the vertebral body. When inflated, the latter creates a cavity in the collapsed trabecular structure of the body. After removing the balloon through the same cannula, bone cement is introduced, in this case under low pressure, which fills the created cavities and fixes the vertebral body. The individual steps are presented in Fig. 5. There are also alternative devices that resemble a metal jack from a special alloy and are integrated into the vertebral body.

**LITERATURE REVIEW**

The aim of the current study was to compare the three main methods of treatment of osteoporotic compression vertebral fractures – conservative treatment, vertebroplasty and kyphoplasty, by key clinical endpoints, which include pain control, quality of life, functionality and safety profile.

**MATERIAL AND METHODS**

We searched the global literature for randomized clinical trials and meta-analyses comparing the three main methods of treating OVCF to show statistically significant large-scale differences. We compared with them our clinical experience for the last 10 years.

**RESULTS**

From the analysis of the collected information, a significant discrepancy was found in the large randomized trials regarding the therapeutic superiority of surgical procedures compared to conservative treatment. Some authors claim that the therapeutic superiority of vertebro- and kyphoplasty in terms of pain and quality of life is exhausted within 6-12 months of the follow-up period, with patients in the interventional and conservative arm in the series of Rousing et al. show a leveling of the follow-up [18].

Significant superiority in the immediate postoperative period is reported in almost all publications [19-25]. Exceptions are two studies by Buchbinder et al. and Kallmes et al., who compared vertebroplasty with a placebo procedure in which no statistically
significant difference was observed between the operative group and the placebo-treated group in the early postoperative period [26, 27]. The randomized clinical trials are presented in Table 1.

_Table. 1. Randomized clinical trials comparing surgical treatment to the best conservative_

| Author      | N   | Therapy | Age, years | Follow-up, months | Superiority of VPL/KPL over control group |
|-------------|-----|---------|------------|-------------------|------------------------------------------|
| Chen 2014 (19) | 46  | VPL     | 65         | 12                | Yes                                      |
|             | 43  | Conservative | 66        |                   |                                          |
| Xie 2013 (20) | 77  | KPL     | 67         | 9                 | No                                       |
|             | 87  | Conservative | 67        |                   |                                          |
| Blasco 2012 (21) | 64  | VPL     | 71         | 12                | Yes, up to 2 months                      |
|             | 61  | Conservative | 75        |                   |                                          |
| Farrokhi 2011 (22) | 40  | VPL     | 72         | 36                | Yes, incl. after 36 months               |
|             | 42  | Conservative | 74        |                   |                                          |
| Boonen 2011 (23) | 149 | KPL     | 72         | 9                 | Yes, regarding pain, no difference in HRQoL |
|             | 151 | Conservative | 74        |                   |                                          |
| Klazen 2010 (24) | 101 | VPL     | 75         | 11                | Yes                                     |
|             | 101 | Conservative | 75        |                   |                                          |
| Rousing 2010 (18) | 25  | VPL     | 80         | 12                | Yes, up to 6-12 months                   |
|             | 24  | Conservative | 80        |                   |                                          |
| Kallmes 2009 (27) | 68  | VPL     | 73         | 1                 | No                                      |
|             | 63  | Placebo  | 74         |                   |                                          |
| Buchbinder 2009 (28) | 38  | VPL     | 74         | 6                 | No                                      |
|             | 40  | Placebo  | 79         |                   |                                          |
| Voormolen 2007 (25) | 18  | VPL     | 72         | 0.5               | Yes                                     |
|             | 16  | Conservative | 74        |                   |                                          |

Despite its minimally invasive nature, both any surgical intervention and VPL and KPL have adverse events related to the procedure. The most common complications considered in practice are:

- Leakage of bone cement to the paravertebral space and spinal canal;
- Neurological complications from direct surgical trauma;
- Pulmonary thromboembolism – both associated with bone cement embolism due to intravenous intravasation, and from mobilized organized thrombi in long-term patients who are at high risk;
- Infections related to the procedure – the surgical wound, spondylitis, etc.;
- Acute myocardial infarction;
- Epidural hematomas;
- Fractures of adjacent vertebrae, etc.

It is worth noting that some of these complications can be observed with a significant delay, somehow speculatively. Prokop et al reported a case of myocardial perforation from a cement embolus two and a half years after kyphoplasty without any previous symptoms from the cardiovascular system [28]. The conclusions of the meta-analysis of Jason et al. on the generally reported complications related to KPL and VPL are presented in Table 2 [29].

Of the six randomized clinical trials comparing VPL and KPL on the main endpoints – pain, quality of life and functionality on the relevant indicators, there was no statistically significant difference in the effect of treatment, both in the direct postoperative outcome and in follow-up to 5 years in some of the publications, Table 3 [30-34].

The authors, comparing the two main operative procedures, noted as the only superiority of KPL over VPL the lower risk of cement leakage to the paravertebral anatomical structures. They note that the phenomenon is at the expense of intraoperative observations, which remain clinically mute and without the additional risk of postoperative complications associated with the procedure [33]. Their overall conclusion is that the additional financial burden that the KPL represents compared to the VPL is not justified with clinically equal end results in terms of quality of life, pain and functional recovery.

_Table. 2. Comparison of complications due to vertebroplasty and kyphoplasty from the data of Jason C. et al. [29]_

| Observed complication     | VPL (%) | KPL (%) | Statistical significance |
|---------------------------|---------|---------|-------------------------|
| Cement leakage            | 1838/9330 (19.7) | 213/3034 (7.0%) | < 0.001 |
| Symptomatic cement leakage | 65/4125 (1.6%) | 3963 (0.3%) | < 0.01 |
| New adjacent level fracture | 565/3515 (17.9) | 134/947 (14.1) | < 0.1 |
| Acute myocardial infarction | 1/1938 (0.05) | 5/951 (0.5%) | < 0.1 |
| Pulmonary thromboembolism  | 33/6601 (0.9) | 2565 (0.4%) | No |
| Hematoma                   | 6/2396 (0.3) | 1603 (0.1%) | No |
| Infection                  | 3/2192 (0.1) | 2646 (0.3%) | No |


Table 3. Conclusions from randomized clinical trials comparing VPL and KPL

| Author | N  | Therapy | Age, years | Follow-up, months | Therapeutic advantage |
|--------|----|---------|------------|-------------------|----------------------|
| Zhou 2015 (30) | 40 | VPL     | 66         | 12                | No                   |
| Li 2015 (31)    | 30 | VPL     | 70         | 0.1               | No, less leakage in KPL |
| Endres 2012 (32) | 20 | VPL     | 63         | 6                 | No, VPL is cheaper procedure |
| Evans 2016 (33) | 59 | VPL     | 75         | 12                | No                   |
| Dohm 2014 (34)  | 191| VPL     | 76         | 24                | KPL is less leakage of new fractures |
| Liu 2010 (35)   | 50 | VPL     | 72         | 60                | No                   |
|                 | 50 | KPL     | 74         |                   |                      |

DISCUSSION

Both vertebroplasty and kyphoplasty are relatively easy to perform, minimally invasive surgical procedures. From our experience, the intervention does not take more than 60 minutes, even if it is necessary to intervene more than one — up to 4 vertebrae per procedure. It can also be performed under local infiltration, spinal or epidural anesthesia, which we perform in disabled patients who do not tolerate intubation. Patients can be mobilized once the direct effects of the drugs administered have passed.

In our practice for the last 10 years more than 850 procedures for VPL and KPL have been performed at OVCF, and our personal experience in comparing the two procedures is comparable to that of the world literature. Despite a significant correction in the kyphotic deformity during kyphoplasty and restoration of the level of the vertebral body by 25-50%, the patients did not show a statistically significant difference in the indicators of quality of life and restoration of functionality. On the other hand, the operative approaches discussed outperform conservative treatment in assessing quality of life related to health and functionality, even with a follow-up period of more than 5 years.

Randomized clinical trials and published meta-analyses show a statistically significant superiority of minimally invasive procedures over conservative treatment in terms of pain assessment. This difference is most pronounced in the direct postoperative period. The statement that with a long follow-up period (over 24 months) the procedures lead to results comparable to that of conservative behavior remains relatively debatable. The general opinion is that two years is too long a follow-up period for a pathology that leads to significant pain and changes in quality of life and where direct and short-term results have much greater clinical value. An additional disadvantage in the long-term follow-up of patients with major pain-related symptoms is the absolute subjective nature of pain assessment. Daily functions and quality of life related to health can be objectively assessed by known and widespread systems (SF-36, QUALEEFO, HRQoLQ, ODI, etc.), but in practice the fully subjective visual analog scale is still used to assess pain (VAS). The disadvantage of these estimates is that they are based on the individual’s current comparison framework. A large proportion of patients over the age of 60 cannot be completely sure exactly how much more severe the pain was 2 years ago than it was at the end of a long follow-up period.

CONCLUSION

In practice, too often the timely diagnosis of osteoporosis and even its complications, in particular osteoporotic compression vertebral fractures, is missed. A more aggressive skinning process is needed for everyone in the risk contingent, due to the significant medical, social and financial consequences of this disease.

In the presence of axial pain in a patient with risk factors, generally over 50 years of age and female, it is necessary to perform imaging studies—radiography, CT, MRI of the relevant segment of the spine. Despite its significantly higher cost, MRI is the most informative of the listed studies and we recommend it in all cases when there is no definitive data on pathology by radiography or in a large number of affected vertebrae, as well as whenever I have available neurological symptoms except axial pain.

Vertebroplasty as well as kyphoplasty have better results in controlling pain with the fastest possible effect. With the exception of the slightly more common, but almost always asymptomatic, leaks of cement in VPL, the two procedures are absolutely comparable in terms of final clinical results—quality of life related to health and functionality. In the same sense, both have a high safety profile, with reported complications that potentially endanger patients’ lives occurring in less than 1% of cases. However, the significantly higher cost of kyphoplasty makes it less applicable. If it is impossible to achieve adequate pain control in a short period—up to 2 weeks with the help of conservative methods, we recommend percutaneous vertebroplasty.
The authors declare that the material has not been published before.

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