Risk of Refracture and Adjacent Vertebra Fracture after Vertebroplasty and Kyphoplasty

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Abstract
Vertebroplasty and kyphoplasty are effective and safe methods for vertebral body augmentation. These procedures are used for pain relief, minimizing vertebral body fracture risks. However, overaugmentation of the treated vertebral body may increase the stress on adjacent vertebral bodies, resulting in incident fractures in the adjacent segments. A variety of factors may affect the occurrence of incident fractures after vertebroplasty and kyphoplasty, including etiology of primary disease, bone mineral density of the adjacent segments, excess amount of cement injection, leakage into the intervertebral disc space, and filling intravertebral clefts. In this analysis, four articles focusing on these risks are reviewed.

Keywords: vertebroplasty, kyphoplasty, fracture, risk
authors who claimed that incident fractures were related to vertebroplasty proposed several surrogate markers. The markers included high likelihood of fracture in the adjacent segment and an occurrence within 30 days of the procedure. They also observed a higher incidence of fracture in the adjacent segment after filling intraosseous clefts and leakage of cement into the disc space. Intravertebral fracture pattern in adjacent vertebrae was also different from untreated osteoporotic fractures. In procedure-related fractures of adjacent vertebrae, end plates adjacent to the treated vertebra were more commonly observed. Inferior end plate fracture of the vertebra rostral to the treated vertebra were commonly observed, in spite of the fact that such fractures were rare in the natural history of osteoporosis. Biomechanical data were reviewed against the hypothesis of a causal relationship between incident fractures and vertebroplasty. This data demonstrated that vertebroplasty restored normal load bearing in the spine with restored segmental stiffness and intradiscal pressure. Clinical data presented no significant difference between natural course of incident fractures in untreated osteoporosis patient and patients who had undergone a vertebroplasty procedure.

**Analysis:** This is a review article that evaluates the relationship between the new onset (incident) vertebral fracture and the procedure of vertebroplasty. The authors emphasized the necessity of well-designed, randomized, controlled trials to demonstrate or exclude a causal relationship. They, however, performed a comprehensive review of existing literature on the subject. Compared to the data of incidental fracture during natural course of the osteoporosis, vertebroplasty may be a risk factor for the adjacent segments within 30 days after the procedure. Also cement leakage into the disc space and filling of intravertebral clefts in the index vertebra may pose a higher risk for the incidents fractures in the adjacent segments. Fracture pattern can be a clue in searching underlying cause of incident fractures. Inferior end plate fractures are rare in the untreated osteoporosis patients but it happens frequently in the upper segment of vertebroplasty. The superior end plate is the most common site for osteoporotic fractures during the natural course of the disease. This fact was also noted by the authors that superior end plate fractures of inferior segment may not be typical although it seems suspicious. The main mechanism may be stiffness of the index vertebra that changes the biomechanical forces and load transfer to the adjacent vertebrae.


This is a retrospective review of osteoporosis patients who underwent vertebroplasty procedure in one institute. Three hundred thirteen patients were treated at 463 levels for vertebral fractures that were osteoporotic in nature. Sixty-three patients (20.1%) were treated at 65 levels for intraosseous clefts. The presence of intraosseous clefts and its relationship to subsequent fractures were analyzed. In patients who had intraosseous clefts in treated vertebrae, 33.3% developed subsequent fractures adjacent to the treated clefts, whereas 20.8% of patients without intraosseous clefts in their adjacent vertebrae had fractures after the procedure. There was no difference in timing of subsequent fractures between two different groups. They concluded that patients with osteoporotic vertebral fractures containing clefts are at increased risk for subsequent fractures and treatment of these clefts is associated with increased rates of adjacent fracture.

**Analysis:** This study observed that the presence of intraosseous clefts might increase the risk of subsequent fractures in osteoporosis patients. These patients have nearly a twofold increased risk of subsequent fracture after the vertebroplasty. Vertebral adjacent to treated clefts have a higher risk of harboring fractures compared to the remote vertebrae, although there is no difference in the timing of subsequent fractures. Before reaching a certain conclusion, it may be necessary to review the etiopathogenesis of intraosseous fractures and their implications in the biomechanics. As it is indicated in this article, presence of intraosseous clefts may represent an aggressive form of the disease. However, there is no supportive evidence in the literature that those patients with intraosseous cleft have an earlier incident fractures in the natural course of the disease. Regardless, these findings should be taken into consideration for planning if the adjacent vertebrae needs prophylactic vertebroplasty. This warrants biomechanical studies and prospective randomized controlled studies to assess the risks and cost effectiveness.


That is retrospective review of osteoporotic patients treated with kyphoplasty in one institute. Thirty-eight patients with osteoporosis were included in the study and 47 levels were treated with kyphoplasty. The most common levels were L1 and L2. Among them, 10 patients with 17 levels had subsequent fractures. Eleven of 17 levels were adjacent to treated index vertebra and only four levels were located on a distant site. Eight out of 10 patients had their fractures within 60 days after the treatment and at least one level was adjacent to the treated vertebra. Nine of 17 level were above to the treated vertebra. Remote fractures occurred later compared to the fractures of adjacent levels.
Analysis: This study identifies a clear risk for the occurrence of subsequent fractures after kyphoplasty in the adjacent levels within 60 days after the treatment (21%). After the first 60 days, the rate of subsequent fractures declines and becomes similar to the natural history (approximately 5%). Biomechanical properties of cement may need to be evaluated, especially for kyphoplasty procedures. Another point that needs to be taken into consideration is the amount of cement injected into the index vertebra. As demonstrated by biomechanical studies, acute changes in stiffness may provoke the fractures at adjacent levels.


The authors of this manuscript studied the biomechanical aspects of vertebroplasty. They investigated the effects of volume and distribution of bone cement on stiffness of the vertebral body. Using finite element model techniques, they simulated an L1 vertebra fracture, and compared the biomechanical aspects of four vertebroplasty models, including bilateral bipedicular, unipedicular approach, right or left and posterolateral approach. For each vertebroplasty simulation, four different volumes of PMMA (1, 3.5, 5 and 7 cc) were investigated, resulting in a total of 16 different cases. They reported that vertebral stiffness recovery after vertebroplasty was strongly influenced by the volume fraction of the implanted PMMA. Only a small amount of bone cement (14% fill or 3.5 cm³) was necessary to restore stiffness of the damaged vertebral body to the predamaged value. Using of a 30% fill increased stiffness by more than 50% compared with the predamaged value. Whereas, the unipedicular distributions exhibited a comparative stiffness to the bipedicular or posterolateral cases, it showed a medial-lateral bending toward the untreated side when a uniform compressive pressure load was applied. They concluded that only a small amount of PMMA (approximately 15% volume fraction) was needed to restore stiffness to predamaged levels and greater filling could result in substantial increase in stiffness well beyond the intact level.

Analysis: This finite element model study clearly demonstrated the effectiveness of the vertebroplasty for restoration of damaged vertebral stiffness. They demonstrated that only a small amount of PMMA (14% fill or 3.5 CC) was enough for restoration of stiffness and that overfilling of the vertebra might increase the stiffness. The main disadvantage of this study is the lack of information regarding the effect of the overfilling on the adjacent intervertebral discs and vertebrae.

On the other hand, no information was provide regarding the different types of the vertebral compression fractures (wedge vs. uniconcave vs. biconcave vs. burst fractures). They did not also analyze the expansibility of the fracture. As they mentioned, they only studied response to uniaxial compressive loads. Nevertheless, their results regarding the optimum PMMA amount to restore damaged vertebra body is valuable.

Synthesis

The occurrence of incident fractures has been a concern after vertebroplasty or kyphoplasty procedures. The literature review suggests that adjacent vertebrae to the treated vertebra are more commonly affected than the remote levels and procedure related fractures usually occur within 60 days after the procedure. The proposed etiologic factors are increased stiffness of the treated vertebra due to injection of excess amount of cement, filling intraosseous clefts and cement leakage into the intervertebral disc space.

Overaugmentation of the fractured vertebra may increase the stress on the adjacent vertebrae, thus increasing the possibility of fracture. Liebschner et al report that only a small amount of PMMA (approximately 15% volume fraction, almost 3.5 CC) is needed to restore stiffness to predamaged levels and that greater filling can result in a substantial increase in stiffness well beyond the intact level.(4) They reported that bilateral injection is advantageous. The presence of intraosseous clefts within the treated vertebra and cement leakage into the intervertebral disc space is associated with a high risk of fracture at the adjacent vertebrae due to impact of cement on weak endplates.

Analysis of the presented manuscripts reveals that the risk of fracture is higher for adjacent vertebra within 60 days after the treatment, compared to the natural course of the disease in the levels adjacent to treated vertebra. Fribourg et al report that 10 of 17 new fractures (59%) occurred at adjacent levels within 60 days.(3) The risky period was reported to be first 30 days by Trout et al.(1) This may appropriately influence spine specialists to use orthoses for the first 30-60 days after vertebroplasty or kyphoplasty procedures in high risk groups.

The question regarding the necessity of prophylactic vertebroplasty in such cases (eg, cases with intradiscal cement leakage and cases with intraosseous cleft) is yet to be answered. A multicenter, prospective, randomized, controlled study is necessary to establish the real risks of vertebroplasty or kyphoplasty. Such a study could be designed to compare the role of the prophylactic vertebroplasty or kyphoplasty in asymptomatic adjacent levels.

References
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