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Volumetric analysis in a patient with T12 burst fracture treated percutaneously with intravertebral device kyphoplasty (Spine Jack) system

Análisis volumétrico en una paciente con fractura por aplastamiento de T12 tratada mediante cifoplastía percutánea con un dispositivo intravertebral (Spine Jack)

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Keywords:

volumetry, burst fracture, Spine Jack, kyphoplasty, case report.

Palabras clave:

volumetría, fractura por aplastamiento, Spine Jack, cifoplastía, reporte de caso.

ABSTRACT

Introduction: spinal burst fractures constitute a set of injuries capable of causing a great impact in quality of life since they carry significant morbidity and mortality rates, especially in the aging population. The current treatment of this type of spinal injuries is controversial. In cases in which conservative treatment is not satisfactory, it is necessary to resort to techniques that allow the reestablishment of the spinal sagittal balance and the height of the damaged vertebral body. In the last decade, different intravertebral devices were developed that can be inserted percutaneously into the affected vertebra for subsequent bone-cement injection. We present the case of a 68-year-old woman who suffered a fall from her own height presenting direct trauma to the dorsal region, after which she presented dorsal stabbing-like pain with an intensity of 10/10 in the visual analog scale and an important limitation in her all-day living activities. A computerized tomography (CT) scan was performed, and she was diagnosed with a burst fracture of the T12 vertebral body, receiving conservative treatment without obtaining any improvement. Based on the foregoing it was decided to perform a percutaneous vertebroplasty using a Spine Jack device achieving an 8.6% increase in the vertebral body height compared to preoperative measures and a reestablishment in the vertebral body volume. At follow-up the patient reported an important decrease in dorsal pain, being able to return to her daily activities. One of the main goals of kyphoplasty is the restoration of vertebral body height and thus avoid sagittal balance alterations in patients suffering from burst fractures, however, currently there is not a routinely used method to adequately measure the vertebral body volume gained after the procedure. We propose the application of CT volumetric reconstruction to compare both pre and postoperative volumes in vertebrae suffering from burst fractures in order to determine the real scope of restoration offered by these devices both in height and volume of the involved vertebral bodies. **Conclusion:** CT vertebral body volumetric analysis is an effective method to assess the re-expansion in vertebral volume after performing a percutaneous kyphoplasty with an intravertebral device (Spine Jack).

RESUMEN

Introducción: las fracturas vertebrales por aplastamiento constituyen un conjunto de lesiones capaces de causar un gran impacto en la calidad de vida, ya que conllevan importantes tasas de

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*morbilidad y mortalidad, especialmente en la población de edad avanzada. El tratamiento actual de este tipo de lesiones medulares es controvertido. En los casos en los que el tratamiento conservador no es satisfactorio, es necesario recurrir a técnicas que permitan restablecer el equilibrio sagital vertebral y la altura del cuerpo vertebral dañado. En la última década se han desarrollado diferentes dispositivos intravertebrales que pueden ser insertados percutáneamente en la vértebra afectada para la posterior inyección de cemento óseo. Mujer de 68 años que sufrió una caída desde su propia altura presentando traumatismo directo en la región dorsal, tras lo cual presentó dolor dorsal de tipo punzante con una intensidad de 10/10 en la escala analógica visual y una importante limitación en sus actividades de la vida diaria. Uno de los principales objetivos de la cifoplastia es la restauración de la altura del cuerpo vertebral y así evitar alteraciones del balance sagital en pacientes que sufren fracturas por aplastamiento, sin embargo, actualmente no existe un método de uso rutinario para medir adecuadamente el volumen del cuerpo vertebral ganado tras el procedimiento. Proponemos la aplicación de la reconstrucción volumétrica por TC para comparar los volúmenes pre y postoperatorios en las vértebras que sufren fracturas por aplastamiento con el fin de determinar el alcance real de la restauración que ofrecen estos dispositivos tanto en altura como en volumen de los cuerpos vertebrales implicados. **Conclusiones:** el análisis volumétrico del cuerpo vertebral mediante TC es un método eficaz para evaluar la reexpansión del volumen vertebral tras la realización de una cifoplastia percutánea con un dispositivo intravertebral (Spine Jack).*

INTRODUCTION

Spinal burst fractures constitute a set of injuries capable of causing a great impact in quality of life since they carry significant morbidity and mortality rates, especially in the aging population. Up to 90% of spinal fractures are considered to occur in the thoracic and lumbar segments, with crush fractures accounting for up to 14% of cases. These types of fractures are commonly secondary to high-energy trauma, the most common mechanism being falls from different heights, sports injuries and traffic accidents.¹

Burst fractures (BF) are commonly observed at the thoracolumbar junction. According to Bensch & cols up to 48% of this type of fractures involve the vertebral bodies of T12 and L1, due to the force transfer between the thoracic vertebral segment, which is less mobile due to the stability provided by the rib cage, and the much more mobile lumbar segment.^{1,2}

The treatment of BF is still controversial. In the past, conservative or orthotic treatment for at least one month was considered appropriate for most vertebral fractures. However, in cases where axial pain becomes persistent, it is necessary to consider surgical options: vertebroplasty is considered in cases where there is less than 30% loss of vertebral body height, while Kyphoplasty is preferred in cases with a greater loss in vertebral height.³

Vertebroplasty is a method introduced in 1987 for the treatment of pain in patients with vertebral angiomas. It consists of the percutaneous injection of bone cement into the trabecular bone of the injured

vertebral body, thereby achieving substantial pain relief while preventing further loss of vertebral body height. Kyphoplasty, on the other hand, consists of the introduction of an inflatable balloon which creates a cavity within the trabecular bone, which is filled with bone cement with the intention of restoring the height of the affected vertebral body and thus reducing the degree of kyphosis.⁴

In the last decade, intervertebral devices have been developed that are inserted percutaneously into the affected vertebra for subsequent cement injection. Three systems are currently available on the market: Vertebral Stents[®], Osseo Fix[®] and, the most recent, Spine Jack[®].³

The Spine Jack[®] device is an implant made up of Titanium designed to restore the height of the vertebral body in BF cases secondary to osteoporosis, primary and/or secondary bone tumors, or traumatic injuries. It requires a bilateral transpedicular approach and can be used in vertebral bodies from T10 to L5. Once positioned within the vertebral body, it produces a distraction capable of reducing the fracture through ligamentotaxis, especially by acting with the anterior longitudinal ligament. Being a mechanical device (unlike hydraulic devices), it allows a progressive and controlled reduction of the vertebral fracture. This allows recovery of the collapsed vertebral body and provides three-dimensional support of the structure which is required for mechanical stabilization of the vertebral body against axial compression forces. Finally, and once the reduction of the fracture has been achieved, the injection of bone cement or high-viscosity

polymethyl-methacrylate is required, with which the reconstruction and stabilization of the affected vertebra is achieved.^{3,4}

It's possible to evaluate the results obtained with the different Kyphoplasty methods by calculating the volume recovered in the affected vertebral bodies. Komemushi & cols. found that the volume of the vertebral body is directly correlated with the amount of bone cement injected. However, different regions of the spine require different bone cement. Larger amounts of bone cement injected into a vertebral body are capable of increasing both the strength and stiffness of the affected vertebra. It is now possible to use computed tomography images to quantify the volume of the vertebral body prior to the procedure, which can help estimate the volume of cement needed. And finally, it is possible to make comparisons in the vertebral volumetry after the procedure and being capable of quantify the percentage of height and volume restored.^{5,6}

We present the following case of a patient with a T12 BF who was treated with the SpineJack® device at the Neurosurgery department at the “Lic. Adolfo López Mateos” Regional Hospital in Mexico City, Mexico. The present case report was made in accordance with the CARE guidelines.⁷

CASE PRESENTATION

We present the case of a 68-year-old female patient with a history of type II diabetes mellitus. A month and a half prior to her evaluation, she suffered a fall from her own height, presenting direct traumatism to the dorsal region, right arm and wrist, after which she experienced stabbing-like pain in the dorsal region, reported with an intensity of 10/10 in the visual analog scale, which made it impossible for her to rejoin from the ground. She was initially evaluated by an orthopedic surgeon identifying a fracture of the right wrist, which was treated with open reduction and placement of internal fixation. Likewise, a BF of the vertebral body of T12 was diagnosed, for which she was prescribed the use of a lumbosacral girdle and physical therapy, as well as the use of NSAIDs without obtaining any improvement, which is why she was then referred to the Neurosurgery department of the “Lic. Adolfo López Mateos” Regional Hospital in Mexico City.

On physical examination, the patient presented axial pain of variable intensity on palpation of the dorsal region at the level of the spinous processes of T12 and L1. The motor system had a strength of 5/5 in all four limbs on the Daniels Modified Scale and preserved superficial and deep sensitivity. She had muscle stretch

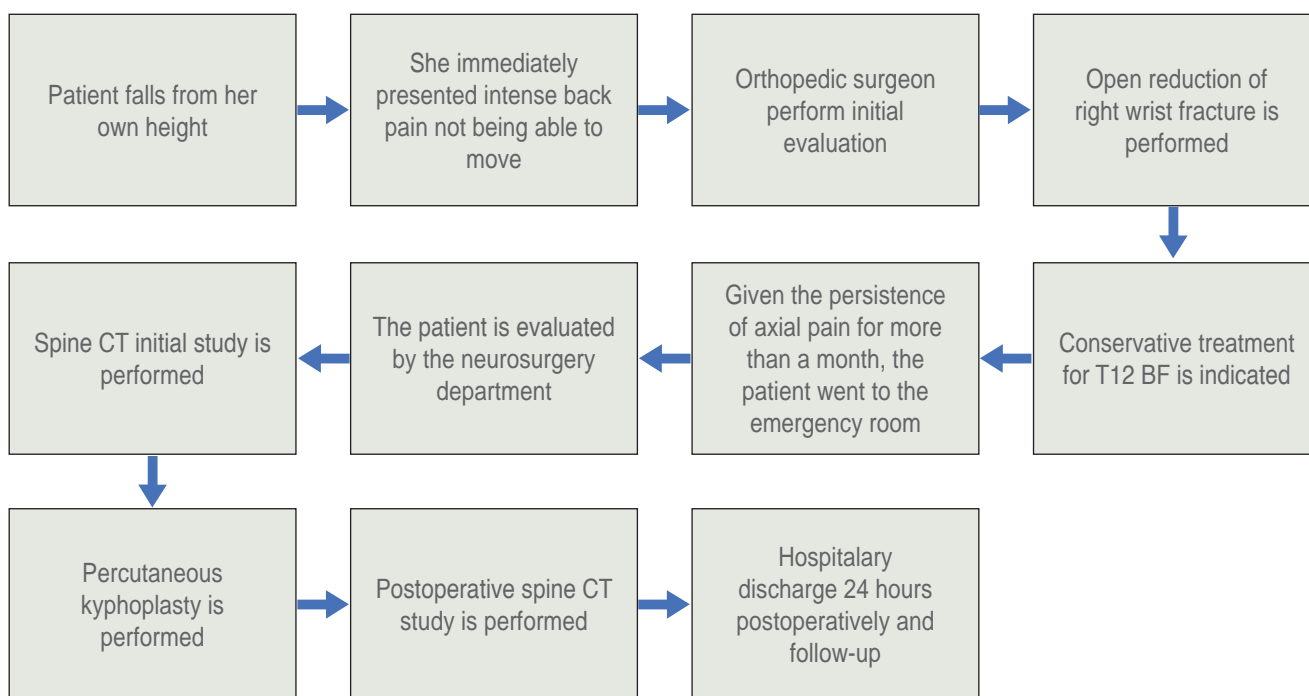


Figura 1: Timeline of the most relevant data events of this case.

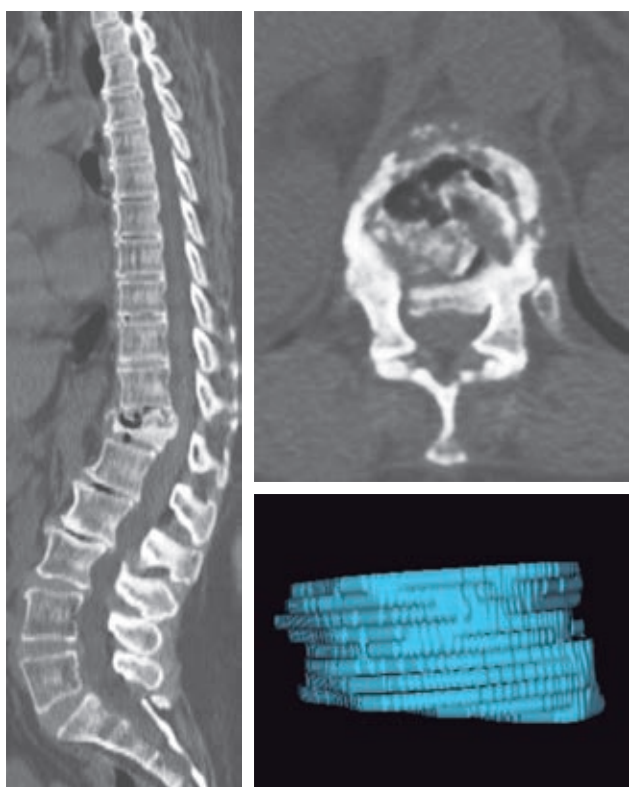


Figure 2: Preoperative computed tomography study in sagittal view showing a marked decrease in the height of the vertebral body of T12 secondary to its fracture by crushing. Axial section where the fragmentation of the vertebral body is observed. As well as the volumetric reconstruction of the affected vertebral body.

reflexes ++ globally and had no gait limitation. The rest of the neurological examination was normal (Figure 1).

A simple spine tomography was performed, where a compression fracture of the T12 vertebral body was observed, which was classified as a A3 type fracture according to the thoracolumbar spine injury classification system of the AO Foundation (*Arbeitsgemeinschaft Osteosynthese*). Additionally, volumetric reconstruction of the affected vertebral body was performed, obtaining a volume of 19.3476 cm^3 (Figure 2).

Based on the foregoing, it was decided to perform a T12 percutaneous vertebroplasty using the Spine Jack[®] device.

TREATMENT

We performed a T12 Kyphoplasty with a bilateral transpedicular intravertebral device, observing

adequate re-expansion of the affected vertebral body and subsequently injecting 7 cubic centimeters of polymethylmethacrylate, without observing any leaks into the intraspinal space.

The procedure lasted 45 minutes, under sedation and local anesthesia application at the puncture sites with Lidocaine with 2% Epinephrine and with minimal bleeding.

Immediately after the procedure, a new spine tomography study was obtained, where a recovery in the anterior wall height of the affected vertebral body was observed. A new volumetric analysis of the vertebral body was then calculated, which turned out to be 21.0140 cm^3 , which represents a volume gain of 1.6664 cm^3 , which is equal to an increase of 8.6% compared to the previous height of the same vertebra (Figure 3 and Table 1).

Twelve hours after the procedure, the patient reported a 50% decrease in pain, this being up to 5/10 on the visual analog scale, without presenting any alterations in the motor or sensory system compared

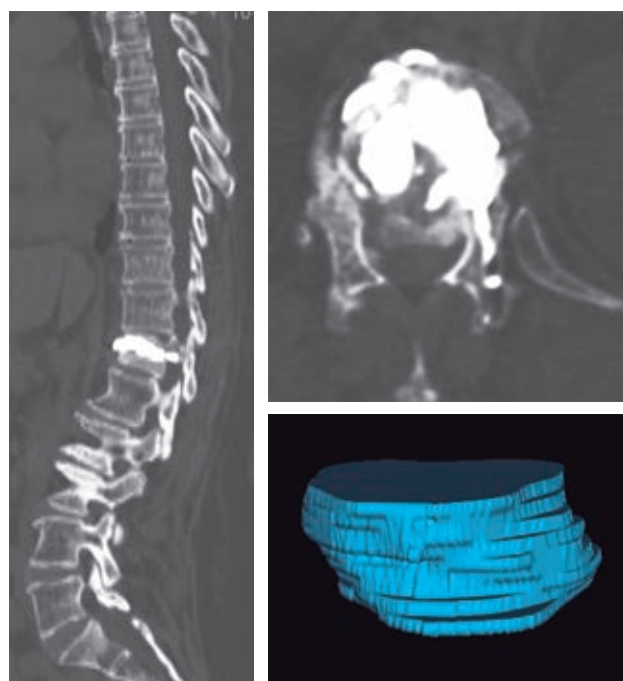


Figure 3: Postoperative computed tomography study in sagittal section showing a hyperdense image with irregular borders in relation to the material used for kyphoplasty. The axial section shows the accumulation of methylmethacrylate in the central portion of the vertebral body. Postoperative volumetric reconstruction was also performed, where partial recovery in the height and morphology of the vertebral body is observed.

Table 1: Pre and postoperative volumes comparative analysis.

	Preoperative	Postoperative	Difference
Vertebral body volume	19.3476 cm ³	21.0140 cm ³	1.6664 cm ³

to the physical examination prior to the procedure. She was able to walk without help. The patient was then kept under medical surveillance for 24 hours after the procedure and was subsequently discharged from hospital and early physical therapy was started, going for a check-up two and four weeks later observing a greater improvement in referred pain and in their ability to carry out their daily activities.

DISCUSSION

One of the main objectives of Kyphoplasty is the restoration of vertebral height and thus avoid sagittal balance alterations in patients suffering from BF, however, an effective and proven method is not routinely used to adequately measure the volume gained in the procedure.

The Spine Jack[®] device used in this case has been shown to be able to achieve a higher percentage of vertebral body height restoration compared to other methods used today. Krüger & cols. compared the use of Spine Jack[®] vs traditional balloon kyphoplasty in BF models, finding a significant difference favoring the former. This translates into a greater recovery in sagittal balance and then a reduction in kyphotic deformity.⁸

Rotter & cols. also described some advantages of the Spine Jack a device, which is the need for smaller amounts of bone cement to achieve an adequate restoration of the volume and height of the vertebral body affected by BF, the requirement being around 10% of the volume of the vertebral body against 30% needed in common balloon kyphoplasty. This means that requiring less bone cement, the risk of complications such as bone cement leaking out of the vertebral body into the spinal canal or lateral peri vertebral space is considerably reduced.⁹

It has been observed in daily clinical practice that the pain caused by thoracolumbar BF is sometimes not limited just to the level of the fractured vertebrae but instead occurs in areas far away from the injured vertebrae, such as the lower back, iliac crests or buttocks. This symptom has been reported to be between 17.2 and 46.2% in recent literature, and it

was also a characteristic symptom in our presented case. Some authors proposed that this particular symptom may involve different mechanisms regarding degenerative changes secondary to BF, as well as an increase in paravertebral musculature load. Addressing this feature Li & cols. compared the efficacy of both treatments in patients with distant lumbosacral pain accompanied by thoracolumbar BF, describing that at 3 days postoperatively and at last follow-up, both the VAS scores of focal and distant pain were significantly lower in both treatment groups than those before surgery, indicating that patients can obtain benefit from either percutaneous vertebroplasty or balloon kyphoplasty.¹⁰

Addressing the clinical and radiographic outcomes for both techniques, Wang & cols. conducted a meta-analysis comparing safety and efficacy of balloon kyphoplasty versus percutaneous vertebroplasty in patients suffering osteoporotic vertebral BF. They reported that in terms of radiographic parameters, balloon kyphoplasty could significantly increase postoperative vertebral body height and decrease the risk of cement leakage. However, comparing the outcomes of both techniques in terms of clinical outcomes, using visual analog scale (VAS) and Oswestry Disability Index scores (ODI), there wasn't any significant difference between the two groups. Kyphoplasty tended to have more favorable outcomes than vertebroplasty for patients with large kyphosis angles, vertebral fissures, fractures in the posterior edge of the vertebral body or a significant height loss in the fractured vertebrae, meanwhile percutaneous vertebroplasty has shown to be more effective in the short-term pain relief. A current recommendation for BF treatment favours balloon kyphoplasty, as a superior option for a superior injected cement volume, the short-term pain relief, the improvement of short- and long term kyphotic angle, and lower cement leakage rate, despite it needs longer operation time and higher material cost compared to percutaneous vertebroplasty. Therefore, both balloon kyphoplasty and vertebroplasty are equally effective in the clinical outcomes of patients suffering BF.¹¹

We propose the use of volumetric analysis to compare pre and postoperative volumes in vertebrae suffering from BF to measure the real scope of restoration offered by these devices both height and volume of the vertebral bodies.

In the specific case of our patient, a recovery close to 10% of the volume of the vertebral body, as well as the clinically significant decrease in pain, make this a case of success, however, additional

studies with a larger number of patients are required in order to analyze if the recovery of vertebral volume could be related to the reduction of pain in these patients, as well as longer follow-up studies to evaluate if the recovery of vertebral volume is directly related to an improvement in the sagittal balance of these patients.

CONCLUSIONS

Vertebral burst fractures are nowadays one of the most common healthcare issues worldwide, and their incidence is directly related with the aging population. The burden of this pathology may impact directly on the ability of performing daily living activities, and thus affecting patient's quality of living. In the past decades both balloon kyphoplasty and percutaneous vertebroplasty have shown to be treatment alternatives in patients suffering thoracolumbar BF, proving to achieve and adequate restoration of the volume and height of fractured vertebrae, with a consequent improvement in patient's referred pain and accompanying symptoms. Both techniques have similar results in achieving an improvement in radiographic parameters (vertebral body height, kyphotic wedge angle and risk of cement leakage) as well as similar results in terms of referred pain and disability. Current recommendations tend to favour balloon kyphoplasty in patients suffering with greater altered radiographic parameters such as chronic pain in relation with BF, meanwhile percutaneous vertebroplasty is recommended in patients suffering with more acute scenarios, having a less risk of cement leakage and a more rapid vertebral body height restoration.

We propose to perform vertebral body volumetric analysis as an effective method to quantify the re-expansion of the vertebral volume after performing a kyphoplasty with an intravertebral device (Spine Jack®), in order to obtain a more comprehensive analysis of pre and post-operative radiographic parameters. Even though more studies addressing this volumetric parameter are needed in order to ascertain this parameter's applicability in daily clinical practice, as well as its possible relation with clinical outcomes.

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Conflict of interest: the authors of this manuscript declare that they have no conflict of interest.