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# SHORT ARTHRODESIS IS AS EFFECTIVE AS LONG ARTHRODESIS FOR THE TREATMENT OF TYPE B THORACOLUMBAR SPINE FRACTURES

## *A ARTRODESE CURTA É TÃO EFICAZ QUANTO A ARTRODESE LONGA PARA O TRATAMENTO DE FRATURAS DA COLUNA TORACOLOMBAR DO TIPO B*

## *LA ARTRODESIS CORTA ES TAN EFICAZ COMO LA ARTRODESIS LARGA PARA EL TRATAMIENTO DE FRACTURAS DE COLUMNA TORACOLUMBAR DE TIPO B*

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## ABSTRACT

Objective: Thoracolumbar spine trauma is a world wide health concern that especially affects males of working age, being associated with an elevated morbidity. AO SPINE Type B fractures are unstable and require surgical stabilization. However, the decision between short or long fixation remains controversial. The objective of this study is to analyze the neurological, orthopedic and functional outcomes in patients with Type B spine fractures who have undergone short and long segment posterior arthrodesis. Methods: A prospective cohort study was performed at the Neurosurgery Department of Hospital Cristo Redentor from January 1, 2013 to December 31, 2018. Patients with spine fractures classified as AO SPINE Type B in the thoracic or thoracolumbar segments were eligible for the study. The variables analyzed included demographic data, information about the trauma, neurological status, the treatment performed, and the outcome. Results: A total of 31 patients were included in the study. The majority were Caucasian males with a mean age of 42.6(±15.6), and the main cause of the spine trauma was falling from height (N=18; 56.2%). Fifteen patients (48.3%) had subtype B1 fractures and 16 (51.6%) had subtype B2 fractures. Eleven (35.4%) patients were submitted to short arthrodesis and 20 (64.5%) were submitted to long arthrodesis. There was no statistical difference between groups in terms of neurological, orthopedic and functional outcomes. Conclusions: There is no difference in outcomes between short or long constructs for patients with type B single fracture in the thoracic, thoracolumbar and lumbar spine segments. ***Level of evidence III; Therapeutic Studies – Investigation of treatment results.***

**Keywords**: Spine; Spinal fractures; Arthrodesis; Epidemiology; Spinal cord injuries.

## *RESUMO*

*Objetivo: O trauma da coluna toracolombar é um problema de saúde mundial que afeta principalmente o sexo masculino em idade ativa, e é associado a morbidade elevada. As fraturas AO SPINE tipo B são instáveis e requerem estabilização cirúrgica. Todavia, a decisão entre fixação curta ou longa permanece controversa. O objetivo deste estudo é analisar os resultados neurológicos, ortopédicos e funcionais em pacientes com fraturas de coluna de tipo B submetidos à artrodese posterior de segmentos curto e longo. M*étodos: Foi *realizado um estudo de coorte prospectivo no Departamento de Neurocirurgia do Hospital Cristo Redentor, no período de 1º de janeiro de 2013 a 31 de dezembro de 2018. Foram elegíveis para o estudo pacientes com fraturas de coluna classificadas como AO SPINE Tipo B nos segmentos torácico ou toracolombar. As variáveis analisadas incluí*ram *dados demográficos, informações sobre o trauma, estado neurológico, tratamento realizado e desfecho. Resultados: Um total de 31 pacientes foi incluído no estudo. Amaioria era do sexo masculino, caucasiano, com média de idade de 42,6 (±15,6), e a principal causa do trauma de coluna foi queda de altura (N=18; 56,2%). Quinze pacientes (48,3%) tiveram fratura do subtipo B1 e 16 (51,6%) tiveram fratura do subtipo B2. Onze (35,4%) pacientes foram submetidos à artrodese curta e 20 (64,5%) à artrodese longa. Não houve diferença estatística entre os grupos quanto aos resultados neurológicos, ortopédicos e funcionais. Conclusões: Não há diferença* nos resultados entre fixações *curtas ou longas para pacientes com fratura única tipo B nos segmentos da coluna torácica, toracolombar e lombar.* ***Nível de evidência III; Estudos terapêuticos - Investigação dos resultados do tratamento.***

***Descritores****: Coluna vertebral; Fraturas da coluna vertebral; Artrodese; Epidemiologia; Traumatismos da medula espinal.*

## *RESUMEN*

*Objetivo: El traumatismo de la columna toracolumbar es un problema de salud a nivel mundial que afecta especialmente al sexo masculino en edad laboral y está asociado a una elevada morbilidad. Las fracturas AO SPINE Tipo B son inestables y requieren estabilización*

Study conducted by the Neurosurgery Department of the Hospital Cristo Redentor, Porto Alegre, Brasil.
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*quirúrgica. Sin embargo, la decisión entre fijaciones cortas o largas sigue siendo controvertida. El objetivo de este estudio es analizar los resultados neurológicos, ortopédicos y funcionales en pacientes con fracturas de columna tipo B sometidos a artrodesis posterior de segmento corto y largo. Métodos: Se realizó un estudio de cohorte prospectivo en el Departamento de Neurocirugía del Hospital Cristo Redentor del 1 de enero de 2013 al 31 de diciembre de 2018. Fueron elegibles para el estudio pacientes con fracturas de columna vertebral clasificadas como AO SPINE Tipo B en los segmentos torácico o toracolumbar. Las variables analizadas incluyen datos demográficos, información sobre traumatismo, estado neurológico, tratamiento realizado y resultado. Resultados: Se incluyeron en el estudio un total de 31 pacientes. La mayoría varones caucásicos con edad promedio de 42,6 (±15,6) y la caída de altura (N=18; 56,2%) fue la principal causa de traumatismo vertebral. Quince pacientes (48,3%) tenían fractura de subtipo B1 y 16 (51,6%) tenían fractura de subtipo B2. Once (35,4%) pacientes fueron sometidos a artrodesis corta y 20 (64,5%) a artrodesis larga. No hubo diferencias estadísticas entre los grupos en términos de resultados neurológicos, ortopédicos y funcionales. Conclusiones: No hay diferencias en los resultados entre fijaciones cortas o largas en pacientes con fractura única de tipo B en los segmentos de columna torácica, toracolumbar y lumbar.* ***Nivel de evidencia III; Estudios terapéuticos–Investigación de los resultados del tratamiento.***

***Descriptores:*** *Columna vertebral; Fracturas de la columna vertebral; Artrodesis; Epidemiología; Traumatismos de la médula espinal.*

## INTRODUCTION

Traumatic thoracic and lumbar fractures are among the leading causes of disability, deformity and neurological deficits in people of working age.[1] These traumatic injuries involve different types of bone and ligament injuries, and classifications have been described for evaluating the type of injury and its correlation with the surgical indications and outcome.[2–5]

The AO SPINE classification categorizes spinal injuries into three major groups: failure of the anterior structures under compression (Type A), failure of the posterior tension band (Type B) and vertebral displacement/dislocation (Type C).[6,7] Surgical treatment aims to restore the stability of the spine, correct vertebral deformity, and decompress neural elements.[8] Posterior spinal fusion using pedicular screws is the gold standard treatment for thoracolumbar fractures.[8,9]

Type B fractures are unstable fractures requiring surgical stabilization.[10,11] Although a worldwide survey demonstrated that the majority of spine surgeons agreed that Type B fractures should be treated surgically, the surgical technique indicated was not evaluated.[12,13] Surgeons can decide whether to perform short or long fixation in type B fractures. The aim of this study is to analyze the neurological, orthopedic and functional outcomes in patients with type B spine fractures who have undergone short and long-segment posterior arthrodesis.

## METHODS

### Study design

A prospective cohort study was performed at the Neurosurgery Department of Cristo Redentor Hospital from January 1, 2013 to December 31, 2018. The study was approved by the Research Ethics Committeeof that hospital (CAAE [*Certificado de Apresentação de Apreciação Ética*(Certificate of Presentation for Ethical Consideration)] 75903717.3.0000.5530) under number 3.744.697.

### Patient eligibility

Patients with spine fractures classified as AO SPINE Type B in the thoracic or thoracolumbar segments, restricted to the fracture of a single vertebra.

### Variables analyzed

The variables analyzed included demographic data (age, sex, race), information about the trauma (trauma mechanism, number of vertebrae involved, vertebral segment involved, fracture subclassification), neurological status (at hospital admission, hospital discharge and late follow-up), the treatment performed (short or long arthrodesis) and information about the postsurgical outcomes (postsurgical Cobb angle and pain).

The injured spine segment was classified as thoracic, thoracolumbar or lumbar. Thoracic fractures were defined as injuries affecting the spine segment from T1 to T10, thoracolumbar fractures as affecting spine segments T11 to L2 and lumbar fractures as vertebral injuries affecting segments L3 to L5.

Type B fractures were further classified into three subtypes: B1, B2, and B3, by two independent reviewers with previous experience with AO Spine fracture classifications. Subtype B1 injuries are monosegmental osseous failures of the posterior tension band extending into the vertebral body (fracture line crossing the pedicle); subtype B2 injuries show disruption of the posterior tension band with or without osseous involvement (disruption of the posterior ligamentous complex); and subtype B3 are injuries that disrupt the anterior longitudinal ligament which serves as the anterior tension band of the spine.[6,14]

Neurological status was evaluated based on the Frankel scale.[15]

Short arthrodesis was defined as fixation of two adjacent vertebral levels, in the vertebrae above and below the fractured vertebra. Long arthrodesis was defined as fixation involving more than two vertebral levels.

Vertebral kyphosis was measured by the Cobb angle, which was calculated using the superior endplate of the vertebrae above the affected vertebra and the inferior endplate of the vertebrae below the affected vertebra.[16]

Pain was evaluated by the Visual Analogue Scale, which scores pain intensity on a scale of 0 to 10. For intensities of 1-3, 4-7 or 8-10, pain was further classified as weak, moderate or severe, respectively.

### Surgical Technique

Under general anesthesia, a urinary catheter was introduced into all patients and 2g of Cefazolin for antibiotic prophylaxis was given intravenously during anesthesia induction. Patients who were allergic to cephalosporins were given vancomycin. Patients were positioned in ventral recumbency with soft pads placed around all bone pressure points for protection. Care was taken not to compress the eyeball.

The skin of the operative area was disinfected with chlorhexidine. Under aseptic conditions, the level of the fracture was confirmed by intraoperative fluoroscopy and a midline skin incision was performed. Bilateral subperiosteal dissection was performed, exposing all the vertebrae to be included in the fusion, dissecting the articular facet and the transverse process of the vertebrae. Cortical bone at the point of screw introduction was removed with rongeurs, and the bone grafts were saved for later implantation. Screw positioning was fluoroscopy guided. Sagittal alignment was corrected and stabilized.

In the short arthrodesis group, pedicle screws were placed at the level of the fractured vertebra, and also in the vertebrae above and below the fracture. In the long arthrodesis group, pedicle screws were not placed at the level of the fractured vertebra, but in the two vertebrae above and the two vertebrae below the fracture.

Patients presenting intracanal bone fragments corresponding to stenosis greater than 50% were submitted to laminectomy of the respective level. Patients with intracanal bone fragments with stenosis greater than 50% (based on CT images) and spinal cord impairment were also submitted to laminectomy, but in those cases, the bone fragment was removed.

Bone cortex of the vertebra included in the instrumentation was removed, and autologous bone grafts were inserted.

A drain was placed under the muscle aponeurosis and exteriorized by a secondary incision. Muscle aponeurosis, and subcutaneous and cutaneous sutures were performed. The drain was left in situ until drainage was <50 mL/24 hours.

### Decision between long and short arthrodesis

All patients with complete spinal cord injury were submitted to long arthrodesis, as these patients have more difficult rehabilitation, with increased sarcopenia of the lower limbs and paraspinal muscles below the level injured. Therefore, to allow greater stabilization of the spine, especially in the sitting position, a long arthrodesis was performed.

Long arthrodesis was also performed in patients whose pedicle fractures prohibited the placement of a screw, and in patients with a Cobb angle $\geq 20^{o}$.

Patients who did not meet those criteria were submitted to either short or long arthrodesis. The decision was made by the senior surgeon responsible for the case, as there is no consensus in the medical literature as to which technique is superior (a gap that prompted this study).

### Statistical analysis

Data were tabulated using the software program Microsoft Excel 2019. Statistical analysis was performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). Numerical variables were submitted to the Kolmogorov-Smirnov Test in order to evaluate their parametricity, and were presented as mean and standard deviation if parametrical, or median and interquartile range if non-parametrical. Parametrical and non-parametrical variables comparing two groups were analyzed with the Student's-t Test and the Mann-Whitney U test, respectively. Parametrical variables compared among three groups were analyzed by ANOVA test. Categorical variables were presented in proportion and analyzed with the Fisher's Exact Test, regardless of whether two or three groups were being compared.

## RESULTS

### Demographic data

A total of 46 patients with type B spine fracture were admitted between January 1, 2013 and December 31, 2018. Fourteen patients presented multiple vertebrae fractures, and were therefore excluded. One patient presented a fracture in the lumbar segment (L3), and was excluded. Thirty-one patients were included in the study, with a mean age of 42.6(±15.6). Most cases were male (78.1%) and Caucasian (93.8%) (Table 1).

### Spine trauma etiology

Fall from height (N=18; 56.2%) was the main cause of spine trauma, followed by traffic accident (N=13; 40.7%). Among the cases of falls from height, 17 out of 18 had fallen from a height of more than 1 meter. Six out of the 13 cases of traffic accidents involved cars and 7 motorcycles (Table 1).

### Subclassification of type B fracture

Fifteen patients (48.3%) had subtype B1 fracture, 16 (51.6%) had subtype B2, and none had subtype B3 fractures (Table 1).

### Spine level injury

The thoracolumbar segment was the most affected segment, occurring in 16 (51.6%) patients, and the thoracic in 15 patients (48.3%) (Table 1). In the thoracic fractures group, T3 and T4 were involved in 1 case each, T5 in 3 cases, T6 in 2 cases, T7 in 4 cases, T8 and T9 were involved in 2 cases each and T10 in 1 case. In the thoracolumbar cases, T12 was fractured in 5 cases, L1 in 8 cases, L2 in 2 cases.

### Treatment related data

As the sample analyzed was compounded by unstable spine fractures, all patients were submitted to surgery. Eleven (35.4%) patients were submitted to short arthrodesis and 20 (64.5%) to long arthrodesis (Table 2). Pedicle screws were placed in the fractured vertebrae in 18 patients (56.3%), laminectomy was performed in 14 cases (43.8%) and the intracanal bone fragment was removed in 2 (6.3%) patients (Table 1).

**Table 1.** Epidemiological data.

| Variable | Result |
|---|---|
| Age (year) | 42.6 (±15.6)* |
| Male | 25 (78.1)° |
| **Race** | |
| White | 29 (93.5)° |
| Black | 2 (6.4)° |
| **Trauma Mechanism** | |
| Fall from height (>1meter) | 17 (54.8)° |
| Fall from height (<1meter) | 1 (3.2)° |
| Motorcycle accident | 7 (22.5)° |
| Car accident | 6 (19.3)° |
| **Segment of vertebral fracture** | |
| Thoracic | 15 (48.3)° |
| Thoracolumbar | 16 (51.6)° |
| **Type B fracture** | |
| B1 | 15 (48.3)° |
| B2 | 16 (51.6)° |
| B3 | 0 (0.0)° |
| **Fusion extension** | |
| Two-level-fusion | 11 (35.4)° |
| Four-level-fusion | 20 (64.5)° |
| Pedicle screw at the fracture level | 18 (56.3)° |
| Laminectomy | 14 (43.8)° |
| Intracanal bone fragment removal | 2 (6.3)° |
| **VAS Pain level at 48 months follow-up** | |
| No pain (VAS 0) | 10 (32.2)° |
| Lower pain (VAS 1-3) | 18 (58.0)° |
| Moderate pain (VAS 4-7) | 2 (6.4)° |
| Severe pain (VAS 8-10) | 1 (3.2)° |

° Number of patients (percentage); * Mean (± standard deviation).

### Neurological status and outcome

The majority of the cases had normal neurological status in the examination at hospital admission (61.2%). Complete spinal cord lesion was observed in 9 (29%) patients. The incomplete spinal cord injurieswere classified as Frankel B (N=0; 0%), Frankel C (N=2; 6.4%) and Frankel D (N=1; 3.2%). Neurological status at hospital discharge of this sample was exactly the same as at hospital admission. However, after 24 months of follow-up, the neurological status of three patients had improved. Two Frankel A cases evolved to Frankel C; and one patient who presented Frankel C in the initial neurological examination improved to Frankel D (Table 3).

In the evaluation of pain at 24 months of follow-up, almost half of the patients had no pain. Among those with pain, the majority described it as low intensity. Less than 10% of the sample reported moderate or severe intensity of pain (Table 1).

### Comparison between subtype B1 and B2 single fractures

There were no differences between the groups regarding epidemiological characteristics, vertebral fracture segment, surgical technique used, or neurological status before or after surgery. The B2 group was submitted to long arthrodesis at a higher proportion than the B1 group (75% versus 53.3% of cases); however this difference was not significant. The authors also found no difference in outcome in terms of postsurgical Cobb angle, neurological status or pain evaluation (Table 4).

### Comparison between the short or long arthrodesis groups

**Table 2.** Description of short and long arthrodesis by the vertebra fractured.

| Vertebra Fractured | Two-level-fusion | | | Four-level-fusion | | |
|---|---|---|---|---|---|---|
| | Number of cases | Most Cranial Vertebra Fused | Most Distal Vertebra Fused | Number of cases | Most Cranial Vertebra Fused | Most Distal Vertebra Fused |
| T3 | 1 | T2 | T4 | 0 | | |
| T4 | 0 | | | 1 | T2 | T6 |
| T5 | 1 | T4 | T6 | 2 | T3 | T7 |
| T6 | 0 | | | 2 | T4 | T8 |
| T7 | 0 | | | 4 | T5 | T9 |
| T8 | 1 | T7 | T9 | 1 | T6 | T10 |
| T9 | 0 | | | 2 | T7 | T11 |
| T10 | 1 | T9 | T11 | 0 | | |
| T12 | 2 | T11 | L1 | 3 | T10 | L2 |
| L1 | 3 | T12 | L2 | 5 | T11 | L3 |
| L2 | 2 | L1 | L3 | 0 | | |

**Table 3.** Neurological status at hospital admission, discharge and follow-up.

| Frankel Score | Hospital Admission° | Hospital Discharge° | 48 months Follow-up° |
|---|---|---|---|
| A | 9 (29.0) | 9 (29.0) | 7 (22.5) |
| B | 0 (0) | 0 (0) | 0 (0) |
| C | 2 (6.4) | 2 (6.4) | 3 (9.6) |
| D | 1 (3.2) | 1 (3.2) | 2 (6.4) |
| E | 19 (61.2) | 19 (61.2) | 19 (61.2) |

° Number of patients (percentage).

**Table 4.** Epidemiology and surgical data according to subtype B1 and B2 of B fracture excluding multiple fractures.

| Variable | B1 | B2 | P Value |
|---|---|---|---|
| Number of patients | 16 | 16 | |
| Age | 42.8 (±17.5)° | 42.4 (±13.9)° | 0.06* |
| Male | 13 (81.3) | 12 (75) | >0.9 |
| **Arthrodesis extension** | | | |
| Two-level-fusion | 7 (46.6) | 4 (25) | 0.2 |
| Four-level-fusion | 8 (53.3) | 12(75) | |
| **Surgical Technique** | | | |
| Laminectomy | 6 (37.5) | 8 (50) | 0.7 |
| Intracanal bone fragment removal | 1 (6.3) | 3 (18.8) | 0.6 |
| **Cobb angle** | | | |
| Admission | 17.2 (+9.6)° | 17.8 (+7.1)° | 0.4* |
| 48 months follow-up | 16.1 (+11.4)° | 16 (+10.9)° | 0.8* |
| **Segment of vertebral fracture** | | | |
| Thoracic | 6 (40) | 9 (56.3) | 0.4 |
| Thoracolumbar | 9 (60) | 7 (43.8) | |
| **Frankel at Hospital Admission** | | | |
| A | 4 (26.6) | 5 (31.3) | >0.9 |
| B | 0 (0) | 0 (0) | |
| C | 1 (6.6) | 1 (6.3) | |
| D | 1 (6.6) | 0 (0) | |
| E | 9 (60) | 10 (62.5) | |
| **Frankel at Hospital Discharge** | | | |
| A | 4 (26.6) | 5 (33.3) | >0.9 |
| B | 0 (0) | 0 (0) | |
| C | 1 (6.6) | 1 (6.7) | |
| D | 1 (6.6) | 0 (0) | |
| E | 9 (60) | 9 (60) | |
| **VAS at 48 months follow-up** | | | |
| No pain (VAS 0) | 6 (40) | 4 (25) | 0.2 |
| Weak pain (VAS 1-3) | 8 (53.3) | 10 (62.5) | |
| Moderate pain (VAS 4-7) | 0 (0) | 2 (12.5) | |
| Severe pain (VAS 8-10) | 1 (6.6) | 0 (0) | |

° Mean (±standard deviation); * Student's-t Test; Number of patients (percentage); Fisher's Exact test.

Eleven patients underwent short arthrodesis and 20 patients long arthrodesis. The patients submitted to short arthrodesis were younger, with a lower Cobb angle at admission and at 24 months after surgery. However, no statistical difference was found when these variables were analyzed. When the vertebral fracture segment was analyzed, it was noticed that the short arthrodesis group presented a higher proportion of thoracic fractures as compared to the long arthrodesis group, although this finding was not statistically significant ($p = 0.09$). Frankel A patients at hospital admission were submitted to long extension arthrodesis, which would explain the statistical difference found between the groups when neurological status at hospital admission and discharge were compared. There was no difference between groups when the variable pain was analyzed (Table 5).

## DISCUSSION

AOSPINE type B fractures are a prevalent and challenging type of spine fracture for which the optimal treatment is a matter of debate, since multiple parameters must be considered, such as: type of fracture, degree of canal impairment, injury to the posterior ligamentous complex and neurological status.[17] The goals of surgical treatment are to stabilize the spine, prevent further neurological injury, decompress neurological structures,avoid long term instability, correct deformity and misalignment, and potentially avoid severe pain.[6,16,18]

The treatment challenge is not deciding on whether surgery should be performed (since type B fractures are unstable and must be treated surgically), but which surgical technique should be performed in order to stabilize the spine and prevent neurological morbidities.

The important point for a decision regarding treatment involves the number of vertebrae fractured. Since type B fractures are usually secondary to high energy traumas, the ratio of multiple fractures is higher when compared to other spine fractures. The incidence of multiple spine fractures, if all types of spine trauma are included, is around 20%,[19] which is lower than the 30% found in this sample. Patients harboring multiple fractures must be submitted to long arthrodesis, since the fusion must include all the fractured vertebrae, extending, at least, to one non-fractured level above and below the injured vertebra.

Althoughthere is a consensus that surgical stabilization is necessary, one of the main difficulties in the treatment decision for patients with a single vertebra type B fracture is deciding onthe extent of the fusion. Historically, long fixation constructs have been used, which included two to three levels above and below the fractured vertebra, as these provide multiple fixation points and sufficient corrective force to reduce the deformity and prevent coronal or sagittal misalignment.[20] However, the increased risk of long-term degeneration of the adjacent segment, particularly in younger patients, led to the use of shorter constructs, to spare motion segments.[4] With the improvement of surgical techniques and instrumentation systems, short-segment pedicle instrumentation has become widely accepted since the first report of Roy-Camille, as an advanced approach to treat these fractures.[21] Direct instrumentation of the fractured

**Table 5.** Comparison between patients submitted to short and long extension arthrodesis.

| Variable | Short | Long | P Value |
|---|---|---|---|
| Number of patients | 11 | 20 | |
| Age | 35(±13.7)° | 47.1(±15.1)° | 0.4* |
| Male | 9 (75) ^ | 16(80) ^ | >0.9 |
| Cobb angle | | | |
| Admission | 14.5 (±9.4)° | 19.3 (+7.1)° | 0.2* |
| 48 months follow-up | 13.9 (±11.9)° | 17.3 (+10.5)° | 0.8* |
| Segment of vertebral fracture | | | |
| T3 | 1 (8.3) ^ | 0 (0) ^ | 0.09# |
| T4 | 0 (0) ^ | 1 (5) ^ | |
| T5 | 1 (8.3) ^ | 2 (10) ^ | |
| T6 | 0 (0) ^ | 2 (10) ^ | |
| T7 | 0 (0) ^ | 4 (20) ^ | |
| T8 | 1 (8.3) ^ | 1 (5) ^ | |
| T9 | 0 (0) ^ | 2 (10) ^ | |
| T10 | 1 (8.3) ^ | 0 (0) ^ | |
| T12 | 2 (16.7) ^ | 3 (15) ^ | |
| L1 | 3 (25) ^ | 5 (25) ^ | |
| L2 | 2 (16.7) ^ | 0 (0) ^ | |
| Intracanal bone fragment Removal | 3 (25) ^ | 1 (5) ^ | 0.1# |
| Laminectomy | 4 (33.3) ^ | 10 (50) ^ | 0.4# |
| Frankel at Hospital Admission | | | |
| A | 0 (0) ^ | 9 (45) ^ | <0.05# |
| B | 0 (0) ^ | 0 (0) ^ | |
| C | 1 (9) ^ | 1 (5) ^ | |
| D | 1 (9) ^ | 0 (0) ^ | |
| E | 10 (81.8) ^ | 10 (50) ^ | |
| Frankel at Hospital Discharge | | | |
| A | 0 (0) ^ | 9 (45) ^ | <0.05# |
| B | 0 (0) ^ | 0 (0) ^ | |
| C | 1 (9) ^ | 1 (5) ^ | |
| D | 1 (9) ^ | 0 (0) ^ | |
| E | 10 (81.8) ^ | 10 (50) ^ | |
| VAS at 48 months follow-up | | | |
| VAS scale | 1 (0-2.5) ¢ | 0 (0-1.75) ¢ | 0.4¢ |
| No pain (VAS 0) | 2 (18) ^ | 8 (40) ^ | 0.7# |
| Weak pain (VAS 1-3) | 8 (72.7) ^ | 10 (50) ^ | |
| Moderate pain (VAS 4-7) | 1 (9) ^ | 1 (5) ^ | |
| Severe pain (VAS 8-10) | 0 (0) ^ | 1 (5) ^ | |

° Mean (±standard deviation); ' Median (Interquartile Interval); ^ Number of patients (percentage); * Student's-t Test; #Fisher's Exact test; "Mann-Whitney U Test.

vertebra with pedicle screw enables short segment fixation in an unstable injury. Pedicle screw instrumentation provides three-column fixation to control axial, translational, and rotational displacements.[11] Therefore, it is currently believed that the arthrodesis should be as short as possible to preserve functional units and adjacent levels.

Pedicular screws must be positioned in the non-fractured part of the injured vertebral body, but contraindications to short posterior arthrodesis are broken pedicles and complete burst fractures of the vertebral body.[8] Therefore, short arthrodesis should be the first option for the treatment of single type B2 fractures.

However, the authors of the present work believe that some cases of single B1 fractures can also be treated with short posterior arthrodesis. Unilateral pedicle fracture can be stabilized by placing a screw in the non-fractured pedicle, creating a construct with the screws in the upper and lower vertebrae. Placement of the screw in the fractured pedicle can also be performed in some cases, depending on the fracture line and the distance of bone fragments. Fracture lines that are longitudinal (antero-posteriorly) and do not displace the pedicle may be suitable for pedicle placement. However, pedicle avulsion or fracture line in a latero-lateral orientation are not suitable for screw placement.

It has also been suggested that short instrumentation could result in loss of correction in sagittal alignment.[22] The authors analyzed sagittal alignment before and after surgery based on the Cobb angle. It was shown that there was no angle difference between patients with B1 or B2 type fractures; also, the comparison between short and long fusions did not demonstrate a difference in sagittal alignment recovery. Therefore, short fusions are as effective as long fusions in terms of spine stabilization and misalignment correction, a finding already described in the medical literature.[11]

The authors believe that patients with complete spinal cord impairment (Frankel A) must be treated with long extension posterior fusions. Although there is no medical literature to support it, this opinion is based on the concept that the muscle capacity to support the sitting position will gradually decline in these patients. Therefore, the fusion may promote the stability required to preserve patients' independence.

The third point of discussion is the need of decompression of neural elements, which can be performed by laminectomy, whether associated with intracanal bone fragment removal or not. It is relevant to point out that patients with no neurologic deficits (Frankel E) do not benefit from this technique. The discussion applies only to patients with spinal cord injury (Frankel B, C or D), who may benefit from neural decompression, which may promote a better cerebral spine fluid flow and better vascular irrigation in the partially compromised neural tissue. However, some reports support the opinion that decompression of neural tissue has not produced a significant neurologic improvement,[23,24] and question whe ther it is an essential therapeutic strategy for functional recovery. Damage to the spinal cord occurs when the bone fragment is retropulsed with great force into the spinal canal.[25] Therefore, since incomplete reduction of retropulsed bone fragments from the injured vertebral body is not associated with delayed neurologic deficit or deterioration, the removal of intraspinal fragments is not necessary.[25]

Finally, the analysis of surgical extension on patient outcome, in terms of neurological recovery and pain, showed no differences. This finding demonstrates that surgery has a major impact on orthopedic stabilization and the prevention of neurological deterioration. Moreover, the lack of difference in pain after long-term follow-up demonstrates that the extension of posterior arthrodesis is not related to the intensity of pain. Since pain is one of the signs of spine instability, it is very important to analyze each case carefully, and perform a surgical procedure that will stabilize the spine.

### Strengths and limitations

This study presents some strengths that should be highlighted. The prospective design enables close follow-up of patients, decreasing the risk of missing variables. The authors analyzed a specific type of fracture, for which the optimal treatment is still under debate. As far as the authors are aware, this is the first study that specifically compares type B fractures, without including type A or C lesions. The inclusion criteria, restricted to patients with type B fractures, and further refinement of the analysis separating the cases by whether they have single or multiple fractures, allows for a clearer and more reliable interpretation of the results.

Some limitations of this study must also be recognized. The results are taken from the experience of a single center, and the decision on whether to perform short or long extension posterior arthrodesis and decompression of neural elements was not guided by well-established criteria, but was decided based on the experience of the senior surgeon responsible for the case. The inclusion criteria applied in this study restricted the number of patients that could be included, so the results were based on groups comprising less than 20 patients each.

## CONCLUSION

There is no difference in outcomes between short or long constructs for patients with type B single fracture in thoracic, thoracolumbar and lumbar spine segments. The extension of posterior fusion did not have any impact on sagittal alignment, neurologic status, or pain outcome, after 24 months of follow-up. Thus, short constructs should be preferred over long constructs in these cases.

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