Spinal Cord Alignment in Patients with Thoracolumbar Burst Fracture

Alinhamento espinopélvico em pacientes com fratura toracolombar explosão

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Abstract

Objective To evaluate the spinopelvic alignment in patients with thoracolumbar burst fracture (TBF) without neurological deficit treated nonsurgically and surgically in a tertiary reference trauma hospital.

Method Retrospective cross-sectional study of patients with single level, type A3 and A4 AOSpine TBF only of the thoracolumbar region. Analysis of clinical data, low back pain (visual analogue scale [VAS]), Denis Pain Scale, quality of life (SF-36), sagittal (TC, TLC, LL, SVA) and spinopelvic (IP, PV, SI, PI-LL) radiographic parameters of patients treated surgically and nonsurgically.

Results A total of 50 individuals with an average age of 50 years old with a mean follow-up of 109 months (minimum of 19 and maximum of 306 months) were evaluated. There was a significant difference between treatments for the Denis Work Scale ($p = 0.046$) in favor of nonsurgical treatment. There was no significant difference between the treatments for lower back pain VAS and Denis Pain Scale ($p = 0.468$ and $p = 0.623$). There was no significant difference between treatments in any of the domains evaluated with the SF-36 ($p > 0.05$). Radiographic parameters were not different between the analyzed groups; however, all radiographic parameters showed significant difference between the population considered asymptomatic, except for pelvic incidence ($p < 0.005$).

Conclusions The spinopelvic alignment was normal in patients with TBF without neurological deficit treated nonsurgically and surgically after a minimum follow-up of 19 months. However, they presented a higher mean pelvic version and discrepancy between lumbar lordosis and pelvic incidence when compared with the reference values of the Brazilian population.

Keywords
- spinal curvatures
- spinal fractures
- spinal injuries

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Resumo

Objetivo Avaliar o alinhamento espinopélvico em pacientes com fratura toracolombar do tipo explosão (FTE) sem déficit neurológico tratados de forma não operatória e operatória em um hospital terciário de referência em trauma.

Método Estudo transversal retrospectivo de pacientes com FTE apenas da região toracolombar, de nível único, do tipo A3 e A4 AOSpine. Análise de dados clínicos, dor lombar (escala visual analógica [EVA]), Escala de Denis, qualidade de vida (SF-36), parâmetros radiográficos sagitais (cifose torácica [CT], cifose toracolombar [CTL], lordose lombar [LL] e eixo vertical sagital [EVS]) e espinopélvicos (incidência pélvica [IP], versão pélvica [VP], inclinação sacral [IS] e a discrepância entre incidência pélvica e lordose lombar [IP-LL]) de pacientes tratados de forma operatória e não operatória.

Resultados O presente estudo avaliou um total de 50 indivíduos com uma média de 50 anos de idade com acompanhamento médio de 109 meses (mínimo de 19 e máximo de 306 meses). Houve diferença significativa entre os tratamentos para Denis trabalho ($p = 0{,}046$) a favor do tratamento não operatório. Não houve diferença significativa entre os tratamentos para EVA dor lombar e Denis dor ($p = 0{,}468$ e $p = 0{,}623$). Não houve diferença significante entre os tratamentos em nenhum dos domínios avaliados do SF-36 ($p > 0{,}05$). Parâmetros radiográficos não se mostraram diferentes entre os grupos analisados; contudo, todos os parâmetros radiográficos mostraram diferença significante entre a população considerada assintomática, com exceção da incidência pélvica ($p < 0{,}005$).

Conclusões O alinhamento espinopélvico foi normal em pacientes com FTE sem déficit neurológico tratados de forma não operatória e operatória, após acompanhamento mínimo de 19 meses. Entretanto, estes pacientes apresentaram maior média de versão pélvica e de discrepância entre lordose lombar e incidência pélvica quando comparados com os valores de referência da população brasileira.

Palavras-chave

- curvaturas da coluna vertebral
- fraturas da coluna vertebral
- traumatismos da coluna vertebral

Introduction

Thoracolumbar burst fracture (TBF) is characterized by comminution of the vertebral body, thoracolumbar kyphosis, and bone fragment projected into the vertebral canal.[1]

Of all fractures involving the spine, 17% are TBFs.[2] This incidence is due to the transition anatomy between the rigid dorsal column by rib summation and coronal orientation of the facets for the mobile lumbar spine with sagittal facetal orientation.[3]

The objectives of TBF treatment are to provide stability, avoid deformity, and optimize neurological recovery.[4] In cases with neural impairment, surgical intervention is mandatory, but in those with normal neurological pattern, there is still doubt about the best treatment option.[5]

Advocates of surgical treatment state that the correction of thoracolumbar kyphosis (TLC) generated by the fracture is fundamental to ensure better clinical and functional results,[6] but the authors who recommend nonsurgical treatment suggest that it avoids surgical complications, has lower cost, and, in the long run, exhibits similar clinical and functional outcomes.[7]

The patient with TBF may evolve with gradual increase of TLC, creating deformities in the sagittal plane with activation of compensation mechanisms in the thorax and lower limbs in an attempt to remain balanced. Some authors have related severe deformities in the sagittal plane with worse indices of function and quality of life.[8]

Most systematic reviews and meta-analyses on thoracolumbar fracture have linked the increase in TLC with chronic pain, worsening function and quality of life;[5–7,9–11] however, few studies have analyzed global spinal parameters of patients with TBF.[12,13]

Our hypothesis is that the spinopelvic alignment of individuals who had TBF is altered in relation to the asymptomatic population due to the increase in TLC.

The aim of the present study was to evaluate the spinopelvic alignment in patients with TBF without neurological deficit treated nonsurgically and surgically in a reference tertiary trauma hospital.

Materials and Methods

A cross-sectional study approved by the ethics committee of the institution (CAAE: 30745118.5.0000.5479) was conducted during routine consultations at the outpatient clinic of the institution between March 2017 and March 2019. All patients who participated signed a free and informed consent form.

The inclusion criteria were: patients with single-level TBF between T11 and L2 as described by Denis,[14] age between 18

and 64 years old at the time of trauma, followed for at least 12 months after the beginning of treatment, without neurological deficit, of types A3 or A4 by the AOSpine classification. The exclusion criteria were the presence of vertebral metastasis, presence of metabolic or endocrine disease, patients operated > 10 days after the fracture, pathological fracture, firearm fracture, neurological deficit, previous spinal surgery, and psychiatric disease.

Clinical data were collected on age, gender, fracture level, AOSpine classification, trauma mechanism, type of treatment, and low back pain (visual analogue scale [VAS]) level, and questionnaires were applied on the Denis Pain Scale, the Denis Work Scale, and the SF-36. Sagittal and spinopelvic radiographic parameters were measured. The results were compared between the surgical and nonsurgical treatment groups, and, in addition, the radiographic parameters of the groups were compared individually with the control sample of the Brazilian population published by Pratali et al.,[15] which is considered normal.

The criteria for surgical indication of the group were TLC > 30°, loss of vertebral body height of 50%, and spinal canal involvement > 50%.[16] The option for either short or long fixation or anterior route association and the type of implant was at the discretion of the surgeon.

Lateral panoramic radiographs with a 36-inch chassis were taken and the patient was placed in the standing position, with the upper limbs supported on a support, shoulders resting at 30° flexion, and elbows slightly flexed.[17] Radiographic parameters were measured with the aid of a validated measurement tool, Surgimap Spine Software (Surgimap, New York, NY, USA).

Applying the Cobb method, we measured the following sagittal parameters: thoracolumbar kyphosis (TLC) thoracic kyphosis (TC), and lumbar lordosis (LL).[18] The spinopelvic parameters were sagittal vertical axis (SVA), pelvic incidence (PI), pelvic version (PV), sacral inclination (SI), and discrepancy between pelvic incidence and lumbar lordosis (PI-LL).[19]

Qualitative variables were described as number and percentage. Data normality was investigated using the Shapiro-Wilk test. The quantitative variables were summarized by means of the mean (standard deviation [SD]) when the data were normally distributed; otherwise, median (P50%), first and third quartiles (P25% and P75%, respectively) were used, in addition to the minimum and maximum values.

To evaluate the association of qualitative variables with the type of treatment, the chi-square test or the Fisher exact test was used when one or more cells presented an expected value lower than five. The comparison between means was performed using the Student t-test; for the medians, the Mann-Whitney nonparametric test was used.

To compare the radiographic findings of the present study with the reference values for the Brazilian population presented by Pratali et al.,[15] the Student t-test was used because the data from the present study were expressed as mean and SD.

All statistical analyses were performed using STATA/SE 15.1 for Windows software (StataCorp, College Station, TX, USA). A significance level of 5% was adopted, that is, p-values < 0.05 were considered statistically significant. All tests were bilateral.

Results

The present study had a total of 50 participants, of which 39 (78%) were men. The mean age of the participants was ~ 49.8 years old, ranging from 20 to 81 years old (±15.2 years). The most frequent trauma mechanisms were fall from height with 31 cases (62%), followed by traffic accidents with 18 (38%). L1 was the most affected level, observed in 21 (42%) patients, followed by T12 with 14 (28%). The average follow-up was of 109 months, with a minimum of 19 and a maximum of 306 months. According to the AOSpine classification, 37 (74%) were defined as A3, and the other 13 (26%) as A4. Surgical treatment was performed in 26 participants (52%), and 24 (48%) received nonsurgical treatment. ►**Table 1** shows the comparison of demographic and clinical data between the two types of treatment.

According to ►**Table 1**, it can be verified that there was no difference between the type of treatment in the mean age, gender, mechanism of trauma, and fracture level ($p > 0.05$). There was a higher percentage of participants with A3 classification in those submitted to nonsurgical treatment (91.7%; $p = 0.006$). In relation to the 26 participants who underwent surgical treatment, 9 (34.6%) underwent VPC, 13 participants (50.0%) underwent VPL, and the other 4 participants (15.4%) underwent VP + VA. The posterior implants found were PP in 18 (69.2%) participants, pedicular screws with upper hooks (hybrid system) in 4 (15.3%), and Cotrel-Doubosset system in 4 (15.3%). ►**Fig. 1** shows the distribution of implants.

Regarding functional outcomes, according to ►**Table 2**, it can be observed that there was a significant difference between treatments, according to the Denis Work Scale ($p = 0.046$): the median presented by the participants who underwent surgical treatment was higher than that of those who underwent nonsurgical treatment. There was no significant difference between the treatments for lower pain VAS and Denis Pain Scale ($p = 0.468$ and $p = 0.623$, respectively).

Regarding quality of life, ►**Table 3** shows that there was no significant difference between treatments in any of the domains evaluated ($p > 0.05$).

►**Table 4** indicates that there was no statistically significant difference between treatments in any of the radiographic parameters evaluated ($p > 0.05$).

According to ►**Table 5**, it can be verified that all sagittal and spinopelvic radiographic parameters had a significant difference between the group submitted to nonsurgical treatment and the sample of Pratali et al., except for PI ($p = 0.674$).

For lumbar lordosis, it was found that the participants of the study by Pratali et al. presented, on average, 9.3 ± 2.0° more than the participants of the nonsurgical group ($p < 0.001$). The participants of the present study (nonsurgical group) presented, on average, 19.6 ± 6.1 mm more in the sacral vertical axis when compared with those in the study

Table 1 Demographic and clinical data according to treatment

Treatment				
	Total ($n = 50$)	**Surgical ($n = 26$)**	**Nonsurgical ($n = 24$)**	***p-value***
Age, mean (SD)	49.8 (15.2)	49.2 (15.4)	50.4 (15.2)	0.848[a]
Sex				
Female	11 (22%)	6 (23.1%)	5 (20.8%)	0.800[b]
Male	39 (78%)	20 (76.9%)	19 (79.2%)	
Trauma mechanism				
Fall from Height	31 (62%)	17 (65.4%)	14 (58.3%)	0.608[b]
Motor Vehicle Accident	19 (38%)	9 (34.6%)	10 (41.7%)	
Fracture level				
L1	21 (42.0%)	10 (38.5%)	11 (45.8%)	0.273[c]
L2	11 (22.0%)	8 (30.8%)	3 (12.5%)	
T11	4 (8.0%)	1 (3.8%)	3 (12.5%)	
T12	14 (28.0%)	7 (26.9%)	7 (29.2%)	
AOSpine rating				
A3	37 (74.0%)	15 (57.7%)	22 (91.7%)	0.006[b]
A4	13 (26.0%)	11 (42.3%)	2 (8.3%)	

[a]Student t-test
[b]Chi-squared test
[d]Fisher exact test
Source: SAME.

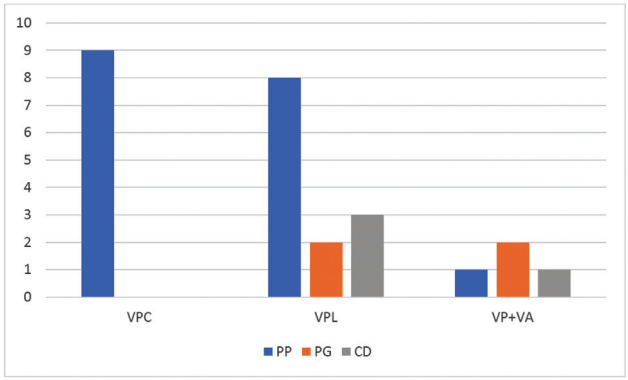

Fig. 1 Distribution of implants.

by Pratali et al. ($p < 0.001$). For sacral inclination, it was observed that the participants of the study by Pratali et al. presented, on average, $6.3 \pm 1.5°$ higher when compared with the participants of the nonsurgical group. The participants of the present study (nonsurgical group) presented higher mean pelvic version and discrepancy between lumbar lordosis and pelvic incidence when compared with the values presented by the study by Pratali et al. ($p < 0.001$), and the mean differences were estimated at $6.2 \pm 1.4°$ and $19.4 \pm 1.8°$, respectively.

According to ►**Table 6**, it can be observed that all sagittal and spinopelvic parameters showed a significant difference between the group submitted to surgical treatment and the control sample of the normal Brazilian population published by Pratali et al.,[15] except for pelvic incidence, which did not present statistical significance ($p = 0.949$).

For lumbar lordosis, it was found that the participants of the study by Pratali et al. presented, on average, $8.0 \pm 2.1°$ more than the participants of the surgical group ($p < 0.001$). The participants of the surgical group presented, on average, 28.9 ± 5.6 mm more in the sacral vertical axis when compared with those in the study by Pratali et al. ($p < 0.001$). For sacral inclination, it was observed that the participants of the study by Pratali et al. presented, on average, $6.0 \pm 1.5°$ degrees more when compared with the participants of the surgical group. The participants of the surgical group presented higher mean pelvic version and discrepancy between lumbar lordosis and pelvic incidence when compared with the values presented by the study by Pratali et al. ($p < 0.001$), and the mean differences were estimated at $5.7 \pm 1.5°$ and $18.8 \pm 1.7°$, respectively.

Discussion

According to the studies surveyed,[2,6,9] we obtained a sample composed mostly of men, with a mean age of 49.8 years old, who had fall from height as the most common mechanism of trauma. However, we presented a mean follow-up in 109 months (minimum of 19 and maximum of 306 months), a follow-up time that was considered long-term among the studies on TBF.

Our study showed no differences between low back pain measured by VAS for patients treated surgically and

Table 2 Visual analog scale of low back pain and Denis Scale according to treatment

Treatment			
	Surgical ($n = 26$)	Nonsurgical ($n = 24$)	*p-value*[#]
VAS low back pain			
Median (P25–P75)	6 (3–7)	5 (3–7)	0.468
Minimum–maximum	0–9	0–8	
Denis Pain			
Median (P25–P75)	3 (2–4)	3 (2–3)	0.623
Minimum–maximum	1–5	1–4	
Denis Work			
Median (P25–P75)	5 (3–5)	3 (3–4.5)	0.046
Minimum–maximum	1–5	1–5	

Abbreviations: P25, 25th percentile; P75, 75th percentile; VAS, visual analogue scale.
[#]Mann-Whitney test
Source: SAME.

nonsurgically. On the contrary, data from Shen et al.[20] suggested that the surgery resulted in better VAS scores compared with nonsurgical treatment in the 1st month, although there were no differences between the groups 6 months after the injury.

Using the Denis Pain Scale, the median of the surgical group was 3 (2 to 4) and that of the nonsurgical scale was 3 (2 to 3); there was no statistically significant difference ($p = 0.623$) between the operated and nonoperated groups. In both groups, the highest prevalence was of patients with moderate pain making occasional use of medication. According to the Denis Work Scale, the median of the surgical group was significantly worse (5 [3 to 5]; $p = 0.046$), with a higher prevalence of patients unable to work. The statistical difference found in the Denis Work Scale in our study does not necessarily establish a better result with the use of thoracolumbar orthosis, because the operated fractures tended to be more severe by the surgical criterion of the group. In addition, the incidence of type A4 lesions, with greater comminution, was significantly higher in the operated group.

Regarding quality of life, we did not find any of the parameters of the SF-36 with a significant difference between groups; however, they were worse when compared with the sample of the Brazilian population considered normal in the study by Laguardia et al.[21] We believe that TBF usually compromises previously healthy people who undergo trauma followed by long treatment, many of whom present with outcomes such as chronic pain, movement limitations, and post-traumatic deformities, a situation that can alter life habits and generate disability for activities of daily living, worsening the quality of life.

Regarding radiographic parameters, we did not observe significant differences in any of the variables analyzed. Most studies on TBF without neurological deficit have related the increase in TLC with outcomes such as chronic pain and worsening function and quality of life.[5–7,9–11] However, the clinical relevance of the radiological outcome is a matter of debate, and there is no study that demonstrates an unequivocal association between radiological and clinical results after TBF of Denis, A3 and A4 AOSpine.

The meta-analysis by Rometsch et al.[11] found no difference in the results of disability or pain between surgical and nonsurgical treatment, which are similar to those of our study. The radiographic analysis of the review was not performed due to the wide variety of different TLC measurement techniques.

Based on the current knowledge on sagittal alignment of the spine, analysis only in focal TLC is not adequate. Analyzing the whole spinopelvic alignment ensures more faithful results of the consequence of the increase in TLC caused by traumatic injury. However, there are few studies that performed a global analysis of the spinopelvic parameters of patients with TBF.[12,13,22]

Koller et al.[12] retrospectively analyzed the spinopelvic parameters of 21 patients, including burst-type fractures of the thoracolumbar and lumbar region without neurological injury (A3 AOSpine) treated nonsurgically with a 9-year follow-up. They found a strong correlation between age and worse closure regarding lumbar VAS in TBF. The elderly were well in the first years after the injury, but then noticed an increase in pain at the fracture level; we understand that this is due to loss of the potential for compensation of sagittal alignment due to sarcopenia and degenerative changes of the spine.

Mayer et al.[22] conducted a retrospective study of 36 adults with exclusive TBF treated surgically. The results demonstrated the interdependence between sagittal alignment and clinical outcomes. They also support the assumption that stable restoration of thoracolumbar alignment to normality and its maintenance has a positive impact on clinical outcome. The statistical analysis, however, did not reach the significance level for the differences between the groups treated posteriorly and by the posterior and anterior

Table 3 Quality of life assessed by the SF-36 scale according to treatment

Treatment			
	Surgical ($n = 26$)	Nonsurgical ($n = 24$)	*p-value*[#]
Functional capacity			
Average	44.2	38.0	0.853
Median (P25–P75)	37.5 (15–75)	35 (20–55)	
Minimum–maximum	0–100	5–100	
Physical limitation			
Average	27	31	0.323
Median (P25–P75)	0 (0–25)	0 (0–12.5)	
Minimum–maximum	0–100	0–50	
Pain			
Average	50.3	50.7	0.830
Median (P25–P75)	45 (22.5–67.5)	43.5 (41–64.8)	
Minimum–maximum	0–100	0–100	
General state of health			
Average	80	66.1	0.090
Median (P25–P75)	55 (30–75)	71 (48.5–82)	
Minimum–maximum	25–95	25–97	
Vitality			
Average	63.6	58.4	0.552
Median (P25–P75)	55 (50–75)	55 (40–75)	
Minimum–maximum	30–100	30–95	
Social aspects			
Average	65.4	59.2	0.357
Median (P25–P75)	62 (38–75)	56 (37.5–75)	
Minimum–maximum	25–100	12–100	
Emotional limitations			
Average	25.5	21.5	0.872
Median (P25–P75)	0 (0–33)	0 (0–33)	
Minimum–maximum	0–100	0–100	
Mental health			
Average	64.6	57.7	0.246
Median (P25–P75)	72 (52–80)	64.5 (48–78)	
Minimum–maximum	32–100	24–96	

Abberviations: P25, 25th percentile; P75, 75th percentile.
[#]Mann-Whitney test
Source: SAME.

combined route. The intergroup analysis revealed no significant differences in global sagittal spinal and pelvic radiographic measurements or clinical outcome measurements.

Regarding sagittal alignment, we observed that the parameters were significantly worse in these patients, both in those who were operated on and in those who were not, compared with the control group of the asymptomatic Brazilian population.[15] One hypothesis is that these patients, although aligned globally, already present some initial factor of compensation of the pelvic version due to residual kyphosis of the thoracolombosacral transition. Possibly, as our sample was composed by young patients (mean age: 49.8 years old; SD: $\pm$ 15.2), there was a greater compensation capacity of the overall alignment as a function of the lumbar and pelvic stabilizing muscles being more efficient than in the elderly. Future studies can be conducted to analyze pelvic compensation capacity in elderly patients when physiological lordosis (natural increase in SVA and PV) and sarcopenia occurs.

Table 4 Radiographic data according to treatment

Treatment			
	Surgical ($n = 26$)	**Nonsurgical ($n = 24$)**	***p-value*[#]**
Thoracolumbar cyphosis (°)			
Median (P25–P75)	15.0 (11.8–22.9)	17.5 (12.2–28.2)	0.299
Minimum–maximum	1.9–31.0	0.1–39.5	
Thoracic cyphosis (°)			
Median (P25–P75)	41.6 (35.2–47.0)	38.3 (31.1–57.2)	0.861
Minimum–maximum	24.9–70.1	12.2–66.8	
Lumbar lordosis (°)			
Median (P25–P75)	52.4 (40.3–57.6)	47.4 (40.0–56.0)	0.587
Minimum–maximum	14.2–82.2	23.0–72.0	
Sacral vertical axis (mm)			
Median (P25–P75)	19.5 (8.9– 34.5)	15.5 (- 4.2– 27.8)	0.207
Minimum–maximum	- 12.0–101.1	- 36.0–104.2	
Sacral slope (°)			
Median (P25–P75)	31.1 (23.6–33.7)	31.7 (27.1–34.1)	0.771
Minimum–maximum	14.6–52.2	19.7–45.5	
Pelvic version (°)			
Median (P25–P75)	17.4 (8.8–23.1)	16.6 (13.6–24.0)	0.655
Minimum–maximum	0.2–47.7	0.6–34.4	
Pelvic incidence (°)			
Median (P25–P75)	50.1 (39.7–63.1)	47.1 (43.0–58.7)	0.946
Minimum–maximum	27.9–77.0	26.2–65.5	
Discrepancy between lumbar lordosis and pelvic incidence (°)			
Median (P25–P75)	10.1 (5.4–13.2)	10.5 (3.8–17.1)	0.946
Minimum–maximum	2.3–43.7	0.0–33.3	

Abbeviations: P25, 25th percentile; P75, 75th percentile.
[#]Mann-Whitney test.

Currently, there is no consensus regarding the influence of muscles on sagittal misalignment. Research in individuals without spinal deformities has shown an increase in fat infiltration of almost 15% with aging.[23] Similarly, some authors have observed decreased volume and increased fat infiltration of the spine ethers in patients with loss of lumbar lordosis.[24] In a prospective cohort, Ferrero et al.[25] related muscle quality with spinopelvic parameters. Sagittal misalignment was associated with increased fatty infiltration and decreased muscle volumes with poor clinical results.

In comparison with the literature, our study presents a homogeneous group of patients (A3 and A4) and a minimum follow-up time of 19 months, which is considered long-term. However, the design of the present cross-sectional study allows us to formulate only hypotheses that can be confirmed or not with prospective studies and with a long-term control group. Moreover, the patients evaluated were all who returned to the outpatient clinic. We know that the loss to follow-up in the context of the Brazilian Unified Health System (SUS, in the Portuguese acronym) is generally relevant. However, it seems that these patients use compensatory mechanisms to maintain the aligned spine globally and locally. We suggest conducting long-term prospective studies to improve the level of evidence of this hypothesis.

Conclusions

The spinopelvic alignment in patients with TBF without neurological deficit treated nonsurgically and surgically after a minimum follow-up of 19 months was normal; however, the patients presented higher mean pelvic version and discrepancy between lumbar lordosis and pelvic incidence when compared with the reference values of the Brazilian population.

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Table 5 Comparison of radiographic parameters between the nonsurgical treatment group and those presented in the study by Pratali et al.[15]

Study			
	Nonsurgical treatment ($n = 26$)	Pratali et al.[15] ($n = 130$)	*p-value*[#]
Lumbar lordosis (°)			
Average (SD)	47.5 (12.4)	56.8 (8.0)	< 0.001
Sacral vertical axis (mm)			
Average (SD)	14.2 (30.2)	- 5.4 (27.0)	< 0.001
Sacral slope (°)			
Average (SD)	30.9 (5.9)	37.2 (6.7)	< 0.001
Pelvic version (°)			
Average (SD)	18.6 (8.6)	12.4 (5.8)	< 0.001
Pelvic incidence (°)			
Average (SD)	49.5 (10.2)	49.4 (8.2)	0.674
Discrepancy between lumbar lordosis and pelvic incidence (°)			
Average (SD)	12.0 (10.1)	- 7.4 (7.7)	< 0.001

Abbreviation: SD, standard deviation.
[#]Student t-test.
Source: SAME.

Table 6 Comparison between the radiographic parameters of the surgical treatment group and those presented in the study by Pratali et al.[15]

Study			
	Surgical treatment ($n = 26$)	Pratali et al.[15] ($n = 130$)	*p-value*[#]
Lumbar lordosis (°)			
Average (SD)	48.8 (16.2)	56.8 (8.0)	< 0.001
Sacral vertical axis (mm)			
Average (SD)	23.5 (22.0)	- 5.4 (27.0)	< 0.001
Sacral slope (°)			
Average (SD)	31.2 (9.0)	37.2 (6.7)	< 0.001
Pelvic version (°)			
Average (SD)	18.1 (11.8)	12.4 (5.8)	< 0.001
Pelvic incidence (°)			
Average (SD)	50.2 (13.7)	49.4 (8.2)	0.949
Discrepancy between lumbar lordosis and pelvic incidence (°)			
Average (SD)	11.2 (8.6)	- 7.4 (7.7)	< 0.001

Abbreviation: SD, standard deviation.
[#]Student t-test.
Source: SAME.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Atlas SW, Regenbogen V, Rogers LF, Kim KS. The radiographic characterization of burst fractures of the spine. AJR Am J Roentgenol 1986;147(03):575–582
2 Denis F, Armstrong GW, Searls K, Matta L. Acute thoracolumbar burst fractures in the absence of neurologic deficit. A comparison between operative and nonoperative treatment. Clin Orthop Relat Res 1984;(189):142–149
3 Fakurnejad S, Scheer JK, Patwardhan AG, Havey RM, Voronov LI, Smith ZA. Biomechanics of thoracolumbar burst fractures: methods of induction and treatments. J Clin Neurosci 2014;21(12): 2059–2064
4 Vaccaro AR, Kim DH, Brodke DS, et al. Diagnosis and management of thoracolumbar spine fractures. Instr Course Lect 2004; 53:359–373
5 Abudou M, Chen X, Kong X, Wu T. Surgical versus non-surgical treatment for thoracolumbar burst fractures without neurological deficit. Cochrane Database Syst Rev 2013;(06):CD005079
6 Siebenga J, Leferink VJ, Segers MJ, et al. Treatment of traumatic thoracolumbar spine fractures: a multicenter prospective randomized study of operative versus nonsurgical treatment. Spine 2006;31(25):2881–2890
7 Gnanenthiran SR, Adie S, Harris IA. Nonoperative versus operative treatment for thoracolumbar burst fractures without neurologic deficit: a meta-analysis. Clin Orthop Relat Res 2012;470(02): 567–577
8 Vaccaro AR, Silber JS. Post-traumatic spinal deformity. Spine 2001;26(24, Suppl)S111–S118
9 Wood KB, Buttermann GR, Phukan R, et al. Operative compared with nonoperative treatment of a thoracolumbar burst fracture without neurological deficit: a prospective randomized study with follow-up at sixteen to twenty-two years. J Bone Joint Surg Am 2015;97(01):3–9
10 Ghobrial GM, Maulucci CM, Maltenfort M, et al. Operative and nonoperative adverse events in the management of traumatic fractures of the thoracolumbar spine: a systematic review. Neurosurg Focus 2014;37(01):E8
11 Rometsch E, Spruit M, Härtl R, et al. Does Operative or Nonoperative Treatment Achieve Better Results in A3 and A4 Spinal Fractures Without Neurological Deficit?: Systematic Literature Review With Meta-Analysis Global Spine J 2017;7(04):350–372
12 Koller H, Acosta F, Hempfing A, et al. Long-term investigation of nonsurgical treatment for thoracolumbar and lumbar burst fractures: an outcome analysis in sight of spinopelvic balance. Eur Spine J 2008;17(08):1073–1095
13 Joaquim AF, Rodrigues SA, DA Silva FS, et al. Is There an Association With Spino-Pelvic Relationships and Clinical Outcome of Type A Thoracic and Lumbar Fractures Treated Non-Surgically? Int J Spine Surg 2018;12(03):371–376
14 Denis F. The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. Spine 1983;8(08):817–831
15 Pratali RR, Nasreddine MA, Diebo B, Oliveira CEAS, Lafage V. Normal values for sagittal spinal alignment: a study of Brazilian subjects. Clinics (São Paulo) 2018;73:e647
16 Tezer M, Erturer RE, Ozturk C, Ozturk I, Kuzgun U. Conservative treatment of fractures of the thoracolumbar spine. Int Orthop 2005;29(02):78–82
17 Marks M, Stanford C, Newton P. Which lateral radiographic positioning technique provides the most reliable and functional representation of a patient's sagittal balance? Spine 2009;34(09): 949–954
18 Kuklo TR, Polly DW, Owens BD, Zeidman SM, Chang AS, Klemme WR. Measurement of thoracic and lumbar fracture kyphosis: evaluation of intraobserver, interobserver, and technique variability. Spine 2001;26(01):61–65, discussion 66

19 Pratali RR, Hennemann SA, Amaral R, et al. Standardized terminology of adult spine deformity for Brazilian Portuguese. Coluna/Columna 2015;14(04):281–285
20 Shen WJ, Liu TJ, Shen YS. Nonoperative treatment versus posterior fixation for thoracolumbar junction burst fractures without neurologic deficit. Spine 2001;26(09):1038–1045
21 Laguardia J, Campos MR, Travassos C, Najar AL, Anjos LA, Vasconcellos MM. Brazilian normative data for the Short Form 36 questionnaire, version 2. Rev Bras Epidemiol 2013;16(04):889–897
22 Mayer M, Ortmaier R, Koller H, et al. Impact of Sagittal Balance on Clinical Outcomes in Surgically Treated T12 and L1 Burst Fractures: Analysis of Long-Term Outcomes after Posterior-Only and Combined Posteroanterior Treatment. BioMed Res Int 2017; 2017:1568258
23 Meakin JR, Fulford J, Seymour R, Welsman JR, Knapp KM. The relationship between sagittal curvature and extensor muscle volume in the lumbar spine. J Anat 2013;222(06):608–614
24 Kang CH, Shin MJ, Kim SM, Lee SH, Lee CS. MRI of paraspinal muscles in lumbar degenerative kyphosis patients and control patients with chronic low back pain. Clin Radiol 2007;62(05): 479–486
25 Ferrero E, Skalli W, Lafage V, et al. Relationships between radiographic parameters and spinopelvic muscles in adult spinal deformity patients. Eur Spine J 2020;29(06):1328–1339