ORIGINAL ARTICLE

Pelvic incidence in thoracolumbar fractures: Is there an impact ?

Incidences pelviennes dans les fractures thoraco-lombaires: Y a-t-il un impact ?

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Abstract

Introduction: In trauma, we can perform a lateral radiography of the lumbosacral hinge taking the femoral heads if we include it in the initial lesion assessment. Thus, the pelvic incidence informs about the type of back as described by Roussouly.
Aim: To describe the clinical and radiological results of these types of back which are operated on for a thoracolumbar fracture.
Methods: We recorded the clinical, radiological data and the characteristics of the fracture of 120 patient operated on for a thoracolumbar spine fracture over a period of 14 years between February 2005 and July 2019. We studied the deformation according to Regional traumatic angulation (ART), Sagittal Farcy Index (SIF), Gardner Segment Kyphotic Deformity (GSKD). Functional evaluation was carried out according to the Denis Pain Scale. Radiological evaluation was based on relative gain and loss.
Results: In individuals with low pelvic incidence, a prevalence of 72% was observed for type A fracture, whereas types B and C accounted for 45.9% (P<0.05) for backs with high pelvic incidence. The Denis Pain Scale score indicated that 90% of individuals with low incidence backs had scores below 3, whereas only 65.6% of those with high incidences had scores below 3 (P<0.05). The loss of correction for backs with low incidences was measured at 1.2°, while for backs with high incidences, it was 3° (p<0.05).
Conclusion: Fractures on backs with low pelvic incidence considered as stiff backs are more frequently of type A, with better functional results and less losses.

Key words: thoracolumber, vertebral fracture, X-rays.

Résumé

Introduction: En traumatologie, l'inclusion de la radiographie latérale de l'articulation lombo-sacrée avec les têtes fémorales dans l'évaluation initiale des lésions permet de déterminer l'incidence pelvienne et le type de dos selon Roussouly.
Objectif: Décrire les résultats cliniques et radiologiques de ces types de dos opérés pour une fracture thoraco-lombaire.
Méthodes: Les données cliniques, radiologiques et les caractéristiques de la fracture de 120 patients opérés pour une fracture de la colonne vertébrale thoraco-lombaire entre février 2005 et juillet 2019 ont été enregistrées. Nous avons analysé l'Angulation Régionale Traumatique (ART), l'Indice de Farcy Sagittal (SIF) et la Déformation Kyphotique du Segment de Gardner (DKSG). L'évaluation fonctionnelle s'est basée sur l'Échelle de Douleur de Denis, tandis que l'évaluation radiologique a pris en compte le gain et la perte relatifs.
Résultats: Chez les individus à incidence pelvienne basse, les fractures de type A prévalaient à 72%, tandis que les types B et C représentaient 45,9% des fractures chez ceux à incidence élevée (P<0,05). L'Échelle de Douleur de Denis révélait que 90% des individus à faible incidence avaient des scores inférieurs à 3, comparativement à 65,6% chez ceux à incidence élevée (P<0,05). La perte de correction était de 1,2° pour les incidences basses et de 3° pour les incidences élevées (p<0,05).
Conclusion: Les fractures chez les individus à incidence pelvienne basse, considérés comme ayant des dos raides, étaient principalement de type A, associées à de meilleurs résultats fonctionnels et à moins de pertes.

Mots clés: thoraco-lombaire, fracture vertébrale, radiographies.

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Introduction

Fractures of the thoracolumbar spine are frequent (1) and severe lesions could affect the functional prognosis and lead to a profound deterioration in the patient's quality of life(2,3). Meanwhile, understanding the anatomical and biomechanical specificities of the spine is a guarantee of success. The pelvic parameters of Duval-Beaupère (4)and their correlations with the spinal curvatures gave rise to the notion of type of back, which affected the therapeutic approaches in degenerative and malformative pathologies. The sagittal balance was evaluated on an X-ray of the entire spine in a standing position as well as the position of the sacrum with respect to the femoral heads. The imagery makes it possible to calculate the pelvic parameters and their correlations with the lumbar lordosis, thus determining the type of back according to the Roussouly classification(5,6).
In trauma, in a bedridden patient only, we dispose a lateral radiography of the lumbosacral hinge including the femoral heads. Thus, the calculated pelvic incidence carries information about the harmony and the type of back. Low pelvic incidence backs are Roussouly types I and II considered as stiff backs. The backs with high pelvic incidence are types III and IV, which are flexible backs.
In this work, our aim was to compare the clinical and functional results of backs with low and high pelvic incidences.

Methods

We conducted a retrospective, descriptive and comparative study over a period of 14 years on 120 patients operated on for a thoracolumbar spine fracture in the department of orthopedic surgery and trauma of our hospital between February 2005 and July 2019.
This study concerned a group of patients operated on by the same surgeon according to the same technique. All patients underwent spinal osteosynthesis via the posterior approach(7,8). A posterior and posterolateral bone graft was systematic.
The study included patients with an age ≥ 15 years with a complete preoperative radiological assessment necessarily including standard radiographs of the lumbosacral hinge taking the two femoral heads in profile, and a minimum retrospect of one year.
The patient's record included clinical and radiological data of each patient, general information about the patient and the circumstances of the accident, the characteristics of the fracture, the clinical and anatomical results postoperatively and in retrospect according to the Denis Pain Scale. The radiological study included the assessment of the type of back based on the estimation of the pelvic incidence measured on standard radiographs of the lumbosacral hinge taking the two femoral heads in profile performed in lying down position (Figure 1).

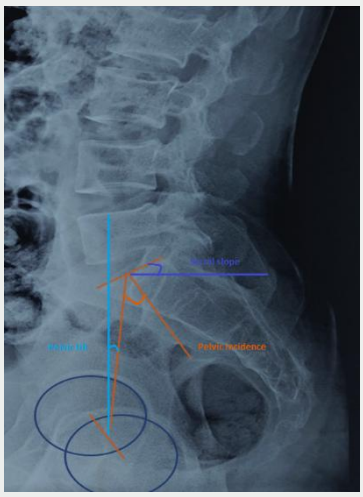

Figure 1. Pelvic parameters

- Pelvic incidence (PI): the angle formed between a line perpendicular to the midpoint of the sacral endplate and a line connecting this midpoint to the midpoint of the the bicoxofemoral axis. it is an anatomical feature unique to each individual that becomes set at the end of growth, regardless of its position. The lower value of PI is approximately 35°, the higher around 85° and the average being 51.9°.
- The sacral slope (SS): the angle created by the horizontal plane and sacral platform when standing, or by the vertical plane when supine . The slope of the sacrum basis on the horizontal varies from 21° to 66°, the average being 40° and the standard deviation 8,2°.
- Pelvic tilt (PT): defined as the angle formed between a line running from the midpoint of the sacral endplate to the midpoint of the bicoxofemoral axis and the vertical axis. In the standing position, the mean pelvic tilt angle, which is open at the back, is 13° ± 6°.
- Sacral slope and pelvic tilt are positional parameters that can be affected by changes in the alignment of the lower extremities: PI = PT + SS.(9–11)

In addition to these parameters, we classified lumbar lordosis using the Roussouly classification:(10)
1. Type 1 Lordosis: Sacral slope < 35°, low pelvic incidence, apex of lumbar lordosis at the center of L5, minimal lower arc of lordosis, negative lordosis tilt angle, significant kyphosis of the thoracolumbar junction and thorax.
2. Type 2 Lordosis: Sacral slope < 35°, apex of lumbar lordosis at the base of L4, relatively flat lower arc of lordosis, higher and more anterior inflection point, decreased lordosis tilt angle, hypolordotic and hypokyphotic spine.
→ For these two types, the pelvic incidence (PI) is less than 50° (PI < 50°).
3. Type 3 Lordosis: Sacral slope between 35° and 45°, apex of lumbar lordosis at the center of L4, prominent lower arc of lordosis, inflection point at the thoracolumbar junction, nearly zero lordosis tilt angle, well-balanced spine.
4. Type 4 Lordosis: Sacral slope > 45°, high pelvic incidence, apex of lumbar lordosis at the base of L3 or higher, prominent lower arc of lordosis, zero or positive lordosis tilt angle, more than 5 vertebrae in lordotic orientation, segmental hyperextension.
→ For these two types, the pelvic incidence (PI) is greater than or equal to 50° (PI ≥ 50°).
We studied the level of the lesion and the classification of the fracture. Also, the deformity evaluation included the Regional Traumatic Angulation (ART), the Sagittal Farcy Index (SIF) (12) and the Gardner Segment Kyphotic Deformity (GSKD) (13,14) through a standard radiological assessment and a CT scan of the thoracolumbar spine.

We estimated the correction by determining the relative gain and losses in the last retrospect, study of the sagittal balance through the sagittal heel in T9 and the Sagittal Vertical Axis (SVA) measured on an X-ray of the whole spine from a frontal and standing position and in profile carried out in the last retrospect.

For data analysis, we utilized SPSS version 25.0 software. The normality of the distribution for quantitative variables was assessed using the Shapiro-Wilk test. Continuous variables with a normal distribution were presented as means with standard deviation (SD), while those without a normal distribution were expressed as medians with semi-interquartile ranges (SIR). Qualitative variables were presented as frequency distributions. To compare the two groups of patients, univariate analyses were performed using various statistical tests. The Student's t-test was used for continuous variables with a normal distribution, the Mann-Whitney test for continuous variables without a normal distribution, and Pearson's Chi-square test for qualitative variables. Statistical significance was considered to be achieved when the p-value was less than 0.05 ($p < 0.05$).

Results

Our group contained 94 men (78.3%) and 26 women (21.7%), with a sex ratio which is equal to 3.6. The average age of our patients was 34.8 years with a standard deviation of 12.2 years. The majority of fractures were the result of a fall from a high place, 66.6% of the cases (fall off scaffolding, fall off a palm tree, etc.), and 26.7% of the cases were caused by a road accident. Trauma to the thoracolumbar spine was associated with other lesions in 49 of our patients. The life prognosis was threatened in 22.5% of the cases, divided into 10% head injuries, 10% chest injuries and 2.5% abdominal injuries.

We counted: 68.3% of the fractures located at the level of the thoracolumbar hinge (L1 is the most affected vertebra: 31.7% of the cases) and 31.7% of the fractures are localized at the level of the lumbar spine. For backs Roussouly's type III and IV, it was found that the fractures are located at the level of the thoracolumbar hinge in 80.3% of the cases. As for the stiff backs types I and II, it was noted that the fractures are localized at the lumbar level in 44.1% of the cases. (p=0.004) (Table 1).

Table 1. determining the distribution of the localization of the fractures according to the type of back

	Thoracolumbar hinge (%)	Lumbar (%)	P(Khi2Test)
Low incidence backs	55.9	44.1	**0.004**
High incidence backs	80.3	19.7	

For Roussouly's backs type I and II, type A was observed in 72.9% of the fractures, while for flexible backs, types B and C were found in 45.9% of fractures. The difference is statistically significant (p = 0.033).

A total of 120 patients were selected for this study with an average retrospect of 50.7 months, with a standard deviation at 21 months. The Denis Pain Scale score was less than 3 in 90% for cases of low pelvic incidence backs and in 65.6% for those of high incidence backs. (p = 0.01). As for the overall radiological results of backs type I and II, the post-operative relative gain was 67.3% for ART, 87.3% for GSKD and 85.1% for SIF. (Figure 2)

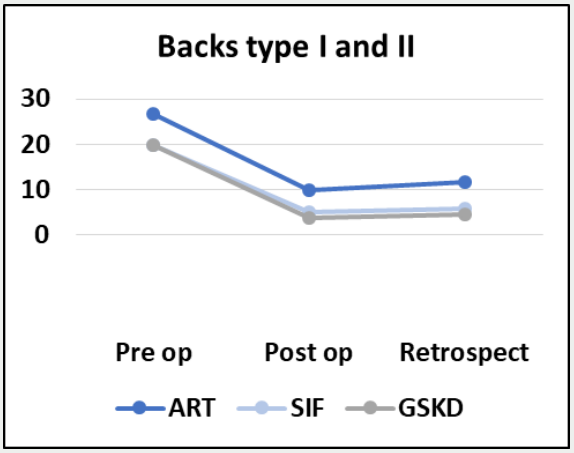

Figure 2. Evolution of radiological values for low incidence backs

As for backs type III and IV, the post-operative relative gain was 128.8% for ART, 131.2% for GSKD and 161.7% for SIF. However, the loss of correction at the last retrospect, for stiff backs was 2.1° for ART, 1.2° for GSKD and 1.5° for SIF, while it was 3.2° for ART, 3° for GSKD and 2.8° for SIF for flexible backs. The difference in terms of relative gain (GR) and loss of correction between these 2 groups was statistically significant with (p <0.05). (Table 2).

Table 2. Relative gain and loss of correction by type of back

	Low incidence backs			High incidence backs			P (Anova test)		
	ART	**SIF**	**GSKD**	**ART**	**SIF**	**GSKD**	**ART**	**SIF**	**GSKD**
Preoperative (°)	26.6	19.8	19.9	21.9	19.6	19.9	0.031	0.887	0.985
Postoperative (°)	10	5	3.8	-3.9	-2.8	-2.2	**0.000**	**0.000**	**0.000**
Relative gain (%)	67.3	85.1	87.3	128.8	161.7	131.2	**0.000**	**0.039**	0.069
Losses (°)	2.1	1.5	1.2	3.2	2.8	3	0.137	**0.012**	**0.000**

ART : Regional Traumatic Angulation ; **SIF** : Sagittal Farcy Index ; **GSKD** : Gardner Segment Kyphotic Deformity

As for the study of sagittal balance, the group of backs types I and II scored 33.3% of the patients balanced at the last retrospect. In the group of backs types III and IV, more than 90.9% are balanced at the last retrospect. It was found on CT images that these low pelvic incidence backs, which are considered as stiff, some pathological backs with radiological indications in favor of the after-effects of Schuermann's disease.

Discussion

Fractures on backs with low pelvic incidence are more frequently of type A, with better functional results and less radiological losses with an anterior arthrodesis and are pathological backs. The majority of fractures were the consequence of a fall from a high place 66.6% of the

cases (fall from scaffolding, fall from a palm tree, etc.). This is also the most frequent etiology for the Blamoutier series(15) 70%, Gajjar(16) 66%, Chua et al.(17) 51,4% and Wang et al. (3) 54,9%. The frequent association of the thoracolumbar spine fracture with other lesions indicates the importance of causal energy. This association of the thoracolumbar spine fracture with other lesions was found in 40.8% of cases which are similar to those in other groups in the literature(18–20). The vital prognosis was threatened in 22.5% of the cases affected by a cranial, thoracic and abdominal trauma; this rate is close to that of Alvine(21) who indicates the occurrence of polytrauma in 20% of the cases. Limb damage was found in 23.3% of our patients, which has also been found in other groups in the literature (20,22,23).

The extended thoracolumbar hinge from T12 to L1, with extension from T11 to L2 (24–28) is a transition zone between a rigid dorsal spine and a mobile lumbar spine. In our group, the anatomical hinge is the most affected one; it represents the site of 68.3% of fractures; this was found in most of the reported series(28–31) (Table 3).

Table 3. level of injury according to the literature

	Thoracolumbar hinge (%)	Lumbar (%)
Steib (29)	90	10
Alvine (21)	71	29
Chatellier (22)	79	21
Our series	**68.3**	**31.7**

The anatomical hinge, unlike the functional hinge which allows the transition between two spinal curvatures, low located in Roussouly's(5,6) (4,5) backs types I and II (located in L4 and L5), and identical to the anatomical hinge in backs types III and IV.

In our series, the fractures affected the hinge in 80.3% of the Roussouly types III and IV backs, which is in conformity with the literature (29–32), while for types I and II, only 55.9% were located at the anatomical hinge; the rest (44.1%) of the fractures involved the lumbar level. This is explained, on the one hand, by the dynamic effect of backs types III and IV and the static effect of the backs of types I and II, and on the other hand, by the mechanism of fractures often in axial compression in stiff backs types I and II and in flexion posterior distraction in flexible backs types III and IV.

Many classifications concerning thoracolumbar fractures have been used in the literature. Some are based on the mechanism and type of fracture, such as the classification of Magerl (34) and that of Denis(35).Others are based on scores calculated from the neurological state, the anatomopathological type of the fracture and the state of the posterior ligament complex, such as the classification of TLICS advanced by Vaccaro(36). Load Sharing Scoring is made up of a score calculated from the degree of compaction of the vertebral body(37). According to Magerl classification, we noticed that type A of Magerl was observed in 73% for back types I and II and 54% for backs types III and IV and the noted difference is statistically significant (p = 0.033). We conclude that important energy causes simple fractures on stiff backs.

The evaluation of the pain symptomatology according to the Denis Pain Scale concluded that patients with types I and II backs have better functional results than patients with types III and IV backs (p = 0.01). This result can be explained by the arthrodesis performed added to the stiffness of those back. As to the radiological results (table 4), the reduction in vertebral and loco-regional deformities obtained after a posterior surgical treatment differs from one series to another.

Table 4. Radiological results in the literature

Series		ART		GSKD		SIF	
		GR%	Loss (°)	GR%	Loss (°)	GR%	Loss (°)
Steib **(22)**		-	-	92	2.9	95	2.1
Pavlos **(34)**		-	-	72	2.8	77	2.2
Our series	**Backs type I and II**						
		67	**2.1**	**87**	**1.2**	**85**	**1.5**
	Backs type III and IV	**129**	**3.2**	**131**	**3**	**161**	**2.8**

ART : Regional Traumatic Angulation ; **SIF** : Sagittal Farcy Index ; **GSKD** : Gardner Segment Kyphotic Deformity ; **GR** : Relative gain

We noticed that the types I and II backs of our series are hypo or normo-corrected and make less loss of correction than the back types III and IV which are hyper-corrected. The difference in terms of relative gain (GR) and loss of correction between these 2 groups is statistically significant (p <0.05). We agree with Roussouly's ideas that backs of types I and II are considered pathological and that we should not try to hyper correct these varieties of backs. Unlike the type III and IV backs, the harmony of the curvatures requires hypercorrection to avoid the losses observed at the last retrospect. In fact, it was observed on the CT images that these low pelvic incidence backs considered as stiff ones are pathological backs on radiological signs in favor of the aftereffects of Schuermann's disease. This confirms our per-operative findings that showed degenerative phenomena affecting the posterior ligament complex (yellow ligament, inter-spinous ligament, joint capsules). This confirms the static character of these spinal columns.

Conclusion

Our study has demonstrated a notable correlation between the type of spine, as classified by Roussouly, and the type of thoracolumbar fracture sustained, particularly highlighting that patients with "stiff" spines (Roussouly types 1 and 2) are more prone to Type A Magerl fractures. These findings have significant implications for clinical presentation and management, underlining the necessity for spine surgeons to consider the Roussouly classification when planning surgical interventions.

"The authors declare that they have no conflict of interest".

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