

Surgical treatment of thoracolumbar spine fractures Tratamento cirúrgico das fraturas da coluna toracolombar

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ABSTRACT

Objective: To evaluate the indications and results of the surgical treatment of thoracolumbar fractures. **Methods:** Our series consisted of 64 patients (22 women and 42 men, with a mean age of 43 years) with unstable spinal fractures treated operatively in 2001 in our institution. Patients with multiple fractures, osteoporosis and spinal cord injury were not included in this study. Three subgroups were identified according to the surgical approach. 1) 22 patients operated through anterior approach. 2) 22 patients was operated by combined anterior-posterior approach. 3) 20 patients treated by isolated posterior approach. All patients were preoperatively investigated by plain X-ray, CT and MRI. Classification was performed after complete imaging. Patients with posterior column intact were indicated for anterior approach and patients with posterior column injury were indicated for posterior approach. The extent and severity of damage in anterior column was classified according to LSC in all cases. Six and more points in this classification meant that anterior approach must be added to the surgical treatment. The patients were followed for at least 22 months after operation. Transpedicular fixator, when applied exclusively, was routinely removed after fracture was healed. The end-plates angle of the fractured vertebra was assessed after operation and at the end of follow-up. **Results:** Type B fractures were most frequent in our series and occurred in 29 patients. Neither instrumentation failure nor any significant loss of reduction was observed in the first and second groups. In the third group, mean loss of reduction was 3,1°. **Conclusion:** Progress in imaging technologies provokes the changes in use of traditional classification schemes. We can conclude that adequate imaging examination (X-ray, CT, MRI) is crucial for accurate fracture classification including prognostic aspects. Classification viewed in this fashion is the adequate guideline for the selection of the operative approach. Properly selected surgical approach is effective in the prevention of operative treatment failure.

KEYWORDS: Spine; Spinal fractures; Fractures/classification

RESUMO

Objetivo: analisar as indicações e os resultados do tratamento operatório das fraturas toracolombares. **Métodos:** a casuística foi composta por 64 pacientes (22 mulheres e 42 homens), com média de 43 anos, com fraturas instáveis da coluna vertebral, submetidos a tratamento operatório. Os pacientes com fraturas múltiplas, osteoporose e lesões medulares não foram incluídos. Foram criados três subgrupos, segundo a via de acesso cirúrgico: 1) 22 pacientes operados por via anterior; 2) 22 pacientes em que foi utilizado o acesso cirúrgico combinado, posterior e anterior; 3) 20 pacientes em que foi utilizado o acesso posterior. No pré-operatório foi realizada a avaliação radiográfica convencional da coluna vertebral, tomografia computadorizada e ressonância magnética em todos os pacientes. Nos pacientes com a coluna posterior intacta foi utilizado o acesso operatório anterior e, naqueles com lesão da coluna posterior, o acesso posterior. A extensão e a gravidade da lesão da coluna anterior foi classificada pela metodologia Load Sharing Classification – LSC. Os pacientes foram acompanhados por, no mínimo, 22 meses após a operação. Quando foi utilizado o fixador transpedicular, exclusivamente, este dispositivo foi retirado assim que se observou a consolidação da fratura. O ângulo da placa terminal da vértebra fraturada foi medido no pós-operatório imediato e ao final do seguimento do paciente. **Resultados:** as fraturas do Tipo B foram as mais comuns em nosso grupo, ocorrendo em 29 pacientes. Não foram observadas falhas na instrumentação da coluna vertebral nem perda da redução nos pacientes dos primeiro e segundo grupos. No terceiro grupo, houve perda da redução de 3,1° em média. **Conclusão:** o progresso da tecnologia dos exames por imagens da coluna vertebral provocou uma alteração nas classificações tradicionalmente utilizadas para as fraturas toracolombares. A nova classificação, baseada nos modernos recursos auxiliares ao diagnóstico, é um excelente indicador para a seleção da via de acesso operatório a ser empregada. A seleção apropriada da via de acesso operatório é efetiva para a prevenção de falhas do tratamento escolhido.

DESCRIPTORIOS: Coluna vertebral; Fraturas da coluna vertebral; Fraturas/classificação

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INTRODUCTION

Spinal column injuries represent approximately 3% of all trauma cases and 10% of spine injuries are accompanied by injury to the spinal cord. Seventy-five per cent of all spine injuries occur in the thoracolumbar segment. Epidemiological studies show that these injuries affect mainly younger age groups of patients. Also data from our group, consisted of 844 patients with mean age 39 years, underline social and economical impact of these injuries and of results of their treatment.

Significant changes have been made in the algorithm of treatment of spine fractures during the last 15 years. Surgical treatment is now offered not only to patients with spine injuries accompanied with spinal cord lesion, but also to injuries where instability and subsequent deformity is expected. The understanding of principles of spinal column stability and pathophysiology of trauma mechanism is essential for the accurate treatment decision.

Spinal Column Stability

Theory of spinal column stability explains the behaviour of different segments under load pressure and what role does each segment play in spinal column stability. Definition of spinal column stability is given as "ability of the spine to maintain its integrity and correlations between vertebrae under physiological load, so there is no initial or additional compromise to the spinal cord and other neural structures"¹. Assessment of fracture stability and its optimal treatment is based on this definition. Fracture is considered stable if it is able to resist physiological compression, distraction and rotation forces acting on posterior structures, e.g. if the spinal column is able to protect neural structures in upright position without a risk of progressive deformity. However, spinal column fractures often result in instability. Acute instability presents immediately after injury. There is a high risk of further fast and significant fragment dislocation. On the other hand, chronic instability is a slow process possibly resulting in a progressive severe deformity. In most cases this might cause segmentary kyphosis with possible destruction of neural tissue from long-time compression.

Residual fracture stability is a very important concept. Rationale of this concept is based on three-column theory, first proposed by Denis for thoracolumbar fractures², but applicable for the whole spine³. Assessment of residual stability is crucial for treatment decision process. The algorithm introduced by Magerl et al.⁴ (Figure 1), determining the type of injury and its severity, is helpful for basic orientation in this selection process.

• Diagnostics

Technology of spine fracture imaging has significantly improved in the last years. Nevertheless, the value of

high-quality X-ray is still essential in projection of basic shape parameters of spine and fracture and it is also the most accurate tool for evaluation of treatment results.

Computer tomography (CT) depicts perfectly the whole vertebra and is an important guide for surgical planning. It gives information about bone fragments within the spinal canal. There is so far no other imaging technology that is more useful for examining the facets relation than CT. Sagittal reconstruction makes it possible to evaluate the angle of kyphosis and the shape of spinal canal narrowing.

Magnetic resonance imaging (MRI) is dominant in soft tissue imaging: intervertebral discs (herniation, laceration), vessels (thrombosis), nerves (compression, interruption) and mainly the spinal cord (oedema, ischemia, myelomalacia, haemorrhage, compression). Beside the operative revision this is the best diagnostic method for evaluation of ligamentous injury, which is very important for spine stability. As it is, the AO-ASIF classification system is not applicable in preoperative decision making without a MRI examination. There is also an important change in the use of classification systems: if there is a possibility of complex investigation of fracture with modern imaging technologies without a need of operative revision, the classification may be used as guidance for the decision of surgical approach. Thus, we are able to decide which fracture might be optimally treated from dorsal, ventral or combined approach. By adjusting the surgical plan to the fracture pattern the results of treatment might be significantly improved⁵⁻⁶.

• Classification of thoracolumbar fractures

The effort to understand the principles of spine stability lead to the theory of three columns and subsequently produced a number of classification systems that are currently in use. Holdsworth proposed his basic, two-

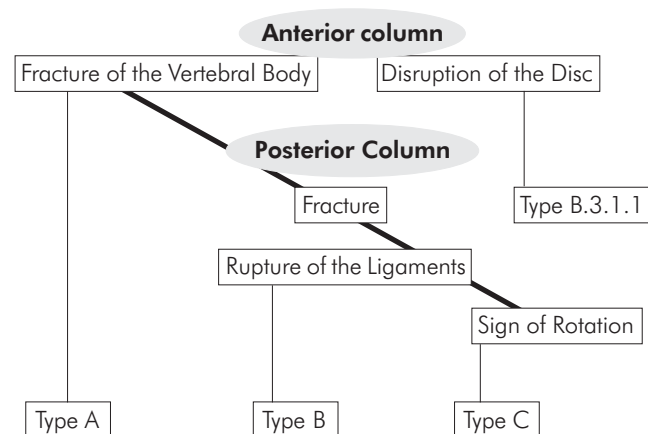


Figure 1
AO-ASIF Classification:
algorithm for determination of the injury types (Magerl et al.)

column theory in 1963⁷. Twenty years later, Denis improved this theory and published his own concept of three columns. Denis also created the classification system emerging from his theory that informs about the residual stability of spinal column for each type of fracture².

In classification published by Magerl in 1985⁸, the three-column theory is also used, with focus on injury of the middle column and location of the axis of spine rotation. This valuable classification helps to understand the character and the extent of damage of each of the spine structures. Unfortunately, this Magerl's classification has only limited potential to assess the severity of injury, the fact that led other authors to propose their modifications. Finally, a new classification was created on the basis of Magerl's concept, named "Comprehensive classification of thoracolumbar fractures" and accepted also by the Association for the Study of Internal Fixation (ASIF); therefore the abbreviation of this classification is AO-ASIF. This classification is based on anterior and posterior column theory and divides all fractures into three categories, further divided into 55 groups, which define various fractures of thoracic and lumbar spine⁴. Very important feature of this classification is the information about (in) stability of injury we are dealing with. A simple algorithm is used to assess this parameter, as shown on Figure 1, where bold arrow show the direction from stable to unstable fractures, e.g. decrease in residual fracture stability.

Blauth et al.⁹ tested the reliability of this classification. The reliability rate was 67% (41-97%) when basic categories (A, B, C) were used. High reliability was found during evaluation of A category injuries. The study revealed satisfying correlation in determining of treatment method, but in the same time pointed out, that indication of surgical approach (anterior, posterior, combined) is currently the most important goal.

"Load Sharing Classification" (LSC) by McCormack, Holt, Karaikovic and Gaines⁽¹⁰⁾, aimed on setting a guideline for indicating the method of treatment. This

classification involved only injuries to the anterior spinal column. Basis for LSC is formed on data from the group of 28 patients with three-column fracture were operated during period of 1986-1988 with transpedicular screw insertion, with 3-4 years of follow-up after surgery. There was a subgroup of 10 patients with pedicle screw breakage. Retrospective analysis of X-ray images, CT axial and sagittal reconstruction scans discovered that the risk of breakage correlated with the significant damage of the vertebral body. Subsequently, authors proposed a scoring system that considers a) the amount of damaged vertebral body, b) the spread of the fragments in the fracture site, c) the amount of corrected traumatic kyphosis. Each of these three parameters is rated with up to 3 points (Figure 2).

This classification covers also fractures of "pincer type" and "coronal split" that may be rated with 6 and more points⁶. Authors of LSC classification claim that their system allows the prediction of pedicular implant failure and to choose the best candidates for the anterior surgical approach. The AO-ASIF does not possess these prognostic attributes⁵. It does not give answer to question what fracture is more likely to loose the correction gained by operative reduction, either. Our own study confirms that AO-ASIF and LSC classification do not relate to each other because they provide different data about fracture⁶. However, this offers an opportunity to use LSC as an addition to AO-ASIF classification.

Surgical Treatment

• Indications

Following indication scheme is used by authors (Figure 3). This scheme respects the priority of protection of neural tissue. As soon as possible neural lesion is suspected and diagnosed, immediate treatment is started. Treatment is focused on spinal canal decompression and restoration of spinal column stability. In patients with a poor medical condition, cranio-bifemoral traction is considered instead.

For surgical treatment of thoracolumbar fractures, both anterior and posterior approaches may be used.

• Posterior surgical approach

Posterior approach is very fast and technically simple to carry out. It is suitable for emergency conditions and represents no excessive stress for the patient. Magerl set orientation points for pedicle screw insertion, with slight variations for thoracic, lumbar and sacral segments, respectively. Based on our own experience, we recommend AP projection fluoroscopy as more suitable for orientation. The pedicle has oval shape in this projection. The C-arm should be slightly declined towards

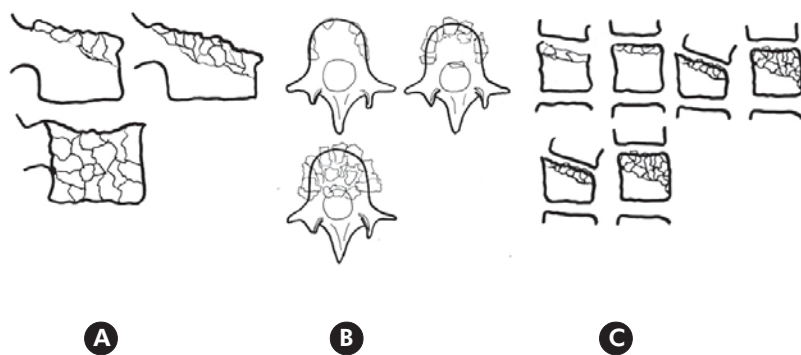


Figure 2
"The load-sharing classification" (McCormack et al.)

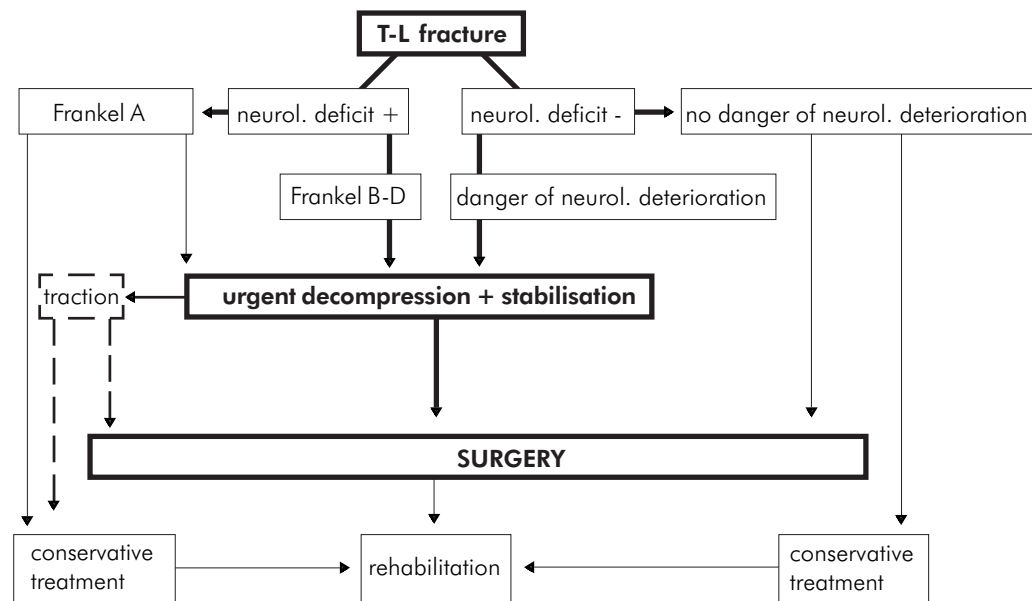


Figure 3
Diagram of the treatment of thoracolumbar fractures

sagittal plane so the screws can be inserted in convergent direction. Convergence of transpedicular inserted screws is very important for the instrumentation stability. A convergence angle of 10-20° is advised for the lumbar segment and 7-10° for the thoracic segment, respectively. One should be aware of occasional difficulty to achieve this angle in thoracic segment.

After pedicle screw insertion, a reduction and lordotisation of collapsed vertebra is performed, using the principle of ligamentotaxis¹¹. Correct position is maintained by internal angle-stable fixation.

The posterior approach enables the repair of vertebral body, consisting of end-plate reduction using special device and filling of the vertebral body with bone grafts or synthetic bone replacement. We have a good experience with use of bioceramic material, which is also recommended by other authors¹². We do not perform transpedicular interbody fusion.

Result of the reduction is displayed on lateral fluoroscopy projection and the decompression of vertebral canal might be verified either sonographically¹³ or by perimyelography (PMG) that has an advantage of continual observation of dural sac shape during the procedures done on vertebral body and control the dural sac integrity.

In case of ineffective fragment distraction (ligamentotaxis) and persistent significant narrowing of vertebral canal, an open revision is indicated to deliberate the vertebral canal. Hemilaminectomy or, rarely, laminectomy approach is used. Fragments are pushed back into the vertebral body or removed under fluoroscopy control (with simultaneous PMG).

• Anterior approach

As the injury has a major impact on vertebral body, the antero-lateral approaches play necessarily an important and logical role in surgical treatment of spine fractures⁽¹⁴⁾. Some authors prefer this approach¹⁵⁻¹⁷. A significant progress has been made in operative technique of this approach during the last years. It is, of course, necessary to keep in mind that these procedures are far more extensive when compared to the posterior approach and as such less suitable for emergency conditions.

The role of these approaches is increasing due to more precise diagnostics and fracture classifications. Thus, isolated anterior approach might be indicated more accurately (Figure 4).

Modern surgical technology contributed also to introduction of less invasive procedures. There is a significant move from large surgical incisions to endoscopic techniques.

The intervertebral space is filled usually with autologous tricortical iliac graft, alternatively with allogeneous femoral/tibial diaphysis grafts or specially designed metallic cages filled with spongy bone, respectively. Expandable cages have been used since recently for vertebral body replacement. These might help to correct the kyphosis and to gain the primary stability.

• Combined approach

Patients in good general condition, in whom anterior approach is not contraindicated (due to osteoporosis, multiple fractures, acute neural lesion etc.), may be offered surgical treatment based on criteria respecting the residual vertebral stability. According to this

concept, isolated anterior approach is chosen for isolated fractures of anterior column (type A). Analogically, fractures of posterior column (type B and C, respectively) are treated using posterior approach. However, injuries of posterior column are often accompanied by injury of anterior column, which must be treated too. Combined surgical approach gives the best long-term results regarding the correction maintenance¹⁸.

There are two options available: either transpedicular fixation or anterior approach (using open exploration or endoscopy). Indication and extent of surgery is determined by surgeon's experience. Nevertheless, additional objective criteria are needed provided by LSC (see above)^{6, 11}. Selection of approach determined by classification scheme has proved to be useful in our experience.

As any other surgery, also spinal procedures bear specific risks¹⁹. Even modern surgical technologies cannot prevent complications. These might be best avoided by experienced and highly educated surgeon with daily practice in treatment of spine fractures.

• Patients sample

In 2001, Spine team of the Liberec Regional Hospital treated surgically 64 patients with unstable spine fractures. Patients with multiple fractures, osteoporosis and spinal cord injury were not included in this study. The series consisted of 22 women and 42 men, with a mean age 43 years. Three subgroups were identified according to the surgical approach. First subgroup

consisted of 22 patients operated through anterior approach. Second subgroup (22 patients) was operated by combined anterior-posterior approaches. 20 patients treated by isolated posterior approach formed the third subgroup.

METHODS

All patients were preoperatively investigated by plain X-ray, CT and MRI. Classification was performed after complete imaging evaluation. Patients with posterior column intact were indicated for anterior approach and patients with posterior column injury were indicated for posterior approach. The extent and severity of damage in anterior column was classified according to LSC in all cases. Six and more points in this classification meant that anterior approach must be added to the surgical treatment. The patients were followed for at least 22 months after operation. Transpedicular fixator, when applied exclusively, was routinely removed after fracture was healed. The end-plates angle of the fractured vertebra were assessed after operation and at the end of follow-up.

RESULTS

Type B fractures (29 cases) were most frequent in our group of patients. Review of diagnoses, fusion extent and LSC points in all three subgroups is shown in Table 1.

Neither instrumentation failure nor any significant loss of reduction was observed in the first and second groups. In the third group, mean loss of reduction was 3,1°.



Figure 4

Compression fracture of L1 – endoscopic stabilization with tricortical bone graft. A) Pre-OP lateral X-ray. B) CT scan L1. C) MR study – T1, T2 and STIR. D) Post-OP lateral X-ray

TABLE 1 - Patients characteristics

Anterior approach group 1 N=22	AO-ASIF	N	
	A	22	
	Fusion	N	LSC
	1 sgm	10	x
Combined approach group 2 N=22	2 sgm	12	x
	AO-ASIF	N	
	B	13	
	C	9	
Posterior approach group 3 N=20	Fusion	N	LSC
	1 sgm	9	6.4
	2 sgm	13	8
	AO-ASIF	N	
Posterior approach group 3 N=20	B	16	
	C	4	
	Fusion	N	LSC
	x	x	4.8

DISCUSSION

AO-ASIF classification cannot be accurately used preoperatively unless the MRI is performed. Leferink et al. stressed the fact that 30% of type B fractures are initially overlooked²⁰.

The AO-ASIF classification has only limited predictive value with regard to possible loss of reduction and instrumentation failure⁵. "Load sharing classification" (LSC)⁽¹⁰⁾, on the other hand, aims on this prediction. As these two classification schemes describe different attributes of fractures⁶, their combination might result in fracture characteristics with a good predictive value.

The surprisingly high proportion of type B fractures is probably due to very high sensitivity of MRI. It is obviously

desirable to further elaborate the use of this diagnostic method to reliably detect real unstable injuries among many other pathological findings. Nevertheless, the high sensitivity guaranteed the safety of the fracture management.

Data from literature show that isolated posterior stabilization has a higher risk of loss of reduction and instrumentation failure^{5,10, 18}. Lower percentage of loss of reduction in our group of patients correlates well with low LSC score in patient subgroup treated with isolated posterior approach.

This concept of selection of surgical approach is limited in several aspects. We do not use it in cases where posterior approach is obviously a method of choice (osteoporosis, multiple vertebral fractures and emergency operations for acute spinal cord injury). It is also advisable to keep in mind specific features of anterior approaches, which have more relative and absolute contraindications with respect to patient's general condition.

CONCLUSION

Progress in imaging technologies provokes the changes in use of traditional classification schemes. Along with development in surgical treatment of thoracolumbar fractures (operative technique, angle-stable implants, vertebral body prostheses), this is the basis for change of view on indications of surgical approaches.

We can conclude that adequate imaging examination (X-ray, CT, MRI) is crucial for accurate fracture classification including prognostic aspects.

Classification viewed from this point of view is the adequate guideline for selection of operative approach.

Properly selected surgical approach is effective prevention of treatment failure.

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