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REVIEW ARTICLE */ DERLEME*

COMPREHENSIVE MANAGEMENT OF TRAUMATIC THORACOLUMBAR VERTEBRAL FRACTURE

TRAVMATİK TORAKOLOMBER OMURGA KIRIĞININ KAPSAMLI YÖNETİMİ

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SUMMARY

The middle section of vertebral spine is composed of three dimensional trabecular networks of rods and plates. This trabecular structure ensures 90 % of the compressive strength especially in the lumbar vertebrae. Moreover, bone marrow inside the trabecular network increases the compressive strength and energy absorption. Anterior components of the vertebral column (cylindrical vertebral body and disc) resist compressive forces while posterior ligamentous elements resist tensile forces. Anterior and posterior elements also enable resistance to diagonal and rotational forces and bending moment.

Key words: Thoracolumbar fractures, ossification, vertebrae

Level of evidence: Review article, Level V

ÖZET

Vertebral omurganın orta bölümü çubuk ve plakaların oluşan üç boyutlu trabeküler ağından oluşur. Bu trabeküler yapı özellikle bel omurları içinde basınç dayanımının % 90'ı sağlar. Ayrıca, trabeküler ağ içindeki kemik iliği basınç dayanımı ve enerji emilimini artırır. Belkemiğinin anterior bileşenleri (silindirik vertebral gövde ve disk) sıkıştırıcı kuvvetlere karşı direnç sağlarken, posterior ligamantöz elemanlar gerilme kuvvetlerine karşı direnç sağlar. Anterior ve posterior elemanlar diyagonal ve rotasyonel kuvvetlere ve eğilme momentinede direnç sağlar.

Anahtar Kelimeler: Torakolomber bölge kırıkları, kemikleşme, omurga

Kanıt Düzeyi: Derleme, Düzey V

INTRODUCTION:

The middle section of vertebral spine is composed of three dimensional trabecular networks of rods and plates (32).Thoracolumbar ossification starts at the lower thoracic area and spreads to the proximal and distal areas. Thoracolumbar vertebrae develop to the adult levels in terms of biomechanics and fracture risk between 8-10 years of age. At the age of 15 the vertebrae gains adult morphological characteristics (18,28).

Thoracolumbar fractures are seen more frequently in males between 20-40 years compared to females (12,21,31). In the USA, approximately sixteen-thousand patients per year suffer from spinal column injuries (14). In a multi-centered study conducted by the Scoliosis Research Society, it was reported that 52 % of thoracolumbar fractures were between T11-L1, 32 % between L2-L5 and 16 % between T1-T10. In a study on 1446 thoracolumbar fractures, Magerl and Engelhardt showed that 28 % of the fractures were seen at L1, 17% were on T12 and 14% were at L2 (31).

Only 1-10 % of all vertebral traumas are seen in children (15). Considering that at least 50 % of the mild and moderate traumas do not refer to the hospital, and the proportion of vertebral traumas detected after autopsy is 12 %, the actual incidence of vertebral traumas in children is likely higher. Vertebral injuries are mostly observed in children younger than five years of age and older than 10 years of age.

The incidence of spinal cord injuries without any radiological findings is seen in 5-70% of all vertebral injuries. Two thirds of cases are seen in children eight years old or younger. Patient examinations showed an instability in the vertebral column, epidural hematoma, cord rupture, necrosis, atrophy, edema, infarction, contusion, with 20 % of these symptoms being treatable (50). Later development of the lesions following trauma and its progression are signs of poor prognosis.

Studies have reported that the most frequent reason of thoracolumbar fractures is traffic accidents (50 %). Other reasons include falling from a high place (21 %), injuries by sharp objects or gunshot (11 %), sports-related injuries (10 %) and other (8 %) (38,43).

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EXAMINATION FINDINGS:

In the examination of vertebral traumas, ecchymosed, skin abrasion, open wound, swelling, hematoma, displacement of vertebral line and gaps between the spine disc protrusions should be inspected. Most patients with vertebral injuries are often polytraumatic, therefore, vertebral injuries may be overlooked at the initial examination (13). Anderson et al reported that 23 % of thoracolumbar fractures were diagnosed after patients left the emergency clinic (5). Dai et al also reported that in 19 % of polytraumatic patients, the diagnosis of thoracolumbar fractures was delayed (10). Thoracolumbar fractures are often overlooked due to other required examinations before thoracolumbar radiography in emergency patients (34). More recently, with the routine use of computed-tomography (CT) in polytraumatic patients, delayed diagnosis of vertebral fractures is very rare (19,40).

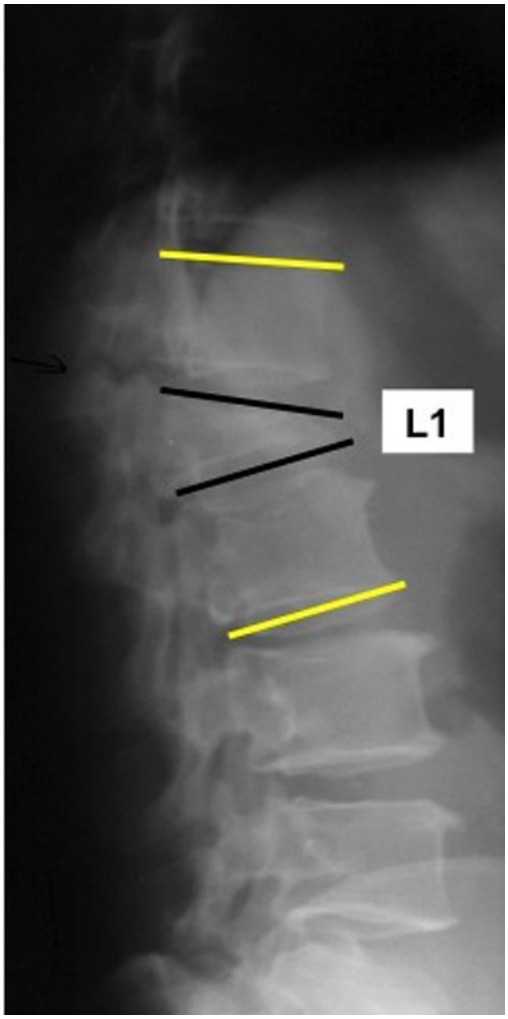

Figure-1. Preoperative sagittal index at L1 vertebra segment was 25 degrees.

The neurological examination of the patient should be performed and recorded carefully, otherwise changes in a patient's neurological condition may not be appreciated, resulting in inaccurate treatments. The American Spinal Cord Injury Association registry form is widely used for neurological evaluation (13).

RADIOLOGICAL EVALUATION:

Sagittal index is significant for the evaluation of kyphosis deformity seen in vertebral fractures. This is calculated on lateral graphs. The sagittal index angle is obtained by substracting the normal kyphosis angle from the measured kyphotic angle (sagittal index=kyphotic angle-normal physiological angle). It is important to know normal physiological angles for measuring sagittal index. These angles are 5º between T1-T11 in the dorsal region; 0º in T12 and L1 and 10º between L2-L5 in lumbar region. A sagittal index up to 15º- 20º is considered normal (Figure-1).

In spine trauma patients, radiological evaluation is performed with standard anteroposterior (AP) and lateral radiographs obtained from both sides. In the AP graphs, loss of lateral vertebral body height, changes in the vertical and horizontal interpeduncular fossa, asymmetry in the posterior structures, luxation in costotransverse joints, perpendicular or oblique fractures in the dorsal structures, irregularity between the spinous protrusions and in the lateral graphs sagittal image, compression degree of the vertebral body, deformation of the posterior line of the vertebral body, dislocation of dorsoapical fragments and height of the intervertebral gap should be evaluated (8).

The sensitivity and specificity of CT is higher than radiography therefore CT or multislice CT should be preferred after the general condition of the patient is stabilized (48). Myelography on its own, or with CT, may identify the compression force on the channel.

MR is important in the evaluation of soft tissues (35). If there is no neural deficit, MR is not essential in the acute phase, but, in the presence of a neural deficit, MR may be used to visualize a cord lesion or epidural hematoma and compression due to the disc or fracture fragments. In the T2-weighted MR images, increased signal in the spine indicates edema and decreased signal is indicative of a hematoma (Figure-2).

CLASSIFICATION:

In the vertebral injuries different classifications were defined according to fracture morphology and stability using the Holdsworth classification, Ferguson-Allen classification, Denis classification and

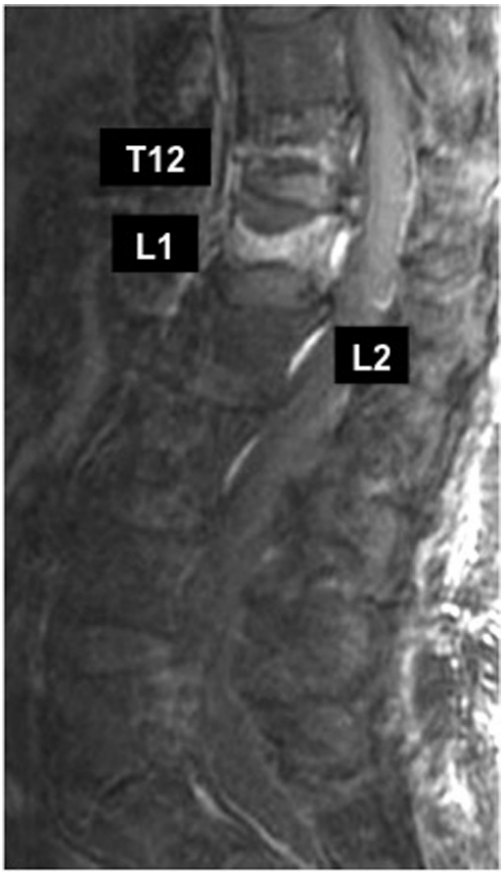

Figure-2. Acute T12-L1 and chronic L2 osteoporotic vertebral compression fractures is shown in the same MRI image. In acute fractures there is typically abnormal contrast enhancement seen on T1 weighted scans with fat saturation.

AO classification Denis classification and AE classification, defined by Magerl, are the most commonly used classifications today (12,17,30).

In the Denis classification, each vertebra is examined as a three-column model. The anterior column is comprised of 2/3 of the anterior vertebral corpus, 2/3 of the intervertebral disc and the anterior longitudinal ligament. The middle column is comprised of 1/3 of the posterior vertebral corpus, 1/3 of posterior intervertebral disc and posterior longitudinal ligament. The posterior column is comprised of the arcus vertebral region from the pedicules and the posterior ligamentous complex (ligamentum flavum, interspinous and supraspinous ligaments). In the classification, the middle column is accepted as the central structure and the classification is made according to the middle column (12).

The AO classification was described by Magerl based on two-column theory, and further defined by Holdsworth, Kelly and Whitesides (17,47). According to this theory, the anterior column consists of the corpus vertebrae and intervertebral disc and the posterior column is composed of the pediculus, lamina, facet joints and posterior ligamentous complex. The anterior column carries the weight and the posterior column bears the tension. In a study of Leibl et al, AO classification was found to be superior to the Denis classification in the decision of treatment (27).

TREATMENT:

Stabilization of the fractured spine is crucial for treatment (3). In the literature, these types of fractures were treated with different procedures, such as a conservative treatment and early surgical treatment. Factors affecting treatment results are fracture type, fracture location and the presence of neurological loss. The severity of thoracolumbar injuries is scored by the TLISS scale which was described by Vaccaro et al.

The questions that need to be answered before starting the treatment of thoracolumbar vertebral fractures are:

1) Is there a neurological defect?

2) Is the neurological defect progressive?

3) Is there a spinal instability due to the fracture?

4) Is there a damage at the posterior ligaments?

5) Is there disc damage?

Conservative treatment:

Radiological image loss detected in the conservative group is fast in the first year, therefore, there is a risk of mechanical instability within the first twelve months. This should be considered during the follow-up period of cases. Nonetheless, there are orthopedists suggesting conservative treatment of thoracolumbar burst fractures (33,46).

According to Krompinger, lack of neurological deficit, channel intrusion less than 50% and a kyphotic angle smaller than 30^0, are necessary for conservative treatment (25). According to Reid, patients with a kyphotic angle smaller than 25^0, without any pathological condition preventing replacement device use, and patients who could adapt to the conservative treatment protocol qualified for conservative treatment (39). But for Denis and Alici, all burst fractures are instable, and therefore they should be treated surgically (4,11).

There are complications of conservative treatment such as neurological loss, progressive channel intrusion, progressive body collapse and progressive kyphotic changes.

Surgical Treatment:

There are some advantages of surgical treatment, including: early mobilization, anatomical reduction of fracture, maintaining spinal alignment and quick recovery of the neurological functions (2,4,11,22).

With surgical treatment, it is aimed to ensure the decompression of the spine and cord, the restoration of physiological and topological interaction of the spinal channel, mono/oligo segmental correction/reconstruction of anterior and posterior vertebral columns, the management of immediate and postoperative long-term stability of corrected areas without disturbing neighboring undamaged segments and the achievement of durable, reliable and fast bone fusion (7).

Common Surgical Procedures:

1. Anterior decompression + anterior fusion (costa/fibular allograft)

2. Anterior decompression + anterior fusion (autograft/allograft) + anterior instrumentation (+/- vertebral spacer/cage)

3.Anterior decompression and anterior fusion (autograft/allograft) + anterior instrumentation (+/- vertebral spacer/cage) + Posterior instrumentation+ posterior fusion (autograft/allograft) at the same session

4. Two-stage anterior-posterior approach

5.Anterior decompression + posterior decompression + anterior instrumentation + anterior fusion

6.Dorso-ventro-dorsal approach (Posterior decompression + temporal posterior stabilization + anterior decompression + anterior fusion (costa/fibular allograft) + posterior fusion (autograft/allograft) + posterior instrumentation

7.Posterior egg-shell method

8.Posterior closing wedge osteotomy (7).

There are studies suggesting the anterior approach as the best method and successful results may be obtained by using anterior instrumentation on its own (23,24). With the anterior approach, it is easier to access to the anterior and middle column compared to the posterolateral or transforaminal approaches, and structural anterior supports, which enables the deformity to be appropriately corrected and fused (1,9,24). The most significant advantage of anterior instrumentation is the inclusion of less mobile segments in the fusion area, therefore, avoiding iatrogenic damage in the adjacent vertebra (6).

Posterior instrumentation after the anterior procedure is a common method for protecting the grafts placed from the anterior aspect and correcting the

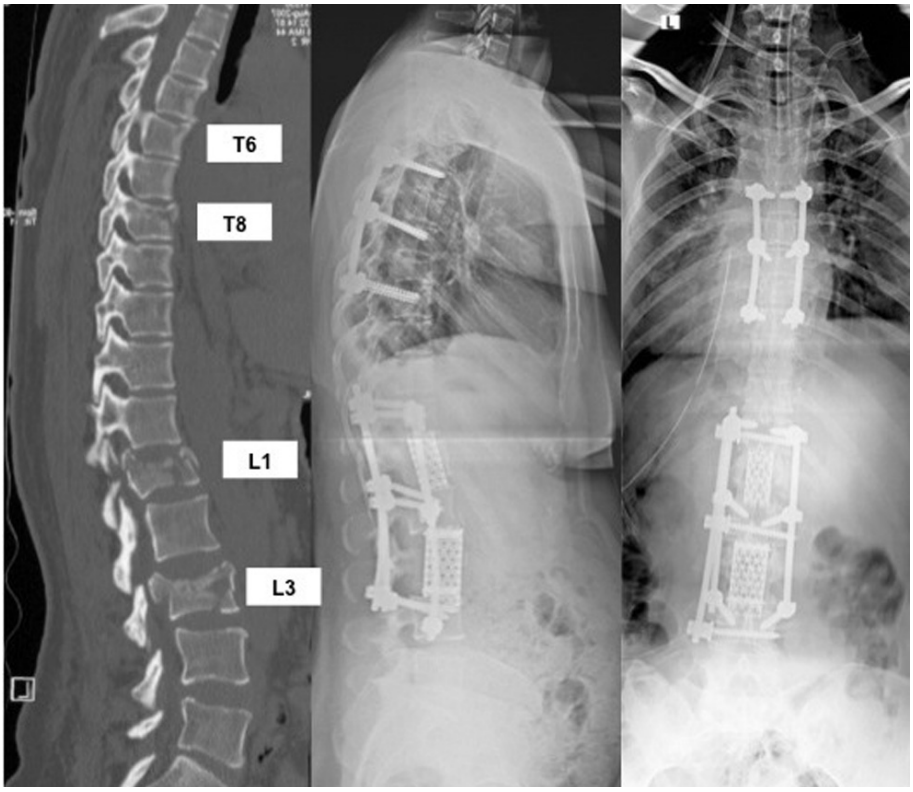

Figure-3. Multiple thoracolumbar vertebra fractures after fall form a great height treated with anterior L1 and L3 lumbar corpectomy and fusion with thoracic and lumbar posterior instrumentation.

vertebral instability (36,41). The complications of the anterior surgery may be related to the surgical procedure, decompression of neural structures and stabilization of the spine (23,26,29).

Pneumothorax or hemopneumothorax may occur. Insufficient repair of diaphragm might result in postoperative respiratory problems with hernia and atelectasis. Urethral injury, thoracic lymph channel injury and spleen rupture may be seen. During the dissection of lumbar vertebra, the ecartation and tension of psoas muscle may result in the compression of the lumbar plexus between the ecartor and transverse and in neuropraxia.

A posterior approach is single stage, has a short operation time without the need of an anterior surgical approach, less intraoperative blood loss, decreased postoperative morbidity, good recovery in the sagittal axis, solid spinal stabilization and fusion with the use of a transpedicular spinal system, sufficient bone graft for fusion, and lack of anterior column insufficiency are the main advantages of a posterior closing wedge osteotomy (7).

The disadvantages of a closing wedge osteotomy include indirect neural decompression, damage of healthy posterior elements, difficulty in supporting the anterior column, necessity of long-term posterior instrumentation and the possible need for an additional anterior procedure (7) (Figure-3).

The placement of an anterior interbody graft support increases the fusion rate with load share and helps the restoration of lordosis. Interbody graft could be placed by a conventional anterior approach, posterior transforaminal or posterior lumbar interbody fusion approach (37). One of the new methods, XLIF (Extreme Lateral Interbody Fusion) has begun to be used for this purpose (36).

Channel decompression is not required for fractures without a neural deficit in children. Short term resting and early mobilization in a cast is performed. In cases with a neural deficit, compression on the spinal channel should be removed by anterior or posterolateral approach, stability should be ensured by posterior instrumentation and fusion should be performed.

There is no major difference in the treatment procedure during pregnancy. Pregnant women show good prognosis after certain diagnoses and appropriate treatment (16).

In recent years alternative treatment methods, such as vertebroplasty (VP) and kyphoplasty (KP) have been developed for the treatment of collapse fractures (49). VP and KP are developed as alternative procedures to stabilization surgery which enable anatomo-functional restoration of vertebrae with less damage and preferred for quick recovery of the symptoms and for enabling patients to return to their social-life in a short time (42,44,45) (Figure-4).

General health condition, age, trauma type, time between trauma and surgery, and experience of the surgeon all significantly affect the success rate of the treatment (20,39).

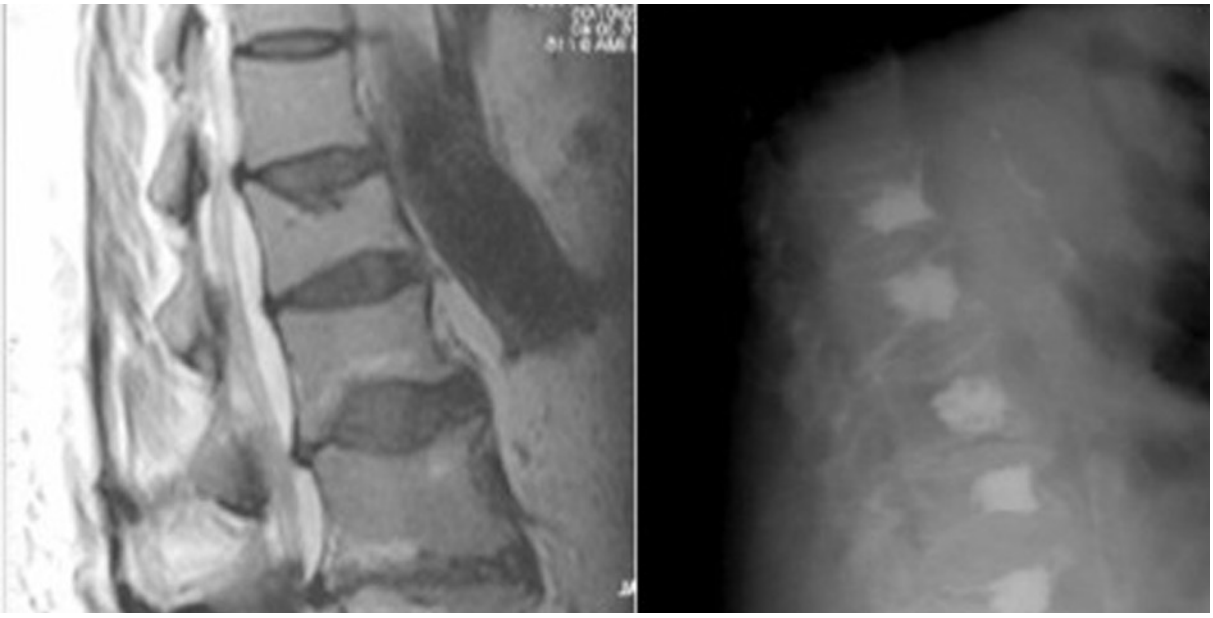

Figure-4. Sagittal T2 weight MRI imaging of the lumbar vertebrae shows acute L1-L5 and chronic T12 osteoporotic vertebral compression fractures. Vertebroplasty for acute fractures with prophylactic vertebroplasty at L2, L3, L4 levels and kyphoplasty for chronic compression fracture at T12 level were done.

REFERENCES

1- Abel R, Gerner HJ, Smit C, Meiners T. Residual deformity of the spinal canal in patients with traumatic paraplegia and secondary changes of the spinal cord. *Spinal Cord* 1999; 37: 14–19.

2- Akbarnia BA. Crandall DG. Burkus K. Matthews T. Use of long rods and short arthrodesis for burst fractures of the thoracolumbar spine. A long - term follow - up study. *J Bone Joint Surg* 1994; 76-A: 1629-1635.

3- Alici E, Berk H, Karakasli A, Gocen S. Instability of the spine fracture. *Turkish J Spine Surgery* 1992; 3: 25-30.

4- Alici E, Kininca M, Gocen S, Berk H, Aksu G. Neurological deficit in relation in the canal encroachtment. Level and type of the thoracolumbar fractures. J *Turkish Spinal Surg* 1997; 8: 39 -42.

5- Anderson S, Biros MH, Reardon RF. Delayed diagnosis of thoracolumbar fractures in multiple-trauma patients. *Acad Emerg Med* 1996; 3: 832–839.

6- Been HD, Poolman RW, Ubags LH. Clinical outcome and radiographic results after surgical treatment of post-traumatic thoracolumbar kyphosis following simple type A fractures. *Eur Spine J* 2004; 13: 101–107.

7- Bilgic S, Yildiz C, Sehirlioglu A. Posttraumatic Kyphosis. *J Clin Anal Med* 2011; 2(3): 135-143.

8- Blauth M, Knop C, Bastian L. In: Tscherne H, Blauth M (eds.) *Tscherne Unfallchirurgie*, vol 3. Springer, Berlin, 1998, pp: 241–381.

9- Bohlman HH, Freehafer A, Dejak J. The results of treatment of acute injuries of the upper thoracic spine with paralysis. *J Bone Joint Surg* 1985; 67-A: 360–369.

10-Dai L-Y, YaoW-F, Cui Y-M, Zhou Q. Thoracolumbar fractures in patients with multiple injuries: diagnosis and treatment – a review of 147 cases. 2004, 56: 348–355.

11-Denis F. Armstrong GWD. Scarls K. Malla L. Acute thoracolumbar burst fractures in the absence of neurologic deficit. A comparison between operative and nonoperative treatment. *Clin Ortop* 1984; 189: 142-149.

12-Denis F. The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. *Spine* 1983; 8: 817–831.

13-Ditunno JF Jr, Young W, Donovan WH, Creasy G. International standarts booklet for neurological and functional classification of spinal cord injury. American Spinal Cord Injury Association. *Paraplegia* 1984; 32: 90-80.

14-El-Khoury GY, Whitten CG. Trauma to the upper thoracic spine: anatomy, biomechanics, and unique imaging features. *AJR Am J Roentgenol* 1993; 160: 95–102.

15-Hadley MN, Zabramski JM, Browner CM, Rekate H, Sonntag VK. Pediatric spinal trauma. *J Neurosurg* 1988; 68: 18-24.

16-Han IH. Pregnancy and spinal problems. *Curr Opin Obstet Gynecol* 2010; 22(6): 477-481.

17-Holdsworth F. Fractures, dislocations, and fracture-dislocations of the spine. *J Bone Joint Surg* 1970; 52-A: 1534–1551.

18-Hubbard DD. Injuires of the spine in children and adolescents. *Clin Ortop* 1975; 100: 56-65.

19-Inaba K, Munera F, McKenneyM, Schulman C, deMoya M, Rivas L, Pearce A, Cohn S. Visceral torso computed tomography for clearance of the thoracolumbar spine in trauma: a review of the literature. *J Trauma* 2006; 60: 915–920

20-Keene JS, Lash EG, Kling TF Jr. Undetected posttraumatic instability of "stable" thoracolumbar fractures. *J Orthop Trauma* 1988; 2: 201–211.

21-Kelly RP, Whitesides TE. Treatment of lumbodorsal fracture-dislocations. *Ann Surg* 1968; 167: 705–717.

22-Knop C, BlauthM, Bühren V, Hax PM, Kinzl L, Mutschler W, Pommer A, Ulrich C, Wagner S, Weckbach A, Wentzensen A, Wörsdörfer O. Surgical treatment of injuries of the thoracolumbar transition. 1: Epidemiology. *Unfallchirurg* 1999; 102: 924–935.

23-Koroyesis PG, Baikousis A. Stamatakis M. Use of the Texas Scottish Rite Hospital instrumentation in the treatment of thoracolumbar injuries. *Spine* 1997; 12: 882-888.

24-Kostuik JP. Anterior Kostuik-Harrington distraction systems for the treatment of kyphotic deformities. *Spine* 1990; 15(3): 169-180.

25-Kostuik JP, Matsusaki H. Anterior stabilization, instrumentation, and decompression for post-traumatic kyphosis. *Spine* 1989; 14(4): 379-386.

26-Krompinger WJ, Fredrickson BE, Mino DE, Yuan HA. Conservative treatment of fractures of the thoracic and lumbar spine. *Orthop Clin North Am* 1986; 17: 161-170.

27-Lange U, Knop C, Bastian L, Blauth M. Prospective multicenter study with a new implant for thoracolomber vertebral body replacement. *Arch Orthop Trauma Surg* 2003; 123(5): 203-208.

28- Lewandrowski K-U, McLain RF. Thoracolumbar fractures: Evaluation, classification and treatment. Frymoyer JW, Wiesel SW (Eds.). *The Adult and Paediatric Spine*. Third Ed., Vol 2., Lippincott Williams and Wilkins, 2004; pp: 817-843.

29- Lonstein JE, Bradford DS, Winter RB (eds.). *Moe's Textbook of Scoliosis and Other Spinal Deformities*. 3rd Edition, WB Saunders, Philadelphia, 1995; 6-22.

30- Lonstein JE, Winter RW. Long multiple struts for severe kyphosis. *Clin Orthop* 2002; 394: 130-138.

31- Magerl F, Aebi M, Gertzbein SD, Harms J, Nazarian S. A comprehensive classification of thoracic and lumbar injuries. *Eur Spine J* 1994; 3: 184–201.

32- Magerl F, Engelhardt P. Brust und Lendenwirbelsäule. In: Witt AN, Rettig H, Schlegel KF (eds), *Orthopädie in Praxis und Klinik, Spezielle Orthopädie* (Wirbelsäule– Thorax – Becken). Thieme, Stuttgart, 1994; pp: 3.82–3.13.

33- Marco RW, An HS. Anatomy of the spine. *Orthopaedic Knowledge Update Spine 2* (eds), American Academy of Orthopedic Surgeons, Illinois, 2002; 7-14.

34- Mumford J, Weinstein JN, Spratt KF, Gocl YK. Thoracolumbar burst fractures - The clinical efficacy and outcome of nonoperative management. *Spine* 1993; 18: 955-970

35- Norbert Boos, Max Aebi. *Spinal Disorders Fundamentals of Diagnosis and Treatment*, Spingers, New York, 2008.

36- Oner FC, van Gils APG, Faber JAJ, Dhert WJA, Verbout AJ. Some complications of common treatment schemes of thoracolumbar spine fractures can be predicted with magnetic resonance imaging. Prospective study of 53 patients with 71 fractures. *Spine* 2002; 27: 629-636.

37- Ozgur BM, Aryan HE, Pimenta L, Taylor WR. Extreme Lateral Interbody Fusion (XLIF): a novel surgical technique for anterior lumbar interbody fusion. *Spine J* 2006; 6(4): 435- 443.

38- Polly DW Jr, Klemme WR, Shawen S. Management options for the treatment of posttraumatic thoracic kyphosis. *Semin Spine Surg* 2000; 12: 110–116.

39- Price C, Makintubee S, Herndon W, Istree GR. Epidemiology of traumatic spinal cord injury and acute hospitalization and rehabilitation charges for spinal cord injuries in Oklahoma,1988–1990. *Am J Epidemiol* 1994; 139: 37–47.

40- Reid OC, Hu R, Davis LA, Saboc LA. The nonoperative treatment of burst fractures of the thoracolumbar junction. *J Trauma* 1988; 28: 1188-1194.

41- Sheridan R, Peralta R, Rhea J, Ptak T, Novelline R. Reformatted visceral protocol helical computed tomographic scanning allows conventional radiographs of the thoracic and lumbar spine to be eliminated in the evaluation of blunt trauma patients. *J Trauma* 2003; 55: 665–922.

42- Suk SI, Kim JH, Lee SM, Chung ER, Lee JH. Anterior-posterior surgery versus posterior closing wedge osteotomy in posttraumatic kyphosis with neurologic compromised osteoporotic fracture. *Spine* 2003; 28(18): 2170-2175.

43- Theodorou DJ, Theodorou SJ, Duncan TD, Garfin SR, Wong WH. Percutaneous balloon kyphoplasty for the correction of spinal deformity in painful vertebral body compression fractures. *Clin Imaging* 2002; 26: 1-5.

44- Thurman DJ, Burnett CL, Jeppson L, Beaudoin DE, Sniezek JE. Surveillance of spinal cord injuries in Utah, USA. *Paraplegia* 1994; 32:665–669

45- Trumees E. The roles of vertebroplasty and kyphoplasty as parts of a treatment strategy for osteoporotic vertebral compression fractures. *Curr Opin Orthop* 2002; 13:193-199.

46- Watts NB, Harris ST, Genant HK. Treatment of painful osteoporotic vertebral fractures with percutaneous vertebroplasty or kyphoplasty. *Osteoporos Int* 2001; 12: 429-437.

47- Weinstein JN, Collalto P, Lehmann TR. Thoracolumbar burst fractures treated conservatively: a long - term follow - up. *Spine* 1988; 13: 33-38.

48- Whitesides TE. Traumatic kyphosis of the thoracolumbar spine. *Clin Orthop* 1977; 128: 78–92.

49- Woltmann A, Bühren V. Emergency room management of the multiply injured patient with spine injuries. A systematic review of the literature. *Unfallchirurg* 2004; 107: 911–919.

50- Wong W, Reiley MA, Garfin S. Vertebroplasty/ kyphoplasty. *J Women's* Imaging 2000; 2: 117-124.

51- Yngve DA, Harris WP, Herndon WA. Spinal cord injury without osseous spine fracture. *J Pediatr Orthop* 1988; 8: 153-159.

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