Treatment of Lumbodorsal Fracture-Dislocations

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THAT PORTION of the spine from D_{11} to L_2 inclusive is of particular interest to the surgeon because most paraplegics sustain trauma to this segment. This discussion applies to no other portion of the spine and includes remote as well as recent injuries.

The impact of indirect trauma is concentrated on the lumbodorsal area because this is the juncture between the mobile lumbar spine and the relatively immobile dorsal spine. This area contains the lumbodorsal enlargement of the spinal cord, terminating in the conus medullaris at about L_2 and a concentration of nerve roots. In this short segment of spinal column a difference of one skeletal segment represents a much wider difference in functional level of the spinal cord. Usually the L_{4-5} level of the spinal cord is at the D_{11-12} interspace; the S_2 level of the spinal cord lies at the D_{12}-L_1 interspace; the S_4 cord level overlies the L_1 vertebral body. All roots from D_{11} distal are exposed to injury over the span of these four vertebral bodies. Damage of variable degrees of reversibility may involve spinal cord or nerve roots, or both.

Without dislocation of posterior elements of the spinal column neurologic damage seldom, if ever, occurs. Because of the relationship between vertebral bodies and neural arches, ligaments binding these posterior elements together hold in the face of

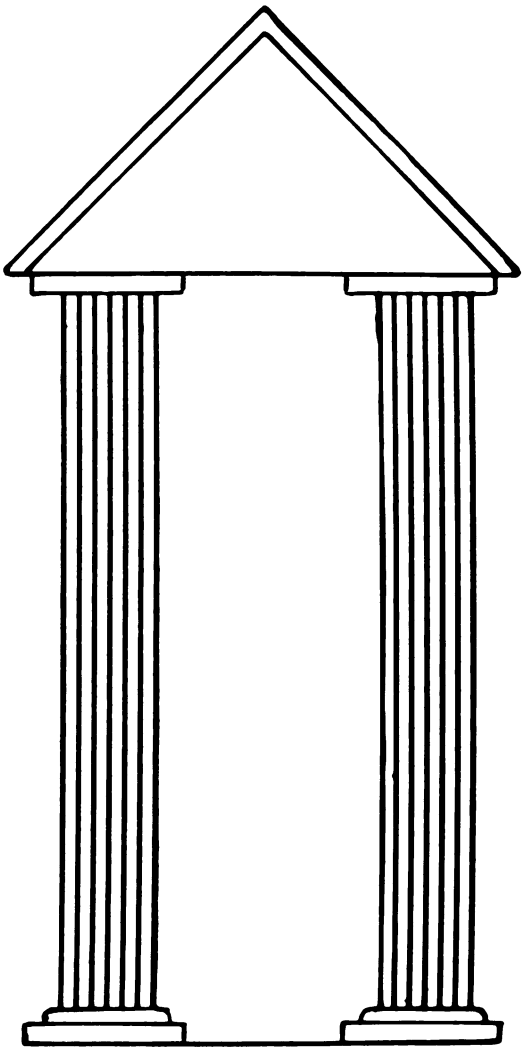

FIG. 1. Schematic representation of the two-column weight-bearing function of the spine: One column, e.g., on the right, represents the hollow column of the neural canal; that on the left, the solid column of the vertebral bodies.

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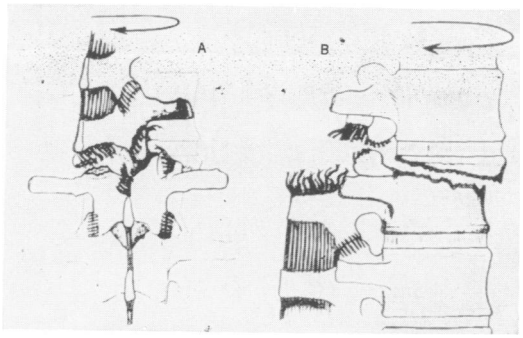

FIG. 2. From Holdsworth: A shows the appearance of the dorsal aspect of the spine with the upper segment (D_{12}) rotated approximately 45° on the lower segment. The superior facet of L_1 on the left has fractured and a pivot point has been established at the apophysial joint on the opposite side, which itself is undergoing a rotary dislocation, most of its ligaments being torn. B represents the same situation as viewed from the right side. The fracture line in the solid column is seen passing through the posterior aspect of the disc, thence along the line of "slice" through the upper portion of the body of L_1 (J. Bone Joint Surg. 45B: 6, 1963).

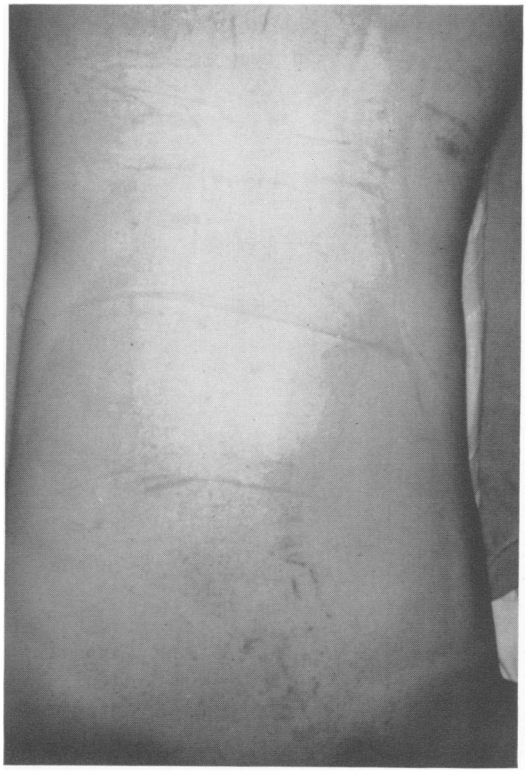

FIG. 3. (Case 6) Clinical photograph of patient on reaching the hospital. Imprint of clothes visible on back. Note abrasion over left scapula, representing the point of impact of the flexion-rotation force.

all but dislocation or extreme collapse of the vertebral bodies. The spine functions not as one column but as two—one of solid bone, one composed of neural arches. While not primarily weight-bearing, the column of neural arches has great strength and is capable of weight-bearing. Working together, these two columns support the body weight (just as the structural columns in the sketch in Fig. 1).

During and following World War II severe injuries of the spine attracted renewed interest. In the past the first decision has been regarding operation with the goal of salvaging neural function. The next decision had to do with stabilizing the spine. In the meantime efforts to prevent bedsores, control infection of the urinary tract and to rehabilitate the patient were made.

Holdsworth[8] in 1953 reported a series of 68 cases of unstable lumbodorsal injury and described a flexion-rotation fracture-dislocation (Fig. 2A, 2B) which characterized most of these injuries. Examination of the back might reveal evidence of the damaging force (Fig. 3) in the form of an imprint over scapula or buttock, and perhaps the outline of a hematoma overlying the spine. He pointed out that careful examination often will disclose the gap resulting from tear of the posterior interspinous liga-

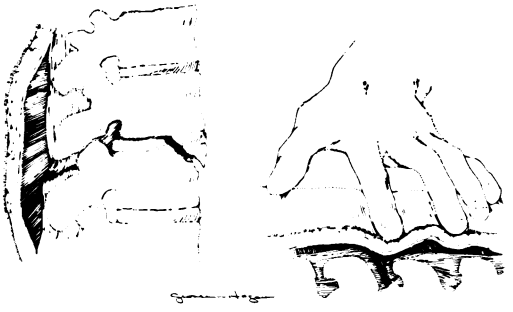

FIG. 4. A slice injury has produced the usual tear in the posterior spinous ligament along with hematoma overlying the injured area. The index finger of the palpating hand appreciates the resulting gap between the spinous processes at the affected level.

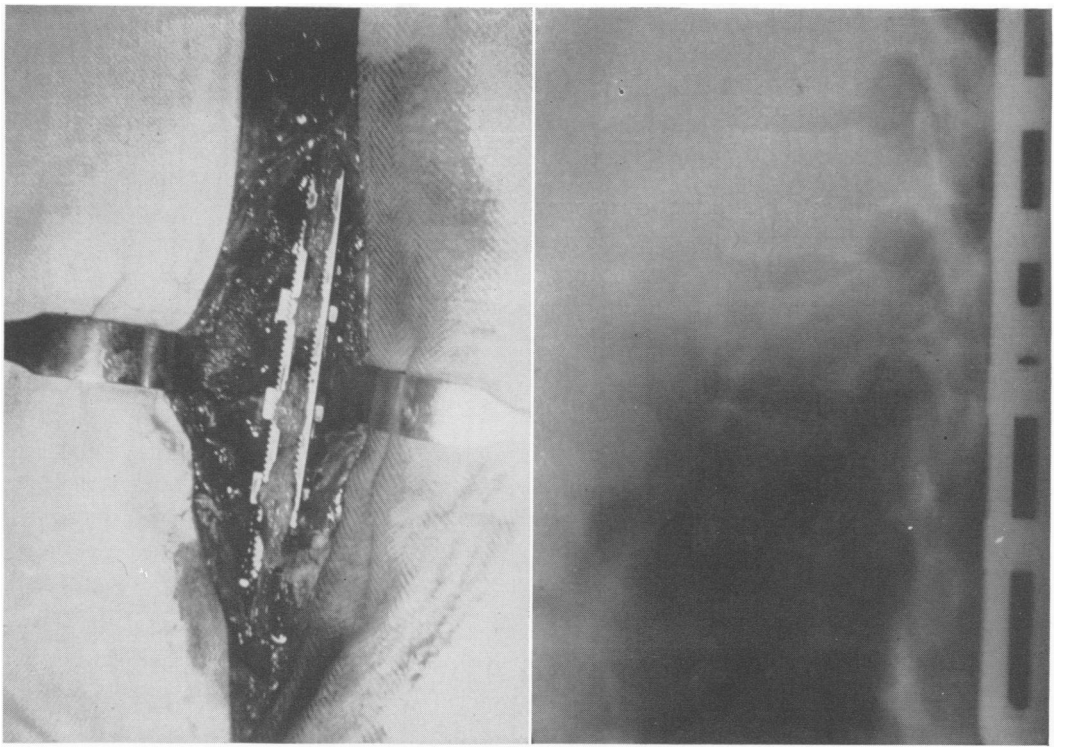

FIG. 5. Holdsworth technic of plating of spine. A. View of surgical field on completion of plating procedure. Note gap in interspinous ligament at level of fracture-dislocation, mid-portion of plated area. B. Lateral view of plated slice injury.

FIG. 6. A flexion compression fracture of the vertebral body. The posterior elements remain intact; neural structures are not jeopardized.

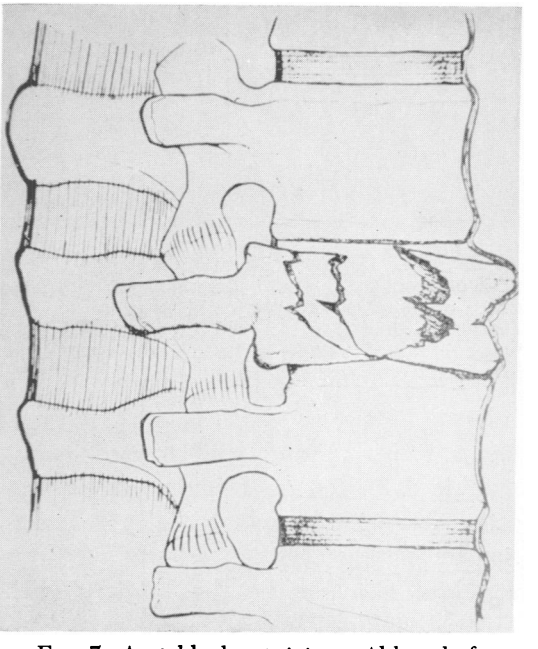

FIG. 7. A stable burst injury. Although fragments of vertebral body encroach somewhat on the spinal canal, neurologic structures remain undamaged (Holdsworth: J. Bone Joint Surg. 45B: 6, 1963).

FIG. 8A. Flexion dislocation for comparison with other types of injury illustrated here. Significance of increased intervertebral space posteriorly between L_1 and L_2 could readily be missed in this view. Identical rotary alignment of upper and lower segments well shown.

ments (Fig. 4) and lead toward radiographic definition of the injury. He advocated that with paraplegia, early stabilization by plating (Fig. 5A, 5B) of posterior vertebral elements be the primary goal. Unstable injuries which remain neurologically negative were to be stabilized by external support. Internal support in paraplegics was required because of intolerance of their tissues to constant external pressure. Acceptance of the plating proposal was limited at first but now is becoming widespread. Holdsworth makes a great point that the procedure of plating in the paraplegic should be limited to slice injuries at the dorsolumbar junction.

This form of treatment requires preservation of residual posterior elements, which virtually precludes laminectomy. From the neurologic standpoint, this course of action depends upon the validity of two premises:

1. Neural structures previously uninjured and those still possessing potential for recovery are in great jeopardy of damage by the sheering action of adjoining segments of the spine rendered mechanically independent by the injury.

2. Local impingement on spinal cord or nerve roots by a small fragment of solid material or by hematoma is a relatively minor consideration.

The possible neurologic dividend, then, in promptly stabilizing these injuries is salvage of nerve roots that have fully or partially escaped destruction and salvage of a rare portion of spinal cord that retains functional capacity. With immediate complete loss of neurologic function at the level of the injury, the most to be hoped for is preservation of some function in a limited number of nerve roots. In terms of ambulation and genitourinary function, preservation of even partial integrity of an additional nerve root may have tremendous significance.

Step-by-step progress in the surgical management of Pott's disease in the first half of the twentieth century may be credited to British surgeons. The nature of Pott's paraplegia was clarified by Butler[2] and surgical reports of first costotransversectomy, then rhachistostomy, and finally approach through more anterior routes appeared. These were contributions of Alexander,[1] Dott,[4] Capener,[3] Seddon,[9, 10, 11] and,

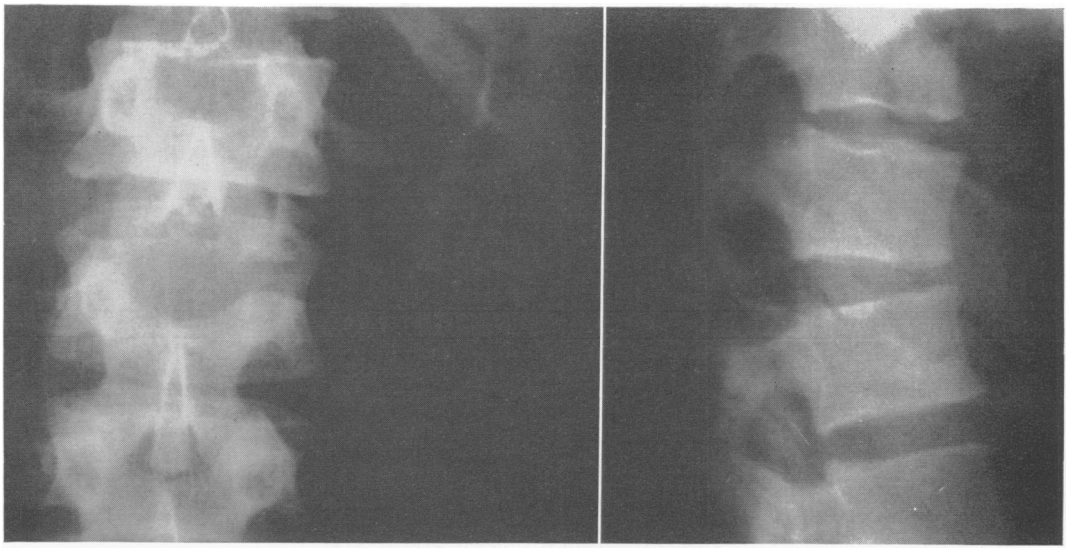

FIG. 8B. The A-P shows on the right side the inferior facet of L_1 perched on the superior facet of L_2. The superior facet of L_2 on the left has been fractured and the free fragment remains articulated with the inferior facet of L_1. A rare example of flexion injury. Patient not included in this series. Rotation element apparently absent in this injury. C. A true lateral shows the posterior opening of the intervertebral space more clearly.

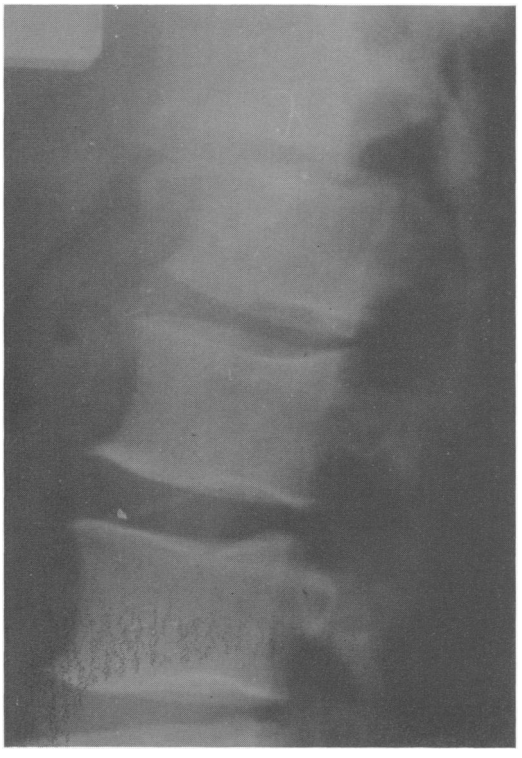

FIG. 9. (Case 1) An excellent example of flexion-rotation fracture-dislocation ("slice" injury). Note disturbed relationship of facets, anterior displacement of body of D_{12} on L_1, discrepancy in rotation between D_{12} and other bodies, and "slice" fragment from body of L_1.

with the support of antituberculous drugs, Hodgson.[5, 6, 7] The latter refined surgical procedures by developing lateral and anterior approaches to the spine.

The effect of antituberculous drugs, however, reduces the problem of Pott's paraplegia toward insignificance. In a sense, Pott's paraplegia was due to pathologic fractures which destroyed the stability of one column of the two-column system. However, increasing numbers of traumatic fractures threaten the stability of the anterior bony column and are similar threats to neural structures. When stability of the remaining posterior column is lost, the surgical technics developed for anterior surgical attack on Pott's paraplegia may be applied.

A working classification of major lumbodorsal injuries follows:

I. Stable fractures
   A. Wedging fractures
      1. Anterior wedging (flexion injuries) (Fig. 6)
      2. Lateral wedging
   B. Stable burst injuries (Fig. 7)

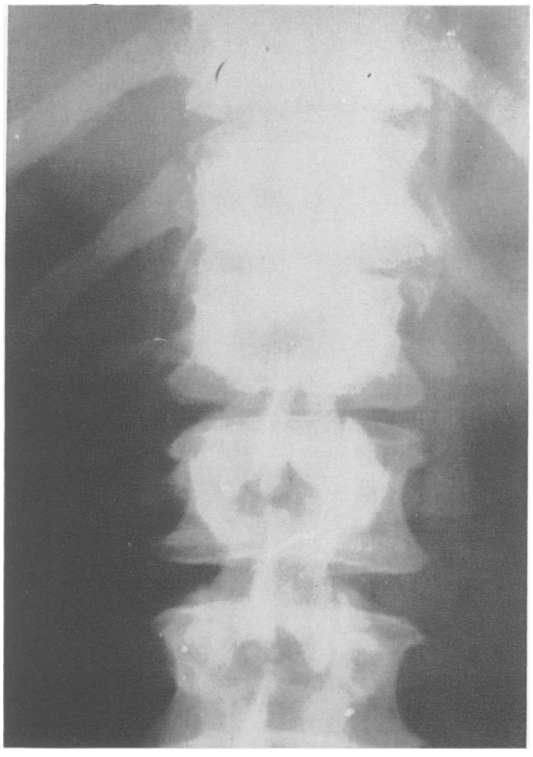

FIG. 10. (Case 1) A-P view. Disturbed alignment of spinous processes and fracture of transverse process of L_1 can be seen.

II. Unstable injuries—dislocation either persists or has been reduced.
   A. Recent injuries
      1. Flexion dislocation (Fig. 8A, 8B, 8C) Fracture generally accompanies
      2. Flexion-rotation fracture—dislocation ("Slice" injuries) (Fig. 9, 10)
      3. Others
         Unstable burst?
   B. Old injuries
      1. Stability restored
      2. Instability persists

Eleven patients who required treatment for lumbodorsal injuries with positive neurologic findings are reported.

This series includes no flexion injuries.

Case 1 (B. T., age 52): Paraplegia following slice injury. Holdsworth plating. Remobilization after minimal delay.

This 52-year-old man became immediately paraplegic when a porch fell upon him, producing a flexion rotation injury with paraplegia (Fig. 9, 10). Shortly following admission to the hospital he developed acute cholecystitis. After this subsided, open reduction and plate fixation of the spine was carried out as described by Holdsworth. Six weeks following injury he was allowed to sit erect. His rehabilitation was thereby accelerated but he gained no neurologic recovery.

Comment. Cases 2, 3, 4, and 5 followed the above pattern.

Case 6 (R. M., age 18): Slice injury with monoplegia. Holdsworth plating, followed by complete recovery.

This 18-year-old woman suffered a mild cerebral concussion and soft tissue injuries. She had

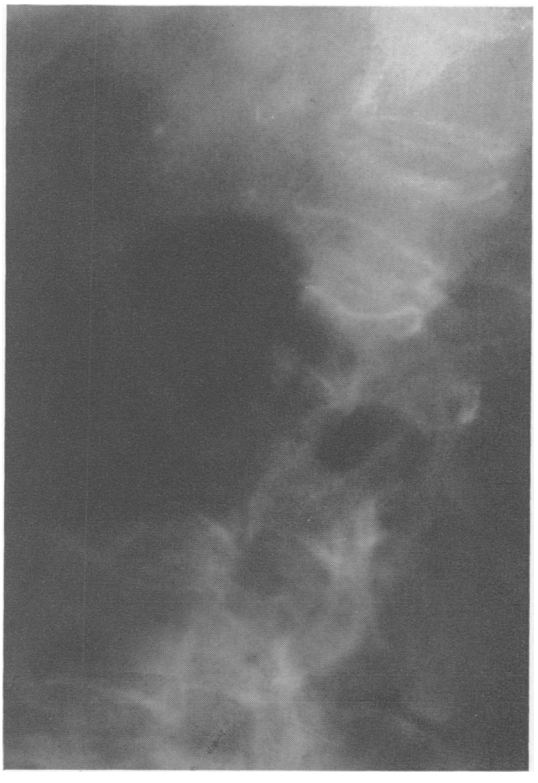

FIG. 11. (Case 7) Lateral roentgenogram of the initial compression fracture, showing anterior wedging of D_{12}.

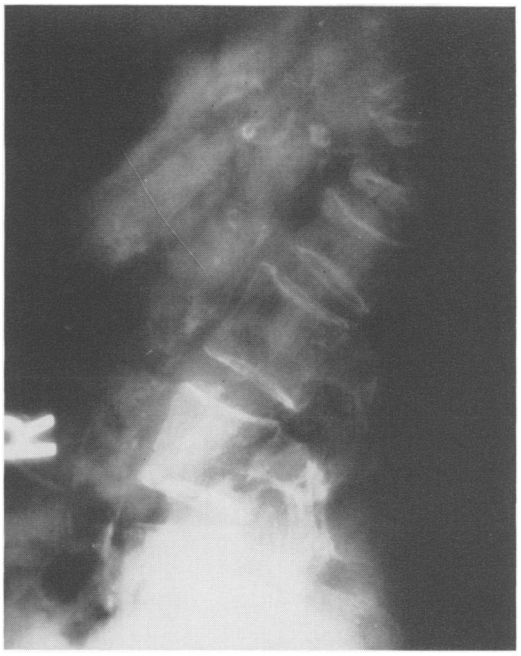

FIG. 12. (Case 7) The additional collapse developing over a period of two months. This was accompanied by subluxation of facets and an increased interval between spinous processes—failure of the posterior column (cf. Fig. 20B).

lumbodorsal pain, and orthopedic examination revealed a palpable gap between the spinous processes of D_{12} and L_1. There was a monoplegia of the left lower extremity without impairment of control of sphincters. Open reduction and internal fixation was carried out on the day of injury. Through the gap between the laminae of D_{12} and L_1 one could see an intact dura posteriorly and laterally. The spinous processes were reduced and plates applied. Within 1 week she recovered from her neurologic deficit, and 3 weeks postoperatively she was allowed to walk in a hyperextension body brace.

Comment. Unfortunately, in no other lumbodorsal injuries has a comparable neurologic recovery been attained.

Case 7 (M. D., age 72): Developed marked angulation of spinal canal as a late complication of mild compression fracture. Neurologic deficit cleared following anterior decompression and bone grafting.

This 72-year-old woman sustained a mild compression fracture of D_{12} three months previously (Fig. 11). Two months later she became acutely worse when there was further spontaneous collapse of the involved vertebral body (Fig. 18). She developed urinary incontinence and mild spasticity in the lower extremities. Medical complications were resolved, following which an anterior decompression was carried out through a transthoracic transdiaphragmatic retroperitoneal approach (Fig. 13–16 inclusive). The 12th dorsal vertebral body was excised and autogenous struts of fibula and rib were inserted (Fig. 17, 18). She had a smooth postoperative course, recovered bladder function, and the spasticity of her lower extremities cleared. Now she is ambulatory without difficulties (Fig. 19).

Comment. This patient is the first example of the applicability of technics developed in the management of Pott's paraplegia to traumatic paraplegia.

Case 8 (R. L., age 16): Laminectomy and posterior fusion following slice injury. Kyphos developed despite fusion. Neurologic deficit diminished following anterior fusion.

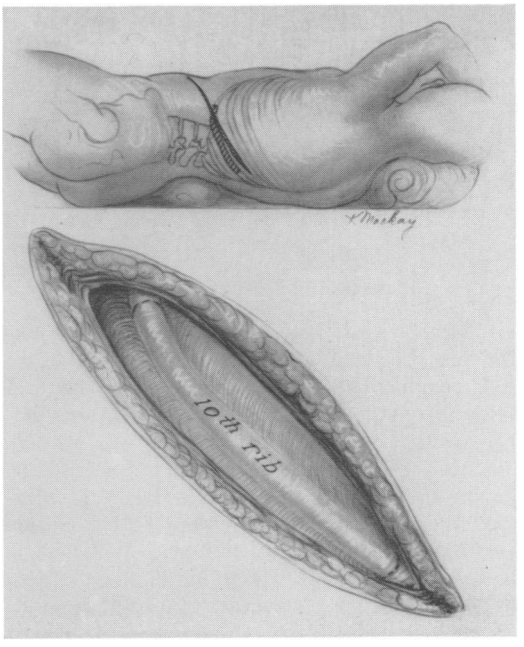

FIG. 13. The Hodgson approach to the anterior aspect of the D_{12} vertebral body. Location of the incision is shown.

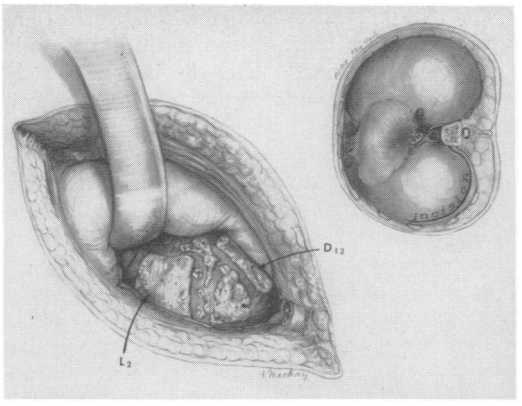

FIG. 14. The route of the incision is shown in cross-section. Close-up view shows the peritoneum and contents retracted anteriorly to expose the damaged D_{12} body.

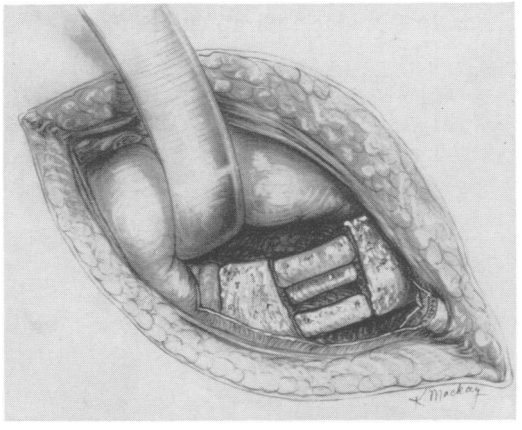

FIG. 15. Dimensions of the D_{12} body reconstructed by bone grafts.

This 16-year-old boy was transferred after earlier care elsewhere. He had suffered a slice injury with complete neurologic deficit at the level of the injury. A three-segment laminectomy was performed at that time and the dura was opened. Contusion of the cord with loose pieces of tissue floating in the dura were described in the operative report. A propping H-type iliac slab fusion was then attempted. Later, on ambulation, a kyphos developed. The posterior graft had fused at either end but had become disrupted in its center. Moreover, there had been early neurologic return in the more cephalad motor dermatomes, with retrogression as the kyphos increased. Through the anterior approach the body of L_1 was partially

FIG. 16. Photographically the same field is shown as represented in Figure 15. Note the bone graft propping apart the remaining substance of the D_{12} vertebral body.

excised and struts of fibula and rib were placed between D_{12} and L_2. These grafts consolidated and the posterior graft became reconstituted. Neurologic improvement occurred to the point at which the patient is ambulatory in short leg braces without crutches, but with persistent urinary incontinence.

Comment. The Hodgson surgical approach to the anterior aspect of the spine was applied. This patient is an example of late salvageability of nerve root function. Finally, anterior instability predisposed to non-union of the posterior graft.

Case 9 (D. B., age 26): Rotation injury at D_{11-12}. One year later persisting gross displacement on attempted sitting. Following anterior fusion, pain relieved and patient able to work regularly.

This 26-year-old man suffered a massive rotation injury at D_{11-12} one year previously. There was gross displacement, and at the level of fracture all ribs proximal on the right side were fractured. No spontaneous fusion ensued and pain accompanied efforts to assume the erect posture. Again grafting was carried out through an anterior approach. Decompression was omitted because of the longstanding displacement. Four months following opera-

FIG. 17 (Case 7) Shows grafts employed in Case 7 actually extending from L_1 to D_{11} body.

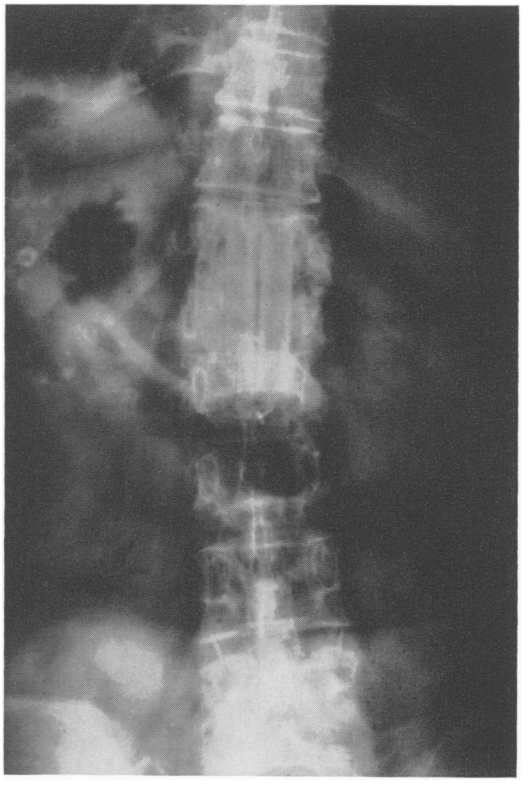

FIG. 18. (Case 7) The appearance of the same grafts in the anterior projection.

tion the patient was able to sit erect without pain. He is now participating in a training program as a dental laboratory technician.

Comment. Extensive crushing of D_{12} and displacement of the superior segment rendered the anterior column unstable and there was increasing displacement and progressive further instability.

Case 10 (C. D., age 29): Unstable burst, followed by laminectomy. Later anterior grafts were inserted, but promptly displaced due to absent posterior stability.

This 29-year-old woman suffered multiple injuries and was treated elsewhere. When she awoke from her head injury she had perineal anesthesia, sacral motor weakness, and inability to control her sphincters. Roentgenograms showed a fracture-dislocation. Following laminectomy which included removal of facets, she failed to improve. Myelogram showed a persistent block, although it had been possible at operation to pass a catheter both cephalad and caudad from the laminectomy site. Through an anterior approach the body of L_1 was excised, decompression accomplished, and fibula struts were placed from D_{12} to L_2. Despite what seemed to be a solid purchase of the grafts on the vertebral bodies, they displaced immediately on transferring the patient from the operating table to a rotating frame. The direction of angulation was lateral. During the ensuing year the space resulting from removal of the vertebral body collapsed somewhat but fusion failed. She has regained sufficient bladder sensibility and sphincter control so that she no longer requires an indwelling catheter. We contemplate the need of further surgical procedures.

Comment. This case crystallized our concept of the behavior of the spine as a two-column system (Fig. 20A, 20B, 20C) and emphasized certain disadvantages of laminectomy.

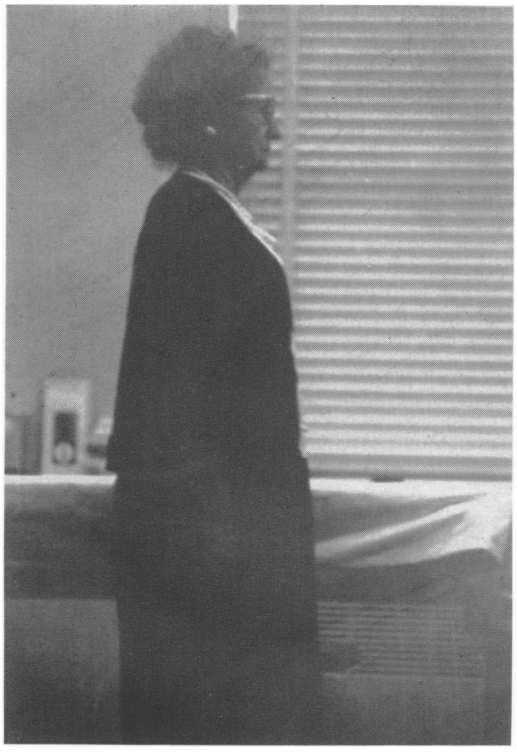

FIG. 19. Patient standing after healing of grafts. Note absence of kyphos.

Case 11 (L. V.): Cumulative instability following injury and repeated laminectomies. Two-stage stabilization, followed by significant neurologic return.

This woman was seen 6 months following initial dorsolumbar injury. She had been treated in another hospital and two laminectomies were performed in a period of 1 week. At the first of these paraplegia was described as complete. Following this, a myelogram demonstrated a block and further laminectomy was done. She had some neurologic return, but on ambulation the spine was unstable and she could not assume the erect posture (Fig. 21, 22, 23). The need for initial posterior stabilization was recognized but because of the extensive laminectomy and marsupialization of the dura, the use of plates seemed precluded (Fig. 24). As an alternative, Harrington rods were used to distract the spine posteriorly and numerous hooks were placed bilaterally. One month later through the anterior approach a fusion was performed from D_{12} to L_2, employing a suitable block of ilium, a rib strut, and iliac chips. The patient now walks with one long leg brace and one cane. She has not, however, regained control of her sphincters.

Comment. This case illustrates the validity of the two-column concept in sta-

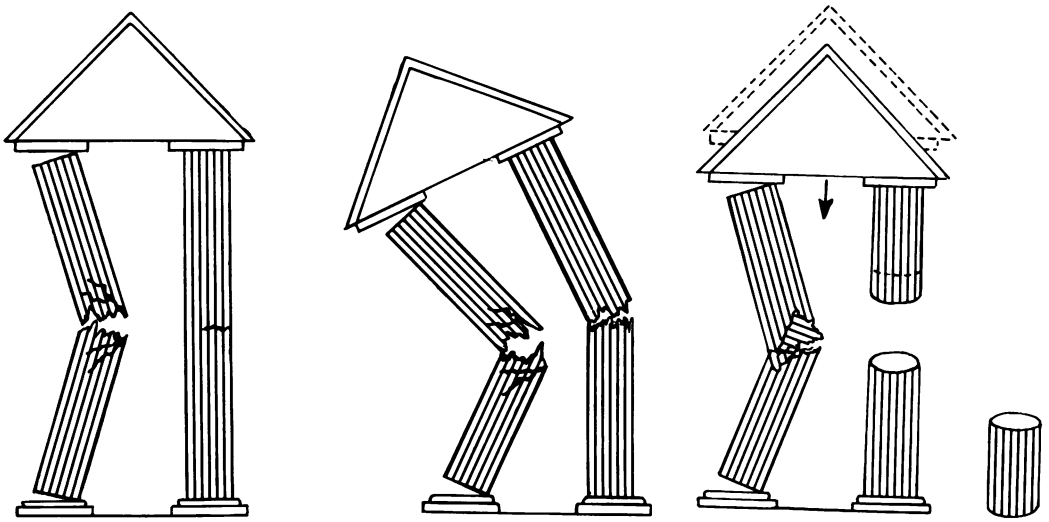

FIG. 20A. The two-column concept of the spine as a weight-bearing structure. With residual stability in the posterior column, anterior collapse is incomplete. B. Loss of posterior column permits pronounced anterior collapse. C. With laminectomy posteriorly and destruction by trauma anteriorly, no stability remains in the spine.

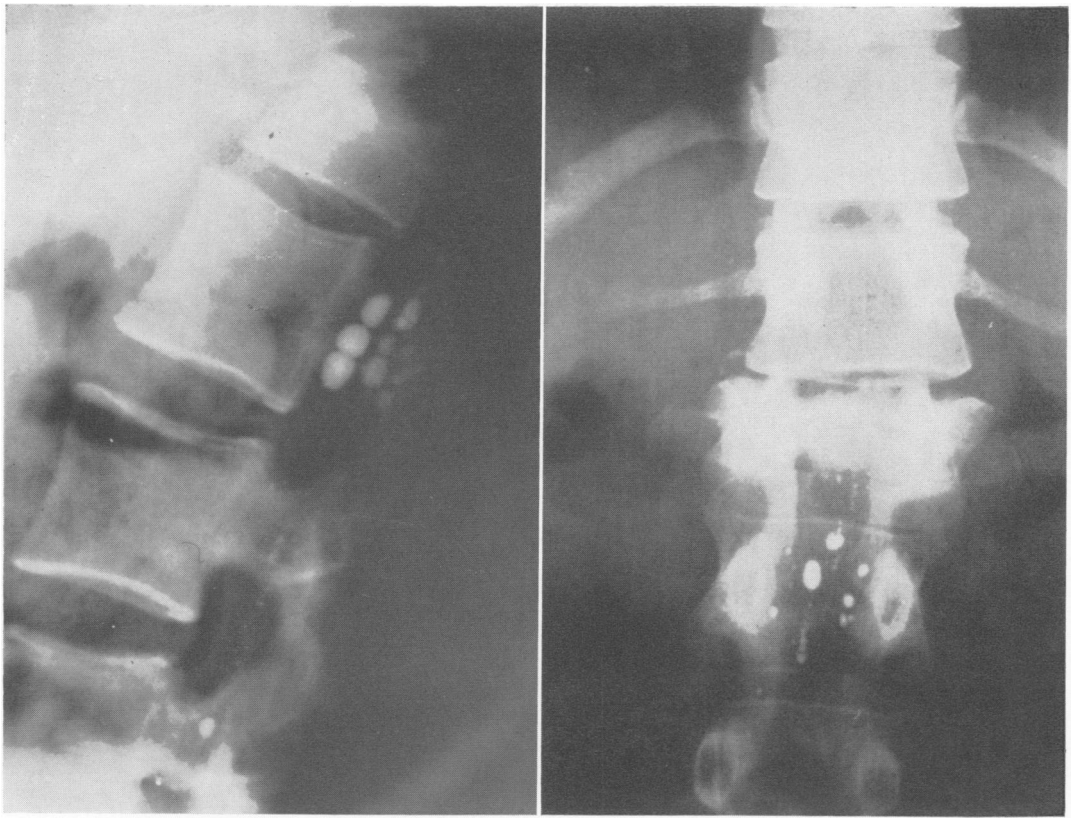

FIG. 21. (Case 11) The lateral projection of the spine rendered unstable by injury plus laminectomy. FIG. 22. The A-P projection of the spine rendered unstable by laminectomy.

bility following fracture-dislocation of the spine.

In these patients there were no mortalities, no wound infections, and no complications other than the slipping of the grafts in Case 10.

The experience recorded here provides insight into the value of stabilizing the spine following dorsolumbar injuries and points up some of the difficulties in accomplishing this. When plating provides good re-stabilization of the posterior column comprised of the neural arches, spontaneous restoration of anterior stability is likely. When this cannot be accomplished or gross instability of the anterior column exists, a two-stage procedure likely will be necessary. The first stage consists of creating as much stability as possible in the posterior column. Then after an appropriate period, surgical attack on the anterior column may include anterior decompression. Osteogenesis and fixation of well-placed bone grafts are needed.

Summary

1. Reestablishment and maintenance of stability are the major goals in the management of severe dorsolumbar injuries.

2. In fresh injuries this can be accomplished by a relatively simple posterior column repair.

3. In an additional group, posterior repair must be supplemented by anterior column repair.

4. The technics of anterior repair elaborated by Hodgson for spinal tuberculosis

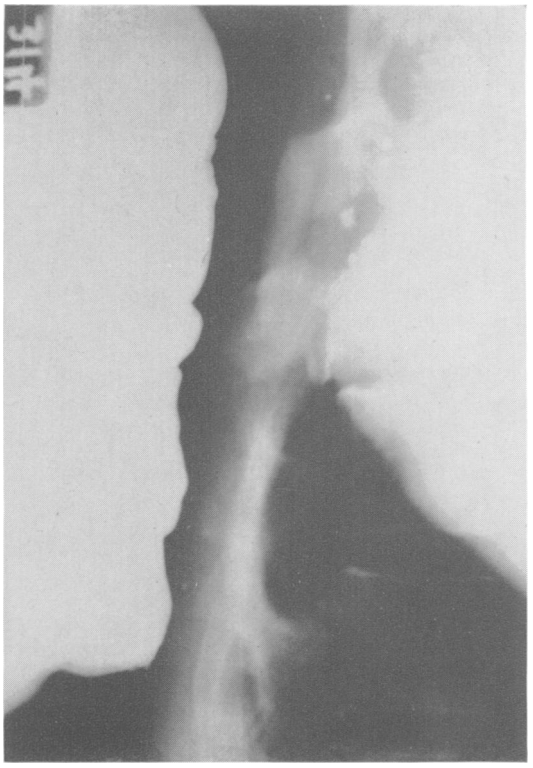

FIG. 23. Lateral roentgenogram showing manual correction obtainable.

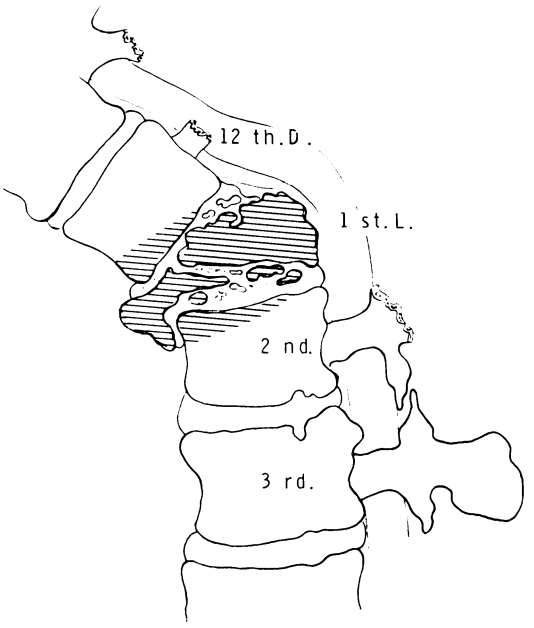

FIG. 24. Diagram to indicate problems encountered in efforts at posterior fixation.

are applicable to lesions derived from spinal trauma.

5. Laminectomy may impair stability to such a degree that it should be reserved for patients in whom indications can be precisely defined.

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DISCUSSION

DR. J. HAMILTON ALLAN (Charlottesville): I would like to comment on two aspects of this interesting paper. In the area between D-11 and L-2, Dr. Kelly reminds us that the fracture dislocation of the spine may injure the spinal cord but not necessarily injure some of the nerve routes emerging from this level and passing down to give function to the lower extremities. So, it is vital to