Park. Trauma Cases Rev 2015, 1:2
ISSN: 2469-5777

Trauma Cases and Reviews

Review Article: Open Access

Managing Fractures at the Thoracolumbar Junction in Developing Nations: A Review of 89 Cases

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Abstract

Fractures at the thoracolumbar junction are the most commonly encountered spine injuries in developing countries. Despite the devastating consequences for those with concomitant neurologic deficits, within hospitals having limited resources there remains an attitude akin to "therapeutic nihilism"; i.e. simply keeping these patients at prolonged bedrest and then bracing them, while "hoping for the best". Over an 18-year period encompassing some 100 working/teaching trips abroad to underserved areas, the author has treated 89 such patients with variable degrees of neurologic compromise for whom at least a one-year period of follow-up was available. Thirty (30) had primarily anterior-column injuries with mild to moderate motor deficits (4/5-3/5; Frankel D), and were braced in extension with a plaster TLSO jacket followed by early mobilization. All retained the ability to walk independently, Forty-nine (49) subsequently developed "glacial" instability. Forty-nine (49) with more serious deficits precluding ambulation (Frankel C) underwent transpedicular, *anterolateral* decompression followed by fusion and subsequent bracing. While 44 were clearly improved neurologically, the "gold standard" of course is whether such patients regain the ability to walk. This was achieved in 79% (39 of the 49). Ten (10) had "immediate and complete" cord injuries (Frankel A)* documented by (1) a *repeat*, detailed neurologic evaluation within 24 hours of admission reconfirming same, and (2) myelography to determine the level of the conus as that related to the fracture location. If *both* criteria for primarily a *cord* injury were met, operative intervention was deferred. *Fifteen (15) others originally assessed to be within this "immediate and complete" cohort were revised to Frankel Bs based upon two separate examinations. They ultimately did undergo anterolateral decompression and fusion, but only after having determined the level of injury to be below the conus per myelography. Consequently these were included in the second group of 49 patients. Six (6) of the 15 regained ambulatory status-or roughly 1/4th of those patents who otherwise would have been relegated to non-surgical treatment and permanent wheelchair status.

Introduction

In medically underserved areas of the world such as sub-Saharan Africa (where the majority of this series was compiled at two rural hospitals [Tenwek and Kijabe; Kenya] among fourteen others included world-wide), the following four approaches to treating thoracolumbar spine fractures have been utilized historically in decreasing order of frequency:

(1) Prolonged bed rest followed by external bracing and attempted progressive mobilization (the broad majority);

(2) Less often, stand-alone autogenous fusion, usually accompanied (and inappropriately so) by removal of the involved *posterior* elements "to decompress the cord";

(3) Infrequently used open reduction-internal fixation (ORIF) utilizing various screw/plate constructs (with or without posterior decompression) [1-4] - presumably due to the lack of appropriate pedicle-screw instrumentation and/or training to safely perform such a procedure; and

(4) Rarely, a transthoracic or retroperitoneal approach for *anterior* access with removal of the offending vertebra and placement of an iliac strut graft [5,6], expedited by an assistant "opening up" the decompressed segment by exerting pressure on the spine from behind as the graft is being inserted.

Due to the high morbidity associated with the most commonly employed approaches in particular (e.g. pulmonary embolism, ARDS with or without pneumonia, decubitus ulcers, etc.) - let alone the overwhelming majority failing to improve neurologically and left with progressive angular instability at best (at worst, fixed deformities precluding pain-free mobilization) - the need was universally recognized to address these fractures more appropriately.

Materials and Methods

Eighty-nine (89) patients who presented with fractures at the thoracolumbar junction and any degree of neurologic deficit were divided into three categories:

(1). Thirty (30) with "minor" deficits (defined as variable sensory loss with mild proximal leg weakness but retained sphincter function) and manifesting primarily anterior-column injury radiographically. To be sure, eight (8) of these did appear to have some middle-column involvement [7-9], albeit with less than 50% canal compromise as determined by myelography (or, rarely, CT). All patients in this group were treated without surgery and mobilized early in some form of TLSO orthoses for 3 months thereafter.

(2). Forty-nine (49) with moderate to severe neurologic deficits that did not preclude altogether the possibility of regaining ambulation, for which *anterolateral* decompression via the transpedicular route and fusion (with or without pedicle-screw instrumentation) was undertaken [5,10]; and

Citation: Park B (2015) Managing Fractures at the Thoracolumbar Junction in Developing Nations: A Review of 89 Cases. Trauma Cases Rev 1:010

Received: July 28, 2015: **Accepted:** September 18, 2015: **Published:** September 21, 2015

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(3). Ten (10) with rigorously defined "immediate and complete" deficits from spinal *cord* injury, for which no *functional* improvement was anticipated and no surgery was performed.

*Insofar as the compilation of this series began long before the Spine Trauma Study Group's introduction in 2005 of the now widely-accepted Thoracolumbar Injury Classification System (TLICS) [3,11] - and recognizing that such relies upon MRI to assess the integrity of the posterior ligamentous complex (PLC) [3,12] - emphasis in our training was placed on the earlier three-column-injury model of Denis [7]. That said, our results retrospectively confirm a strong correlation between the two, as myelography coupled with dynamic radiographs allowed for an "indirect" method of assessing PLC integrity (four cases of delayed instability in category (1) notwithstanding).

Given the absence of CT/MRI in this series (92% of cases), lumbar myelography [13] was undertaken in those patients with substantial neurologic injury in which it was difficult to ascertain whether the majority of the pathology constituted cord, conus, or cauda equina involvement. (This was performed by placing the patient prone on the x-ray table, instilling 6-8 cc of water-soluble, non-ionic contrast [Omnipaque 240] at approximately L.3 L.4, and tilting the table down toward the head followed by AP and lateral filming. Fluoroscopy was not required, as in virtually every instance some obstruction of the contrast was evidenced, precluding its migration cephalad beyond that point).

Lateral lying dynamic flexion/extension x-rays were often used preoperatively to determine the degree of instability (i.e. differentiating strictly anterior-column from middle-column involvement), and always one month after removing the external orthosis (whether operated upon or not). This was done to rule out glacial angular instability, given the stresses inherent at the thoracolumbar junction [14].

Barring complications, patients were seen back at 2-3 months for removal of the orthosis, and again one month thereafter, at which point standing lateral flexion/extension x-rays were done [4]. All were then requested to return at one year for final assessment, and if these requirements were not met, they were excluded from the study.

Patients who fulfilled these criteria were then categorized as (1) those maintaining or regaining ambulatory status; (2) those with improved neurologic function though still wheel-chair dependent; and (3) those unchanged as a result of the treatment undertaken.

Criteria for operative intervention

(1). Mandatory for those patients whose bone and/or neurologic injury precluded a mobilization trial in an external orthosis, though with enough retained neurologic function to warrant anticipating the *possibility* of regaining ambulatory status [1,9,12,15] - determined by at least *two* detailed neurologic examinations at least 12 hours apart, and supplemented by myelography when indicated to define the level of the conus relative to the spinal injury.

(2). *Recommended* for those with no perceived chance of regaining ambulation, but with a fracture and/or dislocation severe enough that mobilization in a wheelchair thereafter would be precluded by intractable pain as a consequence of the deformity; and

(3). Purely *elective* (for those in the second category who initially refused surgery) following a *thorough discussion* with the patient regarding the known risks associated with prolonged bedrest (i.e. DVTs; ARDS; decubitus ulcers; etc.).

*Irrespective of the treatment instituted, all patients received prophylactic S.Q. heparin, sequential compression stockings or Ace wraps while at bedrest, and (depending on cultural restrictions) instruction in intermittent self-catheterization. None were placed on high-dose steroid protocols, as few patients arrived in Casualty within the time restraints mandated to pursue such.

Essentials of the operative procedure

(1). Lengthy enough exposure to accommodate pedicle screw instrumentation one level above and one level below the fracture site [4]*, or two levels above and below if an autogenous posterolateral fusion alone was done. *The author recognizes that most western-trained spine surgeons recommend *two* levels above and below for instrumentation [1,5] though due to limited availability (and hence judicious use), four screws properly placed and bolstered by an eternal orthosis in extension for 2 months were deemed satisfactory - subsequently borne out by only one (1) instrument failure in 34 cases. Nor were cross-links used (theoretically to reduce axial rotation) unless the interspinous ligament was already completely disrupted.

(2). Preservation of any and all posterior elements, albeit using an aggressive *anterolateral decompression* through the pedicle on the side of the most bone destruction/displacement. This was performed by rongeuring away (or, preferably, drilling through) the involved pedicle to access fragments below the thecal sac [1,5] - thereafter either removing them piecemeal or (more often) compressing the fragments anteriorly away from the sac with a right-angle spatula.

(3). When instrumentation was available to reduce the fracture by *compressing* (not distracting) the implanted screw heads and thus compel the migration of offending fragments off the sac (so-called "ligamentaxis") [2,4], it was still deemed essential to perform the transpedicular exposure at the fracture site to assure that a proper decompression *anterolaterally* had been achieved.

(4). The standard landmarks for placement of pedicle screws were adhered to that being at the junction of the facet and its corresponding transverse process, with the screw trajectory being 15-20 degrees medially and penetrating to 80% of the vertebral body [1,2]*.

*Assuming a C-arm is not available (as was the author's experience in the majority of cases)--but that a portable x-ray machine is--intraoperative AP and lateral films were adequate to accomplish the task at hand: to begin with, marking the "eyes" of all four pedicles to be instrumented with Steinman pins at the junction of the transverse process with its facet using the AP view; at the close of the procedure, using the lateral view to assure satisfactory crossing of the "bridge" connecting the posterior elements with the vertebral body and to assure the proper depth of screw placement.

(5). In those cases where instrumentation was not available, care was taken to extend the autogenous fusion two levels above and below the fracture site with bone harvested from the posterior iliac crest. Emphasis was placed on vigorous decortication of the lateral spine, facets, and transverse processes to promote good cancellous-to-cancellous apposition. Given the profound stresses that come into play at the thoracolumbar junction, a *plaster* TLSO jacket was *always* employed for 3 months in this cohort.

Results

(1). Thirty (30) patients defined as having "minor" neurologic deficits (Frankel D) and either (a) primarily anterior-column injury with angulation less than 20 degrees on dynamic x-rays and less than 50% loss of vertebral height, or (b) mild to modest burst fractures with *less* than 50% canal compromise [8,9] (determined by myelography in 5 and CT in 3) were treated with external *plaster* orthoses in extension to assure patient compliance for 3 months. Twenty-six (26) went on to fuse satisfactorily, and all thirty retained ambulatory capacity. Four (4) developed glacial angular instability (three in the modest burst-fracture group, and one with purely anterior-column involvement). Two of this later experienced insidious neurologic deterioration, and one acutely following minor trauma. All three were in the mild to modest burst-fracture cohort, and subsequently underwent fusion alone. Two of the three improved and could walk independently following their delayed arthrodesis; the third was still requiring assisted ambulation at one year of follow-up.

(2). Thirty-four (34) patients with moderate to severe deficits (Frankel C), albeit not felt to *preclude* regaining ambulation, were taken to surgery within 48 hours for attempted reduction, transpedicular anterolateral decompression, and posterolateral

fusion. This cohort was divided into two groups:

(a) Those who had benefit of pedicle-screw instrumentation for purposes of both reduction and internal fixation (24): and

(b) Those in which a stand-alone autogenous posterolateral fusion was performed, given the absence of available instrumentation (10).

α) In the first and larger group, fully 91% (22 of 24) improved at least one Frankel grade [3,16], with 83% (20) regaining and maintaining ambulatory status (16 independent; 4 still requiring walker assistance at one year). Within this group, there were only two with subsequent radiographic evidence of angular instability, one of which had an overt non-union manifest by instrument failure. Two (2) infections were documented, yet neither required removal of the instrumentation. In the entire group, there were no neurologic complications that presumably would have been attributed to suboptimal pedicle-screw placement or conus/cauda equina injury from an overly aggressive anterolateral decompression, despite the lack of C-arm fluoroscopic guidance in over one-half (13) of the cases.

*Of note, 18 of the 24 instrumented procedures were performed by general, orthopedic, or neurological surgeons in training under supervision by the author, with no untoward intraoperative events occurring.

β) In the stand-alone fusion group (10) without benefit of instrumentation, eight (8) experienced neurologic improvement, six (6) of which regained ambulation. There were three with radiographic evidence of non-union, though none accrued delayed progressive neurologic deficits - presumably reflecting satisfactory thecal sac decompression using the transpedicular anterolateral approach. Eight (8) of these 10 cases were done by residents-in-training under intraoperative supervision, though 2 of the 3 non-unions (radiographically) were the responsibility of the author alone.

(3). Twenty-five (25) patients presented with *apparent* "immediate and complete" cord injuries originally felt to preclude any chance at regaining ambulation. *The most important discovery within this group was that fully 60% (8 of 15 eventually operated upon within 48 hours of injury) in fact proved to have *reversible* deficits. That can be attributed to: (a) careful neurologic examination(s) having been performed to rule out "sacral sparing" and assessment of rectal tone, the preservation of either one of which would imply greater cauda equina than conus injury; and (b) in those questionable cases, definitive myelography to ascertain whether the pathology was above or below the cord.

Given the absence of MRI to assess the level of the conus and the status of the posterior ligamentous complex, myelography proved vitally important in this particular cohort of patients. Ten (10) of the 25 were shown to have cord injury *cephalad* to the conus and were not operated upon. Yet in fifteen (15), the level of the pathology was determined to be at or *below* the conus, and these underwent operative intervention despite the severity of their deficits (10 with instrumentation).

Somewhat surprisingly, 6 of the 8/15 who were improved following surgery regained the ability to walk (3 with walker assistance, and 3 independently). All of these were in the instrumented cohort. In other words, at one year of follow-up fully 25% of patients originally described as suffering from "immediate and complete spinal cord" injuries regained ambulatory status.

*Though not included in this study, during the past 4 years twenty-eight (28) additional cases have been reported to the author as having been performed by former trainees in Kenya, Uganda, Vietnam, China, Nicaragua, and Iraq. All such surgeons had what would be considered a *minimum* of hands-on training (having been exposed on average to 3 monitored/instrumented cases each). Their results, reportedly, roughly parallel those in which the author was personally involved - most notably, some 70% with burst fractures/dislocations and significant neurologic deficits who could not be safely mobilized preoperatively having *regained* the ability to walk.

Discussion

Fractures at the thoracolumbar junction are among the most common traumatic spine injuries encountered by neurosurgeons [1,10,15,16]. The author's twenty-year experience working abroad in 26 developing nations has affirmed that there are four limiting factors to the appropriate management of such pathology.

The first is obvious, and accounts for what I do: for all intents and purposes, there are no formally trained spine surgeons in underserved, mainly rural, areas of the world. Anyone with such laborious and expensive training migrates to the cities to be generously remunerated for his or her services and "time-served". That's the reality in the developing world. Yet there's a flip-side to the reality coin: these rural areas are where most such devastating spine injuries occur, and it becomes the local general surgeon's mandate to assume their care by default [17].

The second (subjective) factor is the ill-conceived notion that those patients with fractures at the thoracolumbar junction presenting with moderate to severe neurologic deficits have little or no hope of regaining ambulation in such underserved hospitals. Therefore, far more often than not, they are treated with a period of prolonged bedrest followed by "bracing" - a TLSO orthosis at best; at worst, some form of canvas corset with metal staves.

The third is a lack of familiarity with spinal ORIF techniques among surgeons in charge of their care (usually general surgeons in rural or provincial hospitals, though this particular series did include orthopedic and neurosurgical residents with little or no prior spine-trauma training).

Finally, there are the mistaken assumptions that (a) expensive spinal instrumentation (which few such hospitals have access to) is *required* to successfully reduce and fuse these fractures, and (b) no recourse remains for them to procure such, based on cost alone* (see *Disclosure*).

While the majority of the patients in this series who underwent operation *did* have benefit of spinal instrumentation, by no means is such required - assuming an appropriate transpedicular *anterolateral* (not posterior!) decompression is performed and a meticulous on-lay posterolateral fusion is done, followed by 3 months of bracing in a TLSO *plaster* jacket to assure patient compliance.

Though the number of stand-alone fusions in this series (15) is small as compared to those instrumented (34), the results from the standpoint of neurologic improvement and successful stabilization are roughly comparable - notwithstanding significantly greater ease in reducing the fracture (and slightly less radiographic evidence of non-unions) in those undergoing internal fixation in conjunction with their arthrodeses.

What is otherwise required, of course, are (1) western-trained spine surgeons (whether neurosurgical or orthopedic) willing to go abroad for such working/teaching trips, and (2) local general surgeons willing to make room on their busy schedules (and crowded O.R.s!) to address what is a totally reversible condition in the broad majority of patients with thoracolumbar fractures harboring neurologic deficits, even though they may appear "severe".

Moreover, the track record over the past 18 years affirms that the simplified techniques described in this study can be readily mastered through a minimum of (albeit sequentially reinforced) hands-on training without complications *any greater* than a formally trained spine surgeon.

Which begs the question: So if "complications" *do* arise from the surgery itself (and it bears emphasizing that no patient in this series was made worse neurologically by having undergone surgical treatment), is the patient any worse off than before? Not if one considers the plethora of aforementioned complications associated with the prevailing approaches to this particular problem in underdeveloped countries around the world.

Not only is this simplified surgical approach to thoracolumbar burst fractures and/or dislocations in patients with moderate to severe neurologic deficits arguably more cost-effective in the long run; almost 80% of such patients undergoing open reduction and fusion coupled with an aggressive anterolateral decompression can be anticipated to walk again - when few if any could have done so following such a devastating injury.

Conclusions

1. Those patients with primarily anterior-column injury (and presumed middle-column preservation) [7], even with neurological deficits, do well with simply external bracing in extension for 3 months using a plaster TLSO construct. It is important, however, to perform dynamic standing lateral flexion/extension x-rays one month *after* the orthosis is removed, as subsequent glacial instability remains a threat [14], particularly in cases manifesting some degree of middle-column involvement in concert.

2. All patients felt to have potentially reversible neurologic deficits in the presence of documented burst fractures and/or fracture-dislocations involving more than 50% of the spinal canal should undergo operation [1,3,16] to include: (a) transpedicular anterolateral decompression on the side of greatest bone disruption; followed by (b) as satisfactory reduction as possible given what's available to do so; concluding with (c) either an instrumented fusion one level above and below, or autogenous posterolateral fusion alone (two levels above and below) if instrumentation is unavailable. Following stand-alone fusions an external orthosis should be worn for 3 months; in instrumented cases, 2 months suffices.

3. Great care should be taken not to reject patients out of hand as candidates for surgery despite allegedly presenting with "immediate and complete" neurologic deficits from spinal *cord* injuries at the thoracolumbar junction. Such determinations can only be made by *repeat*, thorough neurological examinations combined with myelography (in the presumed absence of CT/MRI) to assess the level of the conus relative to the fracture, particularly if any "sacral sparing" or retained sphincter tone is detected.

4. Finally, it bears emphasizing that surgeons-in-training performed well over half of the surgical procedures, albeit under operative supervision. And insofar as at least 28 other patients with thoracolumbar fractures *not* included in this series have subsequently been operated upon by surgeons previously trained in the techniques described (nine with instrumentation; nineteen without) - and with outcomes qualitatively similar--is justification enough to continue such training.

Disclosure

Two instrument companies in particular - Synthes (now Johnson & Johnson) and Nuvasive - are making generous efforts to address this "access problem" in those hospitals that have demonstrated a willingness to train both general and orthopedic surgeons in order to meet this pressing need. Neither charges for their equipment, and Synthes in particular deserves credit for having donated instrumentation over the past twenty years.

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