Clinical Article

Short-segment posterior instrumentation of thoracolumbar fractures as standalone treatment

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Abstract/summary

This article reports on the radiographic outcome of unstable thoracolumbar fractures managed with short segment posterior instrumentation as standalone treatment.

Short segment posterior instrumentation is the method of choice for unstable thoracolumbar injuries in our unit. It is considered to be adequate treatment in cases with an intact posterior longitudinal ligament, and Gaines score below 7; as well as fracture dislocations, and seatbelt-type injuries, without loss of bone column bearing integrity.

Sixty-five consecutive patients undergoing this surgery were studied. Patients were divided into two main cohorts, namely the 'Fracture group' (n=40) consisting of unstable burst fractures and unstable compression fractures; and the 'Dislocation group' (n=25) consisting of fracture dislocations and seatbelt-type injuries. The groups reflect similar goals in surgical treatment for the grouped injuries, with reduction in loss of sagittal profile and maintenance thereof being the main aim in the fracture group, appropriately treated with Schantz pin constructs; and maintenance in position only in the dislocation group, treated with pedicle screw constructs.

Data were reviewed in terms of complications, correction of deformity, and subsequent loss of correction with associated instrumentation failure. Secondly, factors influencing the aforementioned were sought, and stratified in terms of relevance.

Average follow-up was 278 days for the fracture group and 177 days for the dislocation group. There was an average correction in kyphotic deformity of 10.25 degrees. Subsequent loss in sagittal profile averaged 2 degrees (injured level) and 5 degrees (thoracolumbar region) for the combined fracture and dislocation group. The only factor showing a superior trend in loss of reduction achieved was the absence of bone graft (when non-fusion technique was employed). Instrumentation complications occurred in two cases (bent connection rod, and 10 degrees loss in regional sagittal profile following 2 degrees of reduction respectively). These complications represent 3.07% hardware failure in total.

Conclusion: Short segment posterior instrumentation is a safe and effective option in the treatment of unstable thoracolumbar fractures as a standalone measure.

Introduction

The thoracic spine allows for minimal flexion and extension, yet permits lateral bending and torsional movement, through coronally oriented facets. The sternum, ribs and costovertebral articulations further stabilise the thoracic spine.

The thoracic spine is a relatively rigid structure with an average of 35 degrees of kyphosis imparted intrinsically. Facet orientation in a coronal plane allows for torsional and lateral bending motion, but mostly restricts flexion and extension.

Costovertebral articulations further stabilise the thoracic region through a common anterior anchor point in the sternum.

The adjacent lumbar spine permits flexion and extension in the primary plane of motion through sagittally oriented facets, with an intrinsic lordosis ranging 30 to 50 degrees (primarily between L4 and S1). T10-L2 spinal levels represent the transition between the rigid thoracic column and a more flexible lumbar column. The spinal weight-bearing axis furthermore translates from kyphosis to lordosis at the T12-L1 intervertebral disc. These factors contribute to the vulnerability of the thoracolumbar region, and influence the recognisable fractures and injury patterns in this region.[1,2]

The debate on appropriate management of injuries to this region still continues. This includes conservative versus operative and in the latter case, which strategy will best serve adequate decompression of neural structures, restoration of vertebral body height, prevention of further or recurring deformity and sparing motion segments.

Proponents of the anterior approach argue the more thorough, direct decompression of neural structures[3-9] combined with the ability to provide constructs with superior mechanical load-bearing properties and related decreased risk for hardware failure. Higher theoretical complication risk exists due to the extent of the visceral approach and iatrogenic paraspinal muscle trauma; however, lower wound and instrumentation related complications are reported.[10] This modality proves especially valuable in burst fractures with incomplete neurology and intact posterior ligamentous structures, with fusion rates of 93% and improvement of at least a Frankel grade in 94.6% of patients in a specific study.[11] In terms of correction in kyphotic deformity, another study showed an average kyphotic deformity of 22.7 degrees corrected to an average of 7.4 degrees with only 2.1 degrees of loss in correction. This was achieved through anterior decompression and two-segment instrumentation reconstruction.[12]

Posterior approach and instrumentation offers direct or indirect decompression of the neural structures, with the added relative ease of the approach. Effective indirect decompression can be achieved through postural reduction and longitudinal distraction with the aid of ligamentotaxis on condition that the posterior longitudinal ligament is intact. Initial improvement of 23% has been shown in mean canal cross-sectional area on CT with eventual 87% of normal canal dimensions at five-year follow-up.[13] Pedicle fixation also allows for short constructs with sparing of motion segments. Short-segment constructs have, however, been implicated in failure of instrumentation (as high as 50%) and subsequent progressive deformity.[14,15] Short-segment instrumentation further offers the advantage over longer constructs of avoiding alteration of segmental mechanics over a longer spinal segment, preserving motion in the adjacent unaffected levels and thereby diminishing subsequent degeneration and junctional pain. The cantilever bearing properties of short-segment constructs set this method up for failure in instances with extensive bony loss of the anterior column. Current literature supports the use of this modality for flexion-distraction or Chance-type injuries.[16,17]

Posterior only stabilisation is criticised as running the risk of instrumentation failure and loss of correction. This study reviews the use of posterior only short-segment fixation in the management of thoracolumbar trauma.

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Materials and methods

Patients, who sustained traumatic junctional fractures of the thoracolumbar spine treated with standalone short-segment posterior instrumentation, for the period December 2001 to July 2007, were retrospectively enrolled in the study.

Injury stratification

In order to reflect bony loss of the anterior two columns, injuries were divided into:

1. Fracture group (n=40) consisting of:
   - Unstable burst fractures, including
     - Neurological fallout
     - Loss of body height > 50%
     - Angulation > 20 degrees
     - Scoliosis more than 10 degrees
   - Unstable compression fractures, including
     - Loss of body height > 50%
     - Angulation > 20 degrees.
2. Dislocation group (n=25) consisting of:
   - Fracture dislocations
   - Seatbelt-type injuries
     (with no relevant loss in bony bearing structure of the anterior columns).

Surgical technique *(Figure 1)*

A standard midline posterior approach was used over the injured region, with subperiosteal dissection to expose the posterior components to the tips of the transverse processes. Mechanical stability was established through posterior instrumentation, as dictated by injury requirements.

Instrumentation utilised included either Schantz pins (6 mm) or pedicle screw constructs.

Schantz pin constructs were typically utilised with reduction in vertebral body height as goal (fracture group), and pedicle screw constructs in the dislocation group, in order to achieve and maintain stability without restoration of vertebral body height.

All constructs were short-segment constructs restricted to adjacent or 'above-and-below' levels, depending on the surgeon's perceived adequacy of bony purchase in the pedicles.

Posterolateral intertransverse fusion was performed in most cases (56). Demineralised cancellous human bone matrix in the form of bone chips (allograft), or a combination of autograft (posterior iliac crest) and allograft was utilised to facilitate fusion depending on the surgeon's preference.

A non-fusion technique was used in nine cases, with the subsequent removal of instrumentation in an attempt to preserve motion. These patients were not selected as a specific subset in terms of age, injury or other factors, and represent the surgeon's preference in the early phase of the study.

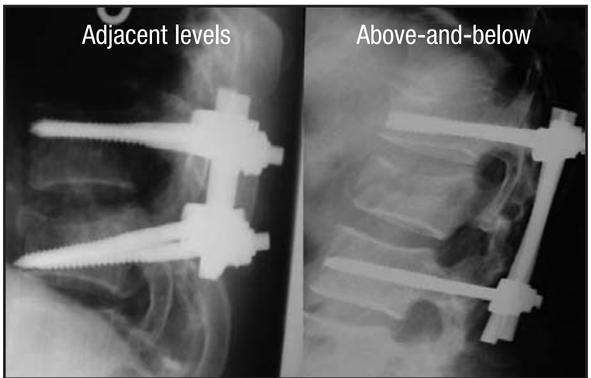

Figure 1

Quantification and survey

Plain film-ray review was performed at three separate instances in time, reflecting the initial post-injury position, the immediate post-surgery position, and the position at latest follow-up.

Measurements were taken at each interval to reflect a local sagittal angle (angle between superior and inferior end-plates of the fractured vertebra, or level of injury), and a regional sagittal angle (angle measured between superior end-plate of most cephalad instrumented vertebra, and the inferior end-plate of the caudad most instrumented vertebra). These angles were then compared to portray trends in reduction in the fracture group; and the maintenance of sagittal profile in both the fracture and the fracture dislocation groups *(Figure 2).*

Posterolateral intertransverse fusion was performed in most cases

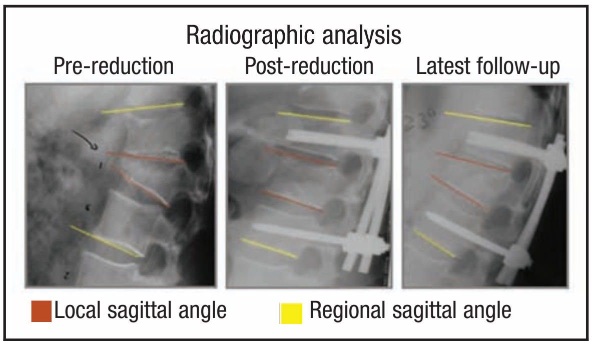

Figure 2

Patients were further broadly categorised into three groups of follow-up, namely, less than three months, three months to one year, and more than one year. Average loss in position could be established for each individual time sub-group, reflecting the continuity of loss in position versus loss related to a specific time interval.

All patients had bony union of the fusion mass, or union of the involved fracture reported, at time of final follow-up in order to be included in the study.

Factors investigated as possible contributors to correction, and or, loss of correction included:

- use of bone graft (no distinction made between allograft or autograft mixed with allograft)
- instrumentation position (adjacent levels, or above-and-below)
- engagement of anterior cortex of vertebral body with instrumentation
- post-operative bracing
- time duration from injury to surgery (special interest in subset of patients managed surgically within 72 hours from injury)
- instrumentation type.

Patient demographics

The study included 65 patients (50 males and 15 females), with a mean age of 36 years (17-62 ± 12.3). Aetiology presented as falls 46% (30 patients) and motor vehicle accidents 54% (35 patients). Of the MVAs, 45% were pedestrians (16 patients) and 54% vehicle occupants (19 patients).

The average duration of follow-up was 278 days in the fracture group (Schantz pin constructs), and 177 days in the fracture dislocation group (pedicle screw constructs). See *Figure 3.*

Forty patients fitted into the fracture category, and 25 patients into the dislocation category.

Thirty-one patients had no other injuries. Other associated injuries included: 22 other orthopaedic injuries, five patients with non-contiguous spinal injuries, five head injuries and seven thoracic injuries.

Neurological compromise was present in 40 patients as charted on admission and again at discharge using the ASIA scoring system *(Figure 4).*

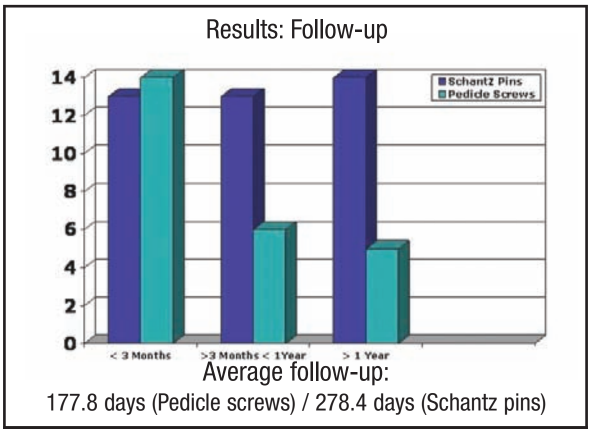

Figure 3

Four patients showed an improvement in ASIA motor score, but not to the extent of advancing a level in ASIA grading.

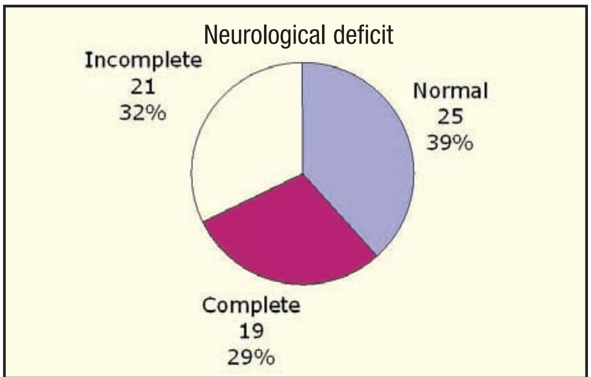

Figure 4

Peri-operative

The average time delay from injury to admission to the Acute Spinal Cord Injury Unit was 4.9 days (0-53 ± 9.9 days). Time delay from injury to time of surgical episode was 9.7 days on average (0-63 ± 12.8 days), with the surgery-to-discharge period spanning an average of 18.64 days (2-88 ± 17.6 days). Average duration of surgery was 100 minutes (30-255 ± 40 minutes).

Average blood loss during surgery was reported as 359 ml (50-2 200 ± 355 ml).

Bone graft was utilised in 56 cases (distinction was made between autograft and allograft), and post-operative bracing (TLSO) used in six patients only. Bracing was utilised early in the study as a matter of surgeon preference, and was not subject to a specific subset of indications.

Results

The fracture group (Schantz pin constructs) showed 10.25 degrees (0-26 ± 6.5 degrees) of reduction on average (55% improvement in deformity) in terms of sagittal profile of the fractured vertebra. Regional sagittal profile improved by an average of 11.6 degrees (0-38 ± 8.9 degrees).

The subgroup of fractures treated surgically within 72 hours from injury incident showed a local sagittal profile improvement average of 9.3 degrees (0-20 ± 6.1 degrees), and a regional sagittal profile improvement of 8.3 degrees (0-22 ± 7.5 degrees) on average.

Average progression in kyphosis of the local sagittal angle and the regional sagittal angle were found to be 2 degrees (18% of reduction) and 5 degrees respectively (51% of reduction). This data was shown for the fracture group in combination with the dislocation group, with no statistical difference demonstrable between the two groups.

Regional loss of correction data was to an extent influenced by one specific case showing 10 degrees regression in regional sagittal angle, following initial correction of 2 degrees (mean median data distribution of 20% shown, however). This case had a reported hardware failure namely a bent connection rod (Schantz pin construct). See *Figure 5*.

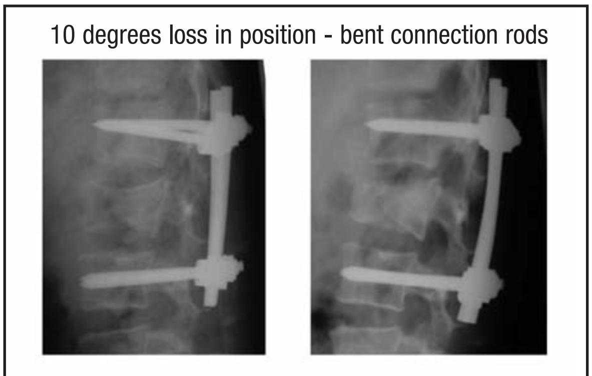

Figure 5

Influencing parameters *(Figures 6-11)*

Bone graft was not performed in nine patients (fracture group). This non-fusion technique displayed a superior trend in loss of sagittal profile. This trend was most markedly demonstrated in the regional sagittal angle. It was not, however, statistically significant (local sagittal angle: p=0.40017; regional sagittal angle: p=0.05568).

In patients with posterior fusions, no clear-cut difference could be shown in loss of position between cases utilising autograft in comparison to allograft (p=0.58 Mann-Whitney U p=0.62).

Levels of instrumentation related to the level of injury, as above-and-below compared to adjacent levels of instrumentation demonstrated no statistically significant influence (local sagittal angle: p=0.01 Mann-Whitney U p=0.82; regional sagittal angle: p=0.82 Mann-Whitney U p=0.97).

Engagement of the anterior cortex of the instrumented vertebral body did not display a statistically significant influence compared to vertebrae with instrumentation not engaging the anterior cortex (local sagittal angle: p=0.29 Mann-Whitney U p=0.93; regional sagittal angle: p=0.51 Mann-Whitney U p=0.26).

No superiority could be demonstrated in terms of maintenance in position between Schantz pin constructs and pedicle screw constructs (local sagittal angle: p=0.22 Mann-Whitney U p=0.62; regional sagittal angle: p=0.52 Mann-Whitney U p=0.59).

Due to the low number of patients managed with bracing post-operatively, no deductions of statistical value could be made.

Time duration from time of injury to time of surgery made no significant difference in terms of degree of reduction and in terms of loss in position.

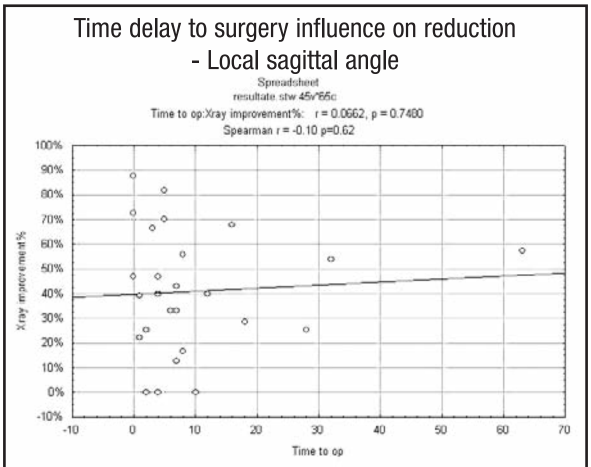

Figure 6

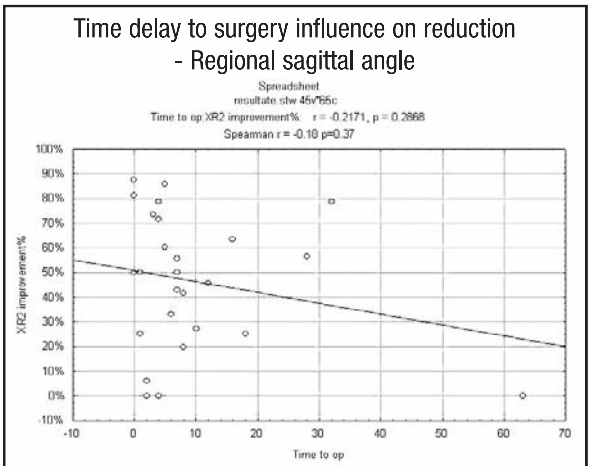

Figure 7

Due to the low number of patients managed with bracing post-operatively, no deductions of statistical value could be made

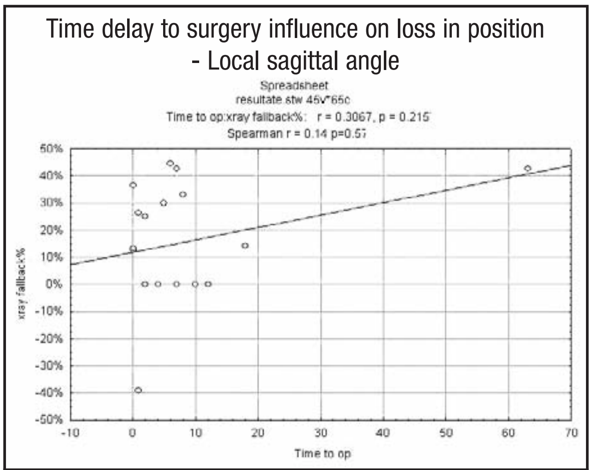

Figure 8

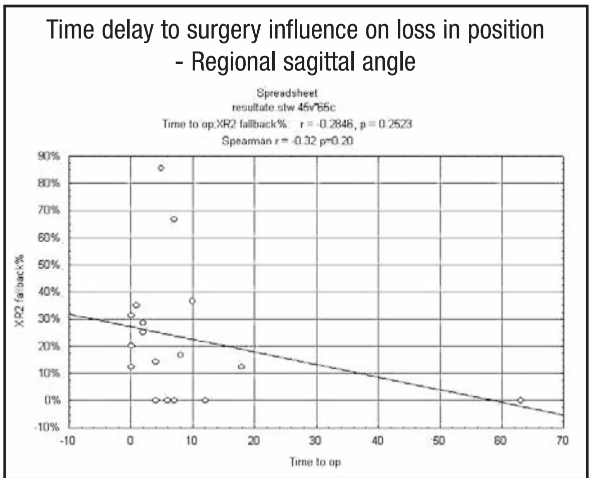

Figure 9

The extent of reduction also did not reflect a clear relation to loss in position (as shown in *Figures 10 and 11*).

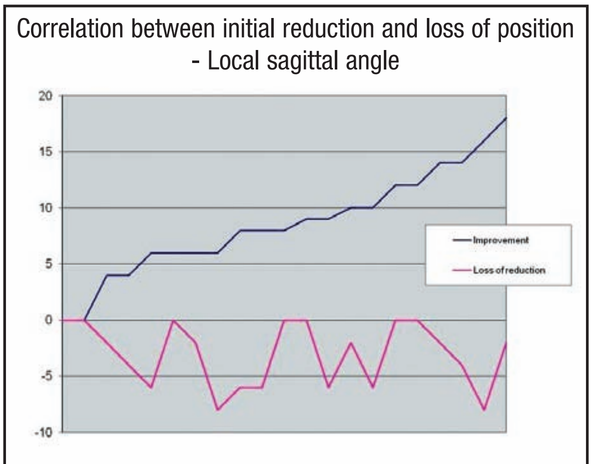

Figure 10

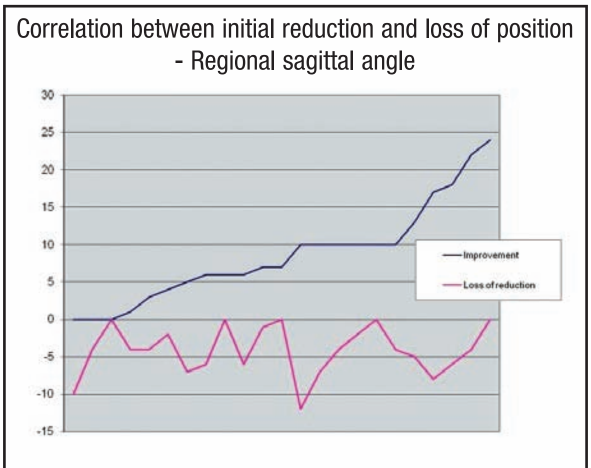

Figure 11

Complications

Including the exaggerated loss in position of the aforementioned case, there was a total of two reported hardware failures. The additional case was reported as bent Schantz pins with no apparent breakage (214 days post-surgery). This entails a 3.07% hardware failure in total. No instances of catastrophic failure or breakage of instrumentation were reported.

A single case was reported to demonstrate misplaced pedicle screws inferior to the pedicle.

Another case developed infection at the bone graft harvest site; this was treated successfully with surgical debridement and antibiotics.

Discussion

Short-segment posterior instrumentation as standalone treatment offers a safe and effective modality in the management of thoracolumbar junctional injuries. Low peri-operative complications presented, and most patients endured a short-term admission to the Acute Spinal Injury Unit prior to discharge to a rehabilitation facility or home. Limited loss in reduction of sagittal profile did occur; this was however restricted to the earliest time sub-cohort, suggesting that that this occurrence coincided with post-operative rehabilitation and mobilisation. No progression could be demonstrated between the three time sub-cohorts, with averages remaining at the position achieved at the end of the immediate post-operative period, the period corresponding with attainment of bony fusion.

No difference could be demonstrated in terms of loss in sagittal profile between the fracture group (Schantz pin constructs) and the dislocation group (pedicle screw constructs). This reinforced the idea that loss in sagittal profile following thoracolumbar fractures is not only attributable to the structural collapse of the bony support column, but that that the adjacent discs also contribute a fair extent of collapse.[18] This phenomenon was present in the dislocation group in the absence of end-plate fractures.

The non-fusion technique compared to fusion was the only factor with bearing on the trend in loss of sagittal profile. Bone graft was not performed in nine patients (fracture group). This was purposefully done, with removal of the utilised instrumentation, post-union, in an attempt to preserve motion in the affected vertebrae. A superior trend was demonstrated in loss of sagittal profile. This trend was most markedly demonstrated in terms of regional sagittal angle further suggesting that multiple intervertebral discs were likely to have been involved in this process. This finding was in contrast with other authors.[19]

From Boden's extensive work on animal models[20] we consider autograft to be the gold standard in terms of promoting fusion.

The type of bone graft did not, however, seem to influence our data in terms of loss in sagittal profile, with fusions performed using allograft only, compared to autograft, showing no statistical difference in terms of loss in position. In the patient with a spinal injury, and especially so in instances with neurology, complications with the bone graft harvest site can probably be avoided by utilising allograft only, without significantly worse loss of position. This however warrants further study.

The levels of positioning (above-and-below vs adjacent levels) of the instrumentation did not influence the maintenance of position in our data series. Aiming to preserve motion segments has been proven to be beneficial,[21] and utilising adjacent level instrumentation did not prove detrimental in terms of maintenance in sagittal profile. Engagement of the anterior vertebral body cortex also did not prove to alter significantly the bearing capabilities of the constructs, reinforcing the sentiment that pedicular fixation achieves fixation through purchase in the pedicle only.

The decision on levels of instrumentation is therefore based on the shortest possible construct to achieve fusion without sacrificing purchase.

Despite this study's focusing on radiological parameters, and not reviewing the clinical outcome as such; a clear benefit was demonstrated in the relatively short in-hospital period of 18.64 days (2-88 ± 17.6 days). This echoes the relatively short in-hospital periods demonstrated in a classic comparison of surgical treatment and conservative management of patients with unstable burst fractures by Rechtine *et al*.[22]

Conclusion

Schantz pin constructs compared well with pedicle screw constructs in the standalone treatment of unstable junctional fractures in terms of durability and maintenance of reduction. It should, however, be emphasised that the differing instrumentation types were used in different injury patterns with very specific indications and surgical aims in the respective subgroups. Pedicle screw constructs are limited in their ability to correct sagittal profile and, despite a slight cost advantage, the decision of appropriate instrumentation should be dictated by – and individualised to – the fracture pattern and the patient.

In spite of cantilever bearing properties, short-segment posterior instrumentation has been shown to offer an acceptable option for treatment in unstable thoracolumbar fractures and dislocations. The procedure has a relatively low complication rate with little blood loss, and low incidence of failure. It provides a cost-effective option for prompt stability, allowing early mobilisation of a patient with a spinal injury.

Bone graft is strongly recommended for all procedures attempting to achieve stability in trauma-related junctional instability.

References

1. Oxland TR, Lin R, Panjabi M. Three-dimensional mechanical properties of the thoracolumbar junction. *J Orthop Res* 1992;**10(4)**:573-80.
2. Frei H, Oxland TR, Nolte LP. Thoracolumbar spine mechanics contrasted under compression and shear loading. *J Orthop Res* 2002;**20(6)**:1333-8.
3. Esses SI, Botsford DJ, Kostuik JP. Evaluation of surgical treatment of burst fractures. *Spine* 1990;**15**:667-73.
4. Gertzbein SD. Scoliosis research society. Multicentre spine fracture study. *Spine* 1992;**17**:528-40.
5. Jacobs RR, Casey MP. Surgical management of thoracolumbar spinal injuries. General principles and controversial considerations. *Clin Orthop* 1989:22-35.
6. Kostuik JP. Anterior fixation for burst fractures of the thoracic and lumbar spine with or without neurological involvement. *Spine* 1988;**13**:286-93.
7. McAfee PC, Bohlman HH, Yuan HA. Anterior decompression of traumatic thoracolumbar fractures with incomplete neurological deficit using retroperitoneal approach. *J Bone Joint Surg (Am)* 1985;**67**:89-104.
8. Riska EB, Myllenen P, Bostman O. Anterolateral decompression for neural involvement in thoracolumbar fractures. A review of 85 cases. *J Bone Joint Surg (Br)* 1987;**69**:704-8.
9. Shono Y, McAfee PC, Cunningham BW: Experimental study of thoracolumbar burst fractures. A radiographic and biomechanical analysis of anterior and posterior instrumentation systems. *Spine* 1994;**19**:1711-22.
10. Kirkpatrick JS. Thoracolumbar fracture management: Anterior approach. *J Am Acad Orthop Surg* 2003;**11**:355-63.
11. Kaneda K, Taneichi H, Abumi K, Hashimoto T, Satoh S, Fujiya M. Anterior decompression and stabilization with the Kaneda device for thoracolumbar burst fractures associated with neurological deficits. *J Bone Joint Surg Am* 1997;**79**:69-83.
12. Sasso RC, Best NM, Reilly TM, McGuire RA Jr. Anterior-only stabilization of three-column thoracolumbar injuries. *J Spinal Disord Tech* 2005;**18**(suppl):S7-S14.
13. Wessberg P, Wang Y, Irstam L, Nordwall A. The effect of surgery and remodeling on spinal canal measurements after thoracolumbar burst fractures. *Eur Spine J* 2001;**10**:55-63.
14. Alanay A, Acoroglu E, Yazici M, Aksoy C, Surat A. The effect of transpedicular intracorporeal grafting in the treatment of thoracolumbar burst fractures on canal remodeling. *Eur Spine J* 2001;**10**:512-6.
15. Tezeren G, Kuru I. Posterior fixation of thoracolumbar burst fracture: Short segment pedicle fixation versus long-segment instrumentation. *J Spinal Disord Tech* 2005;**18**:458-88.
16. Wilke HJ, Kemmerich V, Claes LE, Arand M. Combined anteroposterior spinal fixation provides superior stabilization to a single anterior or posterior procedure. *J Bone Joint Surg Br* 2001;**83**:609-17.
17. Been HD, Bouma GJ. Comparison of two types of surgery for thoracolumbar burst fractures: Combined anterior and posterior stabilization vs. posterior instrumentation only. *Acta Neurochir (Wien)* 1999;**141**:349-57.
18. Oner Cumher F, van der Rijt R, Lino M, Ramos P, Dhert WJA, Verbout AJ. Changes in disc space after fractures of the thoracolumbar spine. *J Bone Joint Surg Br* 1998;**80B(5)**:833-9.
19. Wang S, Ma H, Liu C, Yu W, Chang M, Chen T, Wood KB. Is fusion necessary for surgically treated burst fractures of the thoracolumbar and lumbar spine? *Spine* 2006;**31(23)**:2646-53.
20. Boden SD. Overview of the biology of lumbar spine fusion and principles for selecting a bone graft substitute. *Spine* 2002;**27**:26-31.
21. Hassan D, Haw Chou Lee, Eldin E, Karaikovic, Robert W. Gaines Jr. Decision making in thoracolumbar fractures. *Neurology India* 2005;**53(4)**:534-41.
22. Rechtine GR, Cahill D, Chrin AM. Treatment of thoracolumbar trauma: comparison of complications of operative versus nonoperative treatment. *J Spinal Disord* 1999;**12(5)**:406-9.