Trauma Mon. Inpress(Inpress): e28627. doi: 10.5812/traumamon.28627

Published online 2016 March 2. **Brief Report**

Efficacy of Pedicle Screw Fixation in Unstable Upper and Middle Thoracic Spine Fractures

Amir Abbas Ghasemi[1,*] and Soudabeh Ashoori[1]

[1]Neurosurgery Department, Urmia University of Medical Sciences, Urmia, IR Iran

*Corresponding author: Amir Abbas Ghasemi, Neurosurgery Department, Urmia University of Medical Sciences, Urmia, IR Iran. Tel: +98-9122038271, Fax: +98-4433457036, E-mail: Dr.amirghasemi@ymail.com

Received 2015 March 16; **Revised** 2015 July 3; **Accepted** 2015 September 1.

Abstract

Background: Treatment of unstable upper and middle thoracic spine fractures remains controversial. There is no consensus regarding optimal treatment.

Objectives: In this study, we evaluated the efficacy of pedicular screw in the management of middle thoracic spine fractures to correct kyphosis and anterolisthesis and improve neurologic condition of patients.

Patients and Methods: Twenty-five patients with unstable T1-T10 fractures treated with pedicle screw fixation technique were studied. Neurologic situation, preoperative and postoperative radiographs were evaluated. Radiographic measurements included kyphotic deformity and anterolisthesis. An American Spinal Injury Association (ASIA) scale was used for neurologic classification of the patients.

Results: From a total of 25 patients, 21 cases were male and 4 were female. The mean age of the patients was 35.40 ± 14.39 years. The mean degree of kyphosis improved from 27.04 ± 7.33 degrees preoperatively to 15.96 ± 5.76 degrees at final follow-up. The mean of anterolisthesis improved from 6.44 ± 4.93 mm to 0.96 ± 0.36 mm at final follow-up. Kyphosis (P = 0.0001), anterolisthesis (P = 0.0001) and neurological state (P = 0.01) improved significantly after operation. No cases of hardware failure, neurological deterioration and loss of correction were reported.

Conclusions: Application of pedicular screw in unstable upper and middle thoracic spine fractures is an effective method that can correct kyphotic deformity and anterolisthesis and improve neurologic deficit.

Keywords: Spinal Injury, Thoracic Spine Fracture, Pedicle Screw, Kyphotic Deformity, Anterolisthesis

1. Background

Unstable fractures of the upper and middle thoracic spine have a low prevalence and most of them occur due to high energy injuries which accompany soft tissue damage of the chest and spinal cord (1).

Failure of Denis 3 columns, kyphosis more than 20 degrees, compression of the vertebral body more than 50%, and spinal canal compromise more than 50% are criteria of unstable fracture of thoracic spine that have been considered in studies (2, 3).

The preferred method of fixation for unstable fractures in the upper and middle thoracic spine (T1-10) has been a subject of debate (4-6).Various methods of conservative and surgical techniques have been proposed and used in this field (7-9).

The surgical procedures that can be used in this context are Harrington rod system, Luque linear fixation, and Cotrel-Dubousset technique (10). In spite of increasing knowledge about anatomy, morphometry and biomechanical properties of thoracic vertebrae, there is no general agreement about the best treatment modality of these fractures.

The main advantage of pedicle screw than other devices is that it does not need intact laminae, facet joint integrity or healthy spinous processes and may stabilize three columns of Denis.

The reasons related to the increasing tendency of spine surgeons to use pedicle screw are appropriate reduction, adequate stabilization, rapid decompression of the spinal cord, and rapid mobility of patients after surgery.

Other benefits of fracture fixation using pedicle screws include quick restoration of sagittal and coronal alignment in kyphotic fractures and anterolisthesis correction in fractures with subluxation.

Consequently, the pressure on the spinal canal is removed indirectly. In addition, the fusion prevents from the progressive kyphosis which is a cause of local pain, neurological problems, and devastating psychological consequences (11, 12).

2. Objectives

The aim of this study was to evaluate the efficacy of pedicular screw fixation in unstable fractures of upper and

middle thoracic spine to correct kyphosis and anterolisthesis and improve neurologic status of the patients.

3. Patients and Methods

Twenty-five patients with unstable Upper and middle thoracic spine fractures (T1-10) treated operatively at our institution during the consecutive years of 2009 to 2013 were studied.

Inclusion criteria were skeletally mature patients presenting with fracture dislocation (type C injury according to AO classification) of T1 to T10 vertebrae. Exclusion criteria were skeletally immature patients, polytrauma patients and those with associated head injury. Radiographs, Computed Tomography (CT) scan, Magnetic Resonance Imaging (MRI), and the clinical status were reviewed. General information such as age and sex, date of injury, and clinical status before surgery and during hospitalization were recorded using patient's file.

Patients with incomplete records (in terms of the considered variables) or lack of access to the recorded Information related to the follow-up were excluded from the study.

Neurologic assessment was done using the ASIA scale and each patient's neurologic status was graded as grade A (complete paraplegia) to grade E (normal neurologic status). Radiographic deformity was assessed by calculating kyphosis and anterolisthesis.

Cobb angle between the upper endplate of the first normal vertebra above the fracture and lower endplate of the first normal vertebra below the fracture were measured on radiographs to determine the amount of kyphosis (13). To measure the amount of anterolisthesis, the distance (in millimeter) between the lines drawn along the posterior borders of the vertebral bodies of the injured motion segment was used (14).

The Denis 3 column model of the spine was used for instability definition. When two or more columns were involved by fracture, then it was considered unstable and surgery was performed (15). All operations were performed by the senior surgeon at our institution.

Surgery was performed for the patient in prone position on a padded spinal frame on a radiolucent table. A posterior midline incision was made over the fractured vertebra and extending 3 levels above and below. The incision was deepened to expose the posterior elements of the vertebrae two levels above and below the fractured vertebra. After the pedicles were located, blunt K-wires were placed into the pedicles and their position confirmed using fluoroscope. Then the appropriate size pedicular screws were inserted two levels above and below. Posterior laminectomy was done and any bone fragments inside the spinal canal were removed. Posterior elements were decorticated and bone graft harvested from iliac crest was spread over the fusion bed. Rods were placed over the screws and held by nuts. Acceptable correction of the deformity was achieved using a distractor. In the final step hemostasis was done and the wound was closed in layers. Postoperatively, the patients were given intravenous antibiotics for 5 days and then oral antibiotics were prescribed until suture removal. Intensive physiotherapy was started from first postoperative day. Thoracic Lumbar Sacral Orthosis (TLSO) or cervical TLSO (based on fracture level) was used up to 3 months. All patients were followed in the Out Patient Department (OPD) at monthly intervals. At each follow-up, results were evaluated for neurologic recovery using the ASIA scale and radiologic correction by kyphosis and anterolisthesis measurement.

Data were analyzed using Repeated Measures Analysis. $P \leq 0.05$ was considered statistically significant.

4. Results

Twenty-one patients (84%) were males and 4 (16%) were females. Mean age of the subjects was 35.40 ± 14.39 years (age range, 17 - 67 years).

The mean operation time was 170 minutes (120 - 294 minutes) and mean of bleeding volume during operation was 735 cc (550 to 1000 cc).

Postoperative radiographs and CT scan confirmed the proper screw placement in the pedicles and none of the screws violated the spinal canal. The mean follow-up period was 15 months (6 to 22 months).

During follow-up of patients after surgery, there were no screw or rod failures. None of the patients needed recurrent surgery.

The thoracic spine fracture statistics were as follow:

4 cases (16%) T4/T5, 4 cases (16%) T9/T10, 4 cases (16%) T7/T8, 3 cases (12%) T6/T7, 3 cases (12%) T5/T6, 3 cases (12%) T3/T4, 2 cases (8%) T8/T9, 1 case (4%) T2/T3, 1 case (4%) T1/T2 (Table 1).

The neurologic status (ASIA scale) of patients before the operation was as the following:

13 patients (52%) in the A grade, 5 (20%) in the B grade, and 7 (28%) were in normal condition (E grade).

The neurologic status of patients at final follow-up was as below:

12 patients (48%) were in the A grade, 1 (4%) in the B grade, 4 (16%) in the D grade, and 8 (32%) in normal condition (E grade).

There were significant differences between the initial neurological status and final status, according to the nonparametric test and Wilcoxon signed-Ranks Test ($P = 0.01$).

The mean of kyphosis before surgery was 27.04 ± 7.33 degrees and 15.96 ± 5.76 after surgery.

According to Paired sample t-test, there was a significant difference between the mean of kyphosis before and after surgery in patients ($P = 0.0001$).

The mean of anterolisthesis before surgery was 6.44 ± 4.93mm and 0.96 ± 0.36mm after surgery.

There was a significant difference between the mean anterolisthesis before and after the operation ($P = 0.0001$). Car accident was the commonest mode of injury (72%).

Table 1. Patients Demographic Features, Mode of Injury, Site of Fracture, Neurologic Status, Deformity Parameters, and Follow-up Duration

Patient No	Age, y	Gender	Mode of Injury	Site of Fracture	Preop Deformity		Preop Neurologicstatus (ASIA Grade)	Postop Ddeformity		Final Neurologic Status (ASIA Grade)	Follow-up Duration, mo
					Anterolisthesis	Kyphosis		Anterolisthesis	Kyphosis		
1	21	M	Car accident	T4/T5	6	30	A	0	20	B	16
2	31	M	Fall from height	T9/T10	4	23	A	1	13	A	20
3	29	M	Car accident	T4/T5	8	28	A	2	14	A	13
4	23	F	Car accident	T7/T8	5	27	A	0	12	A	9
5	30	F	Violence	T6/T7	5	21	A	1	8	A	15
6	27	M	Car accident	T6/T7	9	34	A	0	19	A	20
7	25	M	Car accident	T6/T7	9	35	E	3	19	E	19
8	28	M	Car accident	T5/T6	9	29	B	0	14	E	15
9	24	M	Fall from height	T7/T8	5	40	A	0	22	A	12
10	22	M	Car accident	T9/T10	7	29	A	1	15	A	22
11	41	M	Violence	T3/T4	8	21	E	2	10	E	14
12	37	F	Car accident	T8/T9	9	25	E	0	12	E	17
13	63	M	Car accident	T9/T10	6	37	A	2	20	A	20
14	59	M	Car accident	T7/T8	5	26	A	1	20	A	10
15	50	M	Fall from height	T9/T10	7	40	B	2	28	D	14
16	46	F	Car accident	T4/T5	5	26	E	1	17	E	19
17	28	M	Car accident	T5/T6	6	17	E	2	4	E	6
18	37	M	Car accident	T3/T4	5	30	B	0	18	D	13
19	44	M	Fall from height	T8/T9	3	43	A	0	29	A	22
20	57	M	Car accident	T5/T6	8	20	E	3	12	E	21
21	64	M	Car accident	T3/T4	5	24	A	0	14	A	17
22	40	M	Violence	T2/T3	4	19	E	0	11	E	18
23	20	M	Car accident	T4/T5	5	27	A	1	15	A	11
24	22	M	Car accident	T1/T2	6	17	B	1	9	D	7
25	33	M	Car accident	T7/T8	9	19	B	1	10	D	9

Abbreviation: Female, F; Male, M.

5. Discussion

Unstable fractures of the upper and middle thoracic spine are rare. The treatment of unstable thoracic spine fractures remains controversial despite an increased knowledge of the morphometric, anatomic, and biomechanical features of thoracic vertebrae. There is no consensus regarding optimal treatment and various conservative and operative options have been described in the literature with different inclusion criteria, follow-ups and evaluation tools.

Surgical treatment for unstable fractures of the upper and middle thoracic spine should be safe and improve deformity (kyphosis and Anterolisthesis) and neurological deficit resulting from fracture and maintain this condition in the long term. The placement of pedicle screws in the upper and middle thoracic levels is challenging, but can be performed accurately by knowing the anatomy and carefulness. In our study, 25 patients were studied. Among them, 21 were male and 4 were female, which was similar to other studies in trauma victims.

The mean age of patients was 35.40 ± 14.39 years. The mean age of patients in Belmont et al. study was 24 ± 6.3 years (3) and in Fisher et al. study it was 39.9 ± 13 years (16). This revealed that patients were in their productive ages and can return to society. There was no wrong placement of screws and no case of hardware failure or neurologic deterioration after surgery and was similar to a study by Yue et al. (17). In the present study, significant improvement in neurological status was seen in addition to kyphosis and anterolisthesis correction.

The mean of kyphosis before surgery was 27.04 ± 7.33 and 15.96 ± 5.76 degree after surgery; In Payer's study, these values were 23 ± 4.65 and 17 ± 3.96, respectively (18) which in both studies correlation was significant. The mean of anterolisthesis before surgery was 6.44 ± 4.93 mm and 0.96 ±0.36 mm after surgery. These values in Payer et al. study were 8 ± 2.2 and 1 ± 0.54 mm, respectively. The difference was significant in both studies. Our study was limited due to the fact that it was retrospective and lacked controls (18).

However, the positive point of the study was that only unstable fractures of the upper and middle thoracic spine were studied and all surgeries were performed with a uniform method. While, in other studies other posterior instruments were used (Schweighofer et al.) (19), or a wider range of the spine was assessed (Yue et al.) (17), or limited to a small portion of the spine (Fisher et al.) (16) or the number of patients was much lower than our study (8 patients in Payer et al. study) (18). The results of this study indicated that the neurological deficit, kyphotic deformity and anterolisthesis in unstable fractures of the upper and middle thoracic spine can be treated using pedicle screw fixation.

Acknowledgments

We would like to express our sincere thanks to Dr. Behshad Behfar for valuable encouragement extended to us.

Footnote

Authors' Contribution: All of stages related to manuscript was done by Amir Abbas Ghasemi except for acquisition of data which was performed by Soudabeh Ashoori.

References

1. Singh R, Taylor DM, D'Souza D, Gorelik A, Page P, Phal P. Injuries significantly associated with thoracic spine fractures: a case-control study. *Emerg Med Australas.* 2009;**21**(5):419–23. doi: 10.1111/j.1742-6723.2009.01209.x. [PubMed: 19694786]
2. Bastian L, Knop C, Lange U, Blauth M. [Transpedicular implantation of screws in the thoracolumbar spine. Results of a survey of methods, frequency and complications]. *Orthopade.* 1999;**28**(8):693–702. [PubMed: 10506372]
3. Belmont Jr PJ, Klemme WR, Dhawan A, Polly Jr DW. In vivo accuracy of thoracic pedicle screws. *Spine (Phila Pa 1976).* 2001;**26**(21):2340–6. [PubMed: 11679819]
4. Sasso RC, Best NM, Reilly TM, McGuire Jr RA. Anterior-only stabilization of three-column thoracolumbar injuries. *J Spinal Disord Tech.* 2005;**18 Suppl**:S7–14. [PubMed: 15699808]
5. Zdeblick TA, Warden KE, Zou D, McAfee PC, Abitbol JJ. Anterior spinal fixators. A biomechanical in vitro study. *Spine (Phila Pa 1976).* 1993;**18**(4):513–7. [PubMed: 8470014]
6. Knop C, Fabian HF, Bastian L, Blauth M. Late results of thoracolumbar fractures after posterior instrumentation and transpedicular bone grafting. *Spine (Phila Pa 1976).* 2001;**26**(1):88–99. [PubMed: 11148651]
7. Rajasekaran S. Thoracolumbar burst fractures without neurological deficit: the role for conservative treatment. *Eur Spine J.* 2010;**19 Suppl 1**:S40–7. doi: 10.1007/s00586-009-1122-6. [PubMed: 19669803]
8. Stadhouder A, Buskens E, Vergroesen DA, Fidler MW, de Nies F, Oner FC. Nonoperative treatment of thoracic and lumbar spine fractures: a prospective randomized study of different treatment options. *J Orthop Trauma.* 2009;**23**(8):588–94. doi: 10.1097/BOT.0b013e3181a18728. [PubMed: 19704275]
9. Dendrinos GK, Halikias JG, Krallis PN, Asimakopoulos A. Factors influencing neurological recovery in burst thoracolumbar fractures. *Acta Orthop Belg.* 1995;**61**(3):226–34. [PubMed: 8525820]
10. Berlet GC, Boubez G, Gurr KR, Bailey SI. The USS pedicle hook system: a morphometric analysis of its safety in the thoracic spine. Universal Spine System. *J Spinal Disord.* 1999;**12**(3):234–9. [PubMed: 10382777]
11. Korovessis PG, Baikousis A, Stamatakis M. Use of the Texas Scottish Rite Hospital instrumentation in the treatment of thoracolumbar injuries. *Spine (Phila Pa 1976).* 1997;**22**(8):882–8. [PubMed: 9127922]
12. McCullen G, Vaccaro AR, Garfin SR. Thoracic and lumbar trauma: rationale for selecting the appropriate fusion technnique. *Orthop Clin North Am.* 1998;**29**(4):813–28. [PubMed: 9756974]
13. Yong-Jie G, Yong H, Ma WH, Xu RM. [Treatment of thoracolumbar vertebral fractures with posterior short segmental pedicle screw fixation and pedicle screw at the fracture level]. *Zhongguo Gu Shang.* 2010;**23**(4):264–7. [PubMed: 20486376]
14. Keynan O, Fisher CG, Vaccaro A, Fehlings MG, Oner FC, Dietz J, et al. Radiographic measurement parameters in thoracolumbar fractures: a systematic review and consensus statement of the spine trauma study group. *Spine (Phila Pa 1976).* 2006;**31**(5):E156–65. doi: 10.1097/01.brs.0000201261.94907.0d. [PubMed: 16508540]
15. Denis F. Spinal instability as defined by the three-column spine concept in acute spinal trauma. *Clin Orthop Relat Res.* 1984;(189):65–76. [PubMed: 6478705]
16. Fisher C, Singh S, Boyd M, Kingwell S, Kwon B, Li MJ, et al. Clinical

and radiographic outcomes of pedicle screw fixation for upper thoracic spine (T1-5) fractures: a retrospective cohort study of 27 cases. *J Neurosurg Spine.* 2009;**10**(3):207–13. doi: 10.3171/2008.12.SPINE0844. [PubMed: 19320579]

17. Yue JJ, Sossan A, Selgrath C, Deutsch LS, Wilkens K, Testaiuti M, et al. The treatment of unstable thoracic spine fractures with transpedicular screw instrumentation: a 3-year consecutive series. *Spine (Phila Pa 1976).* 2002;**27**(24):2782–7. doi: 10.1097/01.BRS.0000035727.46428.BE. [PubMed: 12486347]
18. Payer M. Unstable upper and middle thoracic fractures. Preliminary experience with a posterior transpedicular correction-fixation technique. *J Clin Neurosci.* 2005;**12**(5):529–33. doi: 10.1016/j.jocn.2004.11.006. [PubMed: 15975792]
19. Schweighofer F, Hofer HP, Wildburger R, Stockenhuber N, Bratschitsch G. Unstable fractures of the upper thoracic spine. *Langenbecks Arch Chir.* 1997;**382**(1):25–8. [PubMed: 9049955]