Short-Segment Fixation of Thoracolumbar Burst Fracture: Plate vs. Rod Systems

The Results Obtained by Adding Pedicular Screws at the Level of Fracture

Meelab P, MD

Department of Orthopaedic Surgery, Saraburi Hospital, Saraburi, Thailand

Objective: *To evaluate the effect of short-segment pedicle screw fixation of thoracolumbar unstable burst fractures by adding pedicle screws at the level of fracture; and to compare the pedicle plate and pedicle rod systems.*

Material and Method: *A retrospective study to evaluate 20 patients with unstable thoracolumbar burst fractures, admitted to Saraburi Hospital from 2006 to 2009. All underwent short-segment pedicle screw fixation with added pedicle screws at the level of fracture. A review of the medical records, including radiographs was completed. The pedicle screw fixation was classified into two types: a plate or a rod system. Evaluation was based on the correction of kyphotic deformity from the time of surgery to at least the end of a six month follow-up period.*

Results: *Twenty patients underwent short-segment pedicle screw fixations (8 plate, and 12 rod systems) with added screws at the level of injury. Surgical correction of kyphotic deformity from 18.4 degrees to 5.10 degrees was obtained. This was of statistical significance, and the correction maintained until fracture union, with only slightly progressive kyphotic deformity. No significant difference was encountered in the comparison of the efficacy of the pedicle plate and the pedicle rod systems.*

Conclusion: *Short-segment pedicle screw fixation remains popular in the treatment of thoracolumbar burst fractures. Adding pedicle screws at the level of injury results in increased stability of the system, and decreases complications. Both pedicle plate and rod systems yield similar clinical outcomes.*

Keywords: *Thoracolumbar burst fracture, short-segment pedicle screw fixation, kyphosis*

The Thai Journal of Orthopaedic Surgery: 36 No.1-2: P1-7
Full text. e journal: *http://www.rcost.or.th, http://thailand.digitaljournals.org/index.php/JRCOST*

Treatment of unstable thoracolumbar burst fracture often requires surgical intervention, and stabilization for early mobilization until fracture union is achieved. It also has the potential for neurological improvement. Optimal treatment is still controversial. The anterior approach leads to direct decompression and fusion, whereas the posterior to indirect decompression and stabilization. Some surgeons recommend a combination of both approaches. The posterior approach has become more popular because it is easier to perform, less invasive, and obtains stability with pedicle screw fixation[1,2,5]. Stabilization of the injured spine with the least number of spinal segments (short-segment fixation; one level above and below the injured level) has become more available compared to the previous (long-segment) option such as the Harrington rod instrumentation. However, various unfavorable results have been reported in short-segment pedicle screw fixation, notably progressive kyphotic deformity. A potential cause of failure may be inadequate stability of the system. A number of spinal surgeons improved system stability by adding pedicle screws at the level of fracture, and have reported satisfactory results[3]. There are two system types: the pedicle plate system and pedicle rod system, and both are now widely used in Thailand[3,7]. No study has reported on comparisons of the results between these two types. At the Orthopaedic Department of Saraburi Hospital, we have used both systems, and frequently added screws at the fracture level in short-segment pedicle fixation. This has been the practice for many years.

The purpose of this study is to evaluate the effect of short-segment pedicle screw fixations in unstable thoracolumbar burst fractures by adding screws at the level of fracture, and comparing the results obtained by the two different pedicle screw systems.

Correspondence to: Meelab P, Department of Orthopaedic Surgery, Saraburi Hospital, Saraburi, Thailand
E-mail: pjarb@hotmail.com, pjortho@gmail.com

Material and Method

This study was retrospective and based on a review of patients' charts and radiographs. Those included were treated at Saraburi Hospital from

2006 to 2009. The patients were all diagnosed as having unstable thoracolumbar burst fracture (defined as kyphotic deformity > 20%, loss of anterior vertebral height > 40%, or canal compromised >50%). Other inclusion criteria were one level fracture, patient age > 15 years, and duration of treatment not delayed more than two weeks. Exclusion criteria were: pedicle fracture involvement (from CT scan), multiple levels of injury, or fracture dislocation, and patients with a follow up period of less than 6 months. All patients underwent surgery: short-segment pedicle screw fixation by one of six orthopaedic surgeons of the Orthopaedic Department, Saraburi Hospital. Two types of pedicle screw systems were employed (the surgeon's decision, based on his familiarity with the instrumentation, and his skills). Method of application may have varied somewhat in the design of each system.

Surgical technique and postoperative care

The PTS system, developed by Professor Prakit Tienboon from Chulalongkorn University[7], was employed as the pedicle screw rod system. Standard posterior approach was used. Pedicle screws were inserted under fluoroscopy. Direction of the pedicle screws was parallel to the upper vertebral end plate. Screws placed in the vertebral body above the injured level should pointed downward, and screws in the vertebral body below should be pointed upwards, because of the abnormal alignment of the injured spine. A total of 6 pedicle screws were inserted, after which the rod instruments were used for connection. The screws at the level of fracture would act as a fulcrum for indirect reduction (3-point reduction maneuver), while the system was tightened to enable rigid construction. Correction of the kyphotic deformity is attained by forcing the screws into parallel, along the contour of the rod. A distraction device may useful for correction of anterior vertebral height.

The Ramathibodi spinal plate system[3] was used in the alternate surgical method (the pedicle screw plate system), with some differences in application. Initially, screws were inserted only one-half length in the same direction as mentioned above. The plate instrument was applied loosely, and all screws were driven into the pedicle slowly. By contouring the plate instrument, the screws were forced to become parallel, and thus the kyphotic deformity was slowly corrected, until the system reached maximum rigidity.

Neither posterior decompression nor bone grafting was performed in any patient. Early ambulation was encouraged, with Jewett bracing for three months. Follow up appointments were scheduled at one, three and six months. During the follow up period, evaluation of radiographic alignment was done in terms of kyphotic deformity correction, and progressive kyphosis. All follow up radiographs were taken in the supine position. Fracture kyphotic deformity was measured from the superior end plate of the vertebral body one level above the injured vertebra to the inferior end plate of the vertebral body one level below. For the evaluation of fracture treatment, Jerome G et al.[8] found this method to be the most consistent in terms of intraobserver and interobserver reliability. Measurement of anterior vertebral height may be difficult and unreliable because of comminution of the vertebral end plate. Therefore, each patient was measured twice by one observer, during a two week period, with measurement randomized, and not arranged by serial number. We then used average values for the assessment. Kyphotic deformity was important both for documentation of the clinical assessment, and for examination of parameters related to treatment outcome.

Statistical analysis

The Wilcoxon Signed Ranks Test was used to analyze the results of the fracture deformity correction comparing a) pre- and post-operative statistics; and b) progressive kyphosis between post-operative and the last follow up period. Comparison between the two different systems was made by using The Mann-Whitney Test. A p-value of less than 0.05 was considered as statistically significant.

Sample size was estimated by Power and Sample size Calculations (Vanderbilt, Version 3.0.2), and to determine the differences in kyphotic angle between groups at 5 degrees, standard deviation (SD) 2.5 degrees, alpha error 0.05, and beta error 0.2. The sample size was 5 per group.

Results

Twenty unstable thoracolumbar burst fracture patients were treated by short-segment pedicle screw fixation (8 with the plate system, and 12 with the rod system), adding pedicle screws on both sides at the level of fracture. Twelve patients were male, and eight female. Their age ranged from 18-63 years (mean age 38 years). The most common cause of injury was a fall from height (14 patients); six patients suffered traffic and other accidents. The operative time was 125-180 minutes (mean 146 minutes) for the pedicle rod system, and a mean of 134 minutes for the pedicle plate system. Unfortunately, some operative notes did not record blood loss. Some demographic data were not complete, leading to a limitation of this study, as for example, when making comparisons in different populations. The follow up period was 6-24 months (mean 7.8 months). After six months following surgery, most patients were lost follow up; all of these had clinical and radiographic union at the fracture site. Two patients reached a maximum follow up of 24 months. Both had lower lumbar back pain because of spondylosis, unrelated to the previous fracture. Radiographic findings in both

showed that kyphosis remained unchanged from the 6 month-follow up.

The efficacy of kyphotic fracture correction from a mean of 18.4 degrees preoperatively, to a postoperative mean of 5.1 degrees is significant ($p < 0.001$), and the same result was obtained in the correction of anterior vertebral height ($p < 0.001$). Comparison between the two pedicle systems (pedicle plate system and pedicle rod system), the significant difference of 5 degrees may affect selection of implant systems. The results of kyphotic deformity correction and progressive kyphosis deformity demonstrated that there was no significant difference between the two groups ($p = 0.757$ and $p = 0.085$ respectively).

There were four patients who demonstrated neurological deficit: one patient with Frankel C, and 3 patients with Frankel D. There was no correlation between neurological deficit and degree of kyphotic deformity; patients with maximum deformity (30 degrees of kyphosis) came with normal neurologic findings, and the four patients with neurological deficit, had kyphotic deformities ranging from 15 to 20 degrees. At last follow up slight clinical improvements were noted: one level for the patient with Frankel C, and one patient with Frankel D . In two patients one of the upper screws penetrated the pedicle but did not injure the nerve root. There were no cases of wound infection. There was one late complication: a patient developed slight bending of the plate at 6 months follow-up.

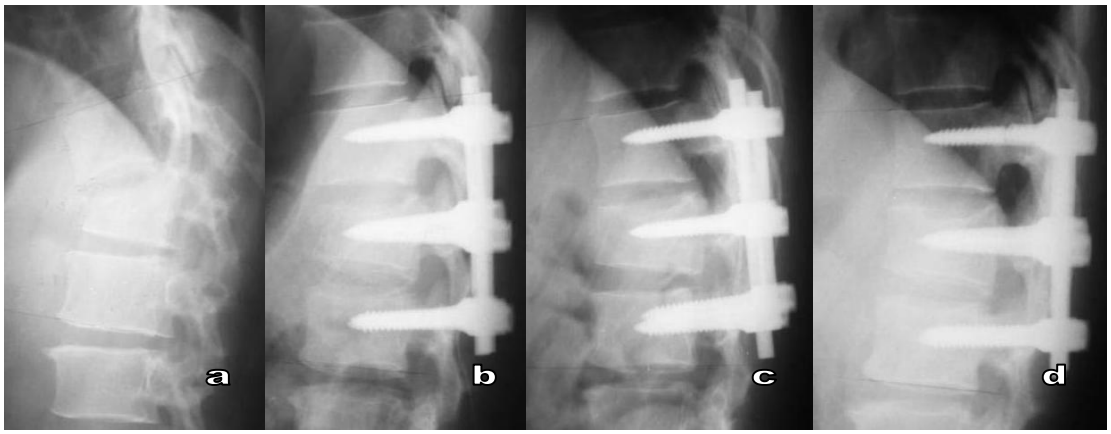

Fig. 1 A male, 34 years old, with a, L1 burst fracture, b, underwent pedicle rod fixation, c, a radiograph at 1-month follow up, and d, fracture union at 6-month follow up (d).

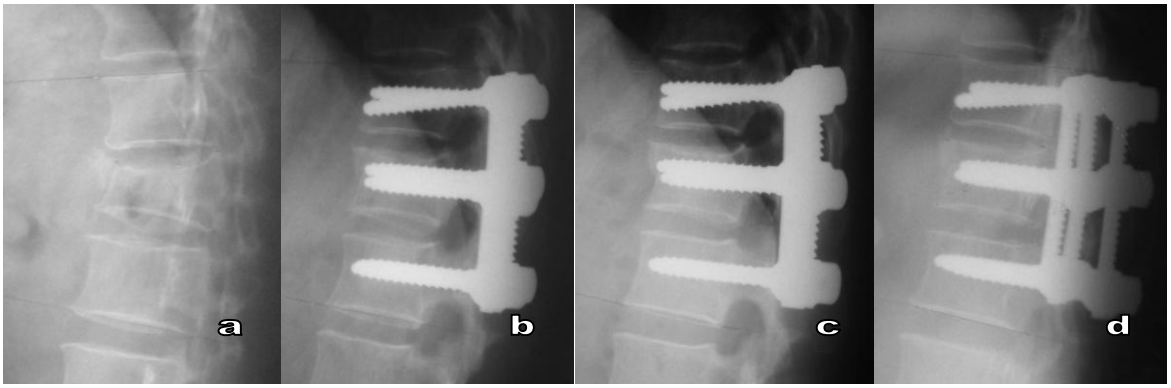

Fig. 2 A female, 41 years old, with a, L2 burst fracture b, post operation with pedicle plate; Ramathibodi Spinal System, c, at 1 month of follow-up, and d, 6 months later.

Table 1 Summary of Data

Case no.	Age (Years)	Level	Pedicle system	Kyphosis pre-op (Degrees)	Kyphosis post-op (Degrees)	Kyphosis last F/U (Degrees)
1	18	L1	Rod	16	9	10
2	51	L2	Plate	8	0	0
3	31	T12	Plate	30	15	21
4	41	T12	Rod	20	9	10
5	24	L3	Rod	6	-2	2
6	38	L2	Rod	12	3	5
7	18	L1	Plate	15	8	10
8	60	L1	Plate	20	5	8
9	50	T12	Plate	14	7	9
10	47	L1	Plate	20	8	10
11	40	T12	Rod	16	6	7
12	50	T12	Rod	30	8	12
13	29	L3	Plate	25	-5	-1
14	41	L1	Plate	20	4	6
15	63	L1	Rod	15	5	6
16	27	L1	Rod	25	8	9
17	25	L1	Rod	20	5	6
18	34	T12	Rod	22	6	7
19	31	L1	Rod	18	0	2
20	42	L2	Rod	16	3	3
Mean	38			18.40	5.10	7.10
SD				6.26	4.48	4.87

Discussion

The principles of the treatment of unstable thoracolumbar burst fracture are the same as for general fracture treatment. Optimal fracture reduction, and maintenance of reduction until union at the fracture site are the goals of treatment. These allow early rehabilitation and may effect improvement of neurological function. Various methods are available for the treatment of these unstable fractures: the anterior approach for direct reduction and fusion, and the posterior approach for indirect reduction with or without decompression. Some authors prefer both approaches. Posterior stabilization is the more popular method because of its simplicity, less soft tissue damage, and low risk of complications[4,5]. In earlier times, the posterior stabilizing technique utilized the Harrington hook and rod instrumentation. An et al[10] reported a disadvantage with the length of the instrumentation, and difficulties in the lower lumbar region, which sometimes required rod removal a year later. Advancement in spinal instrumentation led to the development of pedicle screw fixation in the treatment of spinal diseases. Even later it became popular in the treatment of fractures[11].

Short-segment spinal instrumentation (fixation of one normal vertebra above and one below an injured segment), represents an attempt to restore the anterior column without the need of anterior strut grafting or plate fixation, minimizing the length of spinal segment involved. Parker et al[4] report 45 of 46 patients instrumented by the short-segment technique, and cooperating with 3 to 4 months of spinal bracing, obtained successful healing with virtual anatomic alignment. Yue et al[5] evaluated the use of transpedicular screw fixation in the treatment of unstable thoracolumbar spinal injury (a three year consecutive series) and concluded that this method was a safe, reliable, and effective alternative treatment. Many authors reported the same satisfactory results[1,2,9,10,11]. However, McLaine and other authors[12,15] noted a failure rate of the posterior short-segment pedicle system that ranged from 10 to 50%. Rick et al[6] reported posterior instrumentation resulting in statistically significant initial improvement in sagittal alignment, but lost that gain at follow up. Potential causes might be inadequate system stability. A void was created and eliminated anterior column load sharing, thus exposing the pedicle screw implants to high cantilever bending loads. Transpedicular grafting was attempted to replicate anterior column restoration to prevent angulations. Alanay et al[15] studied 20 consecutive patients, prospectively and randomized, using the short-segment pedicle instrument with or without transpedicular grafting. There was no significant difference between the two groups, each with a 40% to 50% failure rate of > 10 degree correction loss, and 10% hardware breakage. Knop et al[16] report that the preoperative wedge angle of the

vertebral body correlates significantly with the postoperative loss of reduction.

Professor Wichien Laohachareonsombat[3] who has been working at the Department of Orthopaedics, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, added screws at the level of injury, and found that this method can be useful in the initial reduction, and can decrease implant loads. Mahar et al[18] demonstrated that the placement of pedicle screws into the fractured vertebral body generates a segment construct which improved biomechanical stability. Biomechanical testing in a cadaveric model shows that the axial torsion stability is multiplied 2-fold. There appeared to be a trend towards increased stability in flexion-extension and lateral bending. However, the results were not statistically significant. Gaven et al[19] reported in a prospective, randomized study the results of treating 72 unstable thoracolumbar burst fracture patients with and without the fracture level screw combination. Follow up for 50 months found that fracture level screw combination provided better intraoperative correction and maintenance during treatment.

Our study demonstrated that initial deformity correction was statistically significant in terms of kyphotic deformity fracture correction ($p<0.0001$), and anterior vertebral height correction ($p=0.005$). Screws at the level of injury can decrease the bending load on the posterior instrument, eliminate some void in the anterior column by the space-occupying effect, and help in initial reduction by the 3-point reduction maneuver. Measurement the kyphotic angle followed Jerome et al[8], who suggest that accurate measurement of the angle of kyphosis remains an important factor in the examination of parameters related to treatment outcomes. Measurement of anterior vertebral height may be difficult because of a displaced comminuted vertebral endplate. However, we measured twice to increase reliability. At the final follow up (> 6 months, the time by which the fracture should achieved union), this system can maintain reduction (less progressive kyphosis), and the results were statistically significant ($p<0.001$).

Selection of which of the two pedicle screw systems discussed to be used on a patient was made by the surgeon, based on his/her preference for, and knowledge of the implants. This may lead to selection bias. This study compared the results of kyphotic deformity correction, and maintenance of fracture reduction. The pedicle plate system obtains slightly better initial fracture correction than pedicle rod system. However, there was no statistically significant difference. Concerning maintenance of reduction, the pedicle rod system seems to give better results than pedicle plate system. The explanation may be because of the greater stiffness of the rod implant. Again, the results displayed no statistical difference. The limitation of this study are: it was a retrospective study; it was not a randomized, controlled trial; it included a selection bias against disease severity; it had an evaluation bias; the number of cases was small and limited; and the follow up term was short. The loss of patients to follow up after fracture union resulted in incomplete study data.

Conclusion

In the treatment of unstable thoracolumbar burst fracture, the short-segment pedicle screw system provides a simple technique, is less invasive, and has minimal motion segment involvement. With the proper selection of patients, such as a single level fracture, and intact pedicle at the level of injury, adding pedicle screws to the fractured vertebra via either a plate or rod system increases segment construct stability, and yields similar satisfactory outcomes using either of the two systems.

Acknowledgement

My sincerest thanks go to our Orthopaedic staff at Saraburi Hospital who made a professional contribution to this publication, and to our patients who participated in this study. The author is grateful for, and appreciates the help given by Assistant Professor Patarawan Woratanarat MD., PhD. (Clinical Epidemiology), Department of Orthopaedics, Faculty of Medicine, Ramathibodi Hospital. She provided most worthwhile guidance and assistance in the manuscript preparation.

References

1. Sasso RC, Costler HB. Posterior instrumentation and fusion for unstable fractures and fracture-dislocations of thoracic and lumbar spine. Spine (Phila Pa 1976) 1993; 18(4): 450-60.
2. Roy–Camille R, Saillant G, Mazel C. Internal fixation of the lumbar spine with pedicle screw plating. Clin Orthop Relat Res 1986; (203): 7-17.
3. Laohacharoensombat W. Ramathibodi Spinal System: Principle and Surgical Technique. 1st ed. Bangkok: Holistic Publishing company; 2001: 56-65.
4. Parker JW, Las JR, Karaikonic EE, Gains RW. Successful short segment instrumentation and fusion for thoracolumbar spine fracture: a consecutive 4 ½-year series. Spine 2000. 25(9): 1157-70.
5. Yue JJ, Sossan A, Selgrath C, Deutsch LS, Wilkens K, Testaiuti M, et al. The treatment of unstable thoracic spine fracture with transpedicular screw instrumentation: a 3-year consecutive series. Spine (Phila Pa 1976). 2002; 27(24): 2782-7.
6. Sasso RC, Renkens K, Hanson D, Reilly T, McGuire RA Jr, Best NM. Unstable

thoracolumbar burst fractures: anterior-only versus short-segment posterior fixation. J Spinal Disord Tech 2006; 19(4): 242-8.
7. Tienboon P. The Spine: Pedicle Screw Fixation Technique. 1st ed. Bangkok: DanSutha Publishing company; 2010: 84-136.
8. Enad JG, Slakey JB, McNulty PS. Measurement of thoracolumbar kyphosis after burst fracture: evaluation of intraobserver, interobserver, and variability of 4 measurement methods. Am J Orthop (Belle Mead NJ) 2008; 37(4): E60-3.
9. Khan AA, Khanzada K, Ayub S, Ali M. Surgical outcome of transpedicular fixation in thoracolumbar fractures. J Ayub Med Coll Abbottabad 2008; 20(4): 104-7.
10. An HS, Vaccaro A, Cotler JM, Lin S. Low lumbar burst fractures. Comparison among body cast, Harrington rod, Luque rod, and Steffee plate. Spine (Phila Pa 1976) 1991; 16(8 Suppl): S440-4.
11. McAfee PC, Wemer FW, Glisson RR. A biomechanical analysis of spinal instrumentation systems in thoracolumbar fractures. Comparison of traditional Harrington distraction instrumentation with segmental spinal instrumentation. Spine (Phila Pa 1976) 1985; 10(3): 204-17.
12. McLain FR, Sparling E, Benson RD. Early failure of short-segment pedicle instrumentation for thoracolumbar burst fracture: A preliminary report. J Bone Joint Surg Am 1993; 75: 162-7.
13. Sapkas G, Kateros K, Papadakis SA, Brilakis E, Macheras G, Katonis P. Treatment of unstable thoracolumbar burst fractures by indirect reduction and posterior stabilization: short-segment versus long-segment stabilization. Open Orthop J 2010; 4: 7-13.
14. Wei FX, Liu SY, Liang CX, Li HM, Long HQ, Yu BS, et al. Transpedicular fixation in management of thoracolumbar burst fractures: monosegmental fixation versus short-segment instrumentation. Spine (Phila Pa 1976) 2010; 35(15): E714-20.
15. Ahmet A, Emre A, Muharrem Y, Ali O, Adil S. Short-Segment Pedicle Instrumentation of Thoracolumbar Burst Fractures Does Transpedicular Intracorporeal Grafting Prevent Early Failure? Spine 2001; 26: 213-7.
16. 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.
17. Cho DY, Lee WY, Sheu PC. Treatment of thoracolumbar burst fractures with polymethyl methacrylate vertebroplasty and short-segment pedicle screw fixation. Neurosurgery 2003; 53(6): 1354-60; discussion 1360-1.
18. Mahar A, Kim C, Wedemeyer M, Mitsunaga L, Odell T, Johnson B, et al. Short-segment fixation of lumbar burst fracture using pedicle screw fixation at the level of the fracture. Spine (Phila Pa 1976) 2007; 32(14): 1503-7.
19. Guven O, Kocaoglu B, Bezer M, Aydin N, Nalbantoglu U. The use of screw at the fracture level in the treatment of thoracolumbar burst fractures. J Spinal Disord Tech 2009; 22(6): 417-21.

ผลของการใส่สกรูผ่านก้านกระดูกสันหลังยึดตรึงกระดูกแบบช่วงยึดสั้นด้วยแผ่นโลหะเปรียบเทียบกับแบบแท่งโลหะในผู้ป่วยกระดูกสันหลังหักระดับอกและเอวแบบแตกระเบิด

ประจวบ มีแลบ, พบ

วัตถุประสงค์ *: เพื่อประเมินผลของการรักษากระดูกสันหลังส่วนอกและเอวหักแบบแตกระเบิดโดยการใส่เครื่องมือยึดทางด้านหลังชนิดช่วงยึดสั้นร่วมกับการใส่สกรูเพิ่มตรงระดับที่มีการหักโดยเปรียบเทียบระหว่างแบบแผ่นโลหะกับแบบแท่งโลหะ*

วัสดุและวิธีการ*: เป็นการศึกษาแบบย้อนหลังในผู้ป่วยกระดูกสันหลังส่วนอกและเอวหักแบบแตกระเบิดที่ได้รับการผ่าตัดรักษาที่โรงพยาบาลสระบุรี ตั้งแต่ พ.ศ.2549-2552 จำนวน 20 คน โดยสืบค้นประวัติและผลการรักษาจากแฟ้มผู้ป่วยและข้อมูลภาพถ่ายทางรังสี ติดตามในด้านความผิดรูปในมุมก้มตั้งแต่การผ่าตัดแก้ไข จนถึงการติดตามผลเมื่อกระดูกติดแข็งแรงและเปรียบเทียบผลอันเนื่องจากความแตกต่างของชนิดของเครื่องมือที่ใช้คือ แบบเชื่อมสกรูด้วยแผ่นโลหะและแบบเชื่อมต่อสกรูด้วยแท่งโลหะ*

ผลการศึกษา*: ผู้ป่วยได้รับการผ่าตัดรักษาด้วยเครื่องมือแบบแผ่นโลหะ 8รายและแบบแท่งโลหะ 12 ราย พบว่าความผิดรูปในมุมก้มของแนวกระดูกสันหลัง จากมุมก้มเฉลี่ยเริ่มต้นหลังจากอุบัติเหตุ 18.4 องศา เปลี่ยนแปลงเป็น 5.1 องศาลดลงอย่างมีนัยสำคัญทางสถิติ และจากการติดตามการรักษาครั้งสุดท้ายเมื่อกระดูกติดแล้วพบว่าค่ามุมก้มเฉลี่ยเพิ่มขึ้นเป็น 7.1 องศา การรักษาทั้งสองแบบให้ผลการรักษาไม่แตกต่างกันทั้งในเรื่องการแก้ไขความผิดปกติและการเกิดการเปลี่ยนแปลงของมุมก้มในภายหลัง*

สรุป*: การรักษากระดูกสันหลังส่วนอกและเอวหักแบบแตกระเบิดด้วยการผ่าตัดยึดตรึงทางด้านหลังแบบช่วงยึดสั้น โดยการเพิ่มสกรูตรงระดับที่มีการหัก สามารถแก้ไขความผิดปกติในมุมก้มได้ตั้งแต่ภายหลังการผ่าตัดและช่วยป้องกันการเกิดมุมก้มที่จะเพิ่มขึ้นในช่วงที่เกิดการซ่อมแซมของกระดูกที่หักจนเป็นปกติ ผลของการใช้เครื่องมือทั้งสองแบบให้ผลการรักษาที่ไม่แตกต่างกัน*