Postoperative Outcome of Short Segment Percutaneous Screw Fixation Compare with Long Segment Fixation in Thoracolumbar Fracture

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Objectives: *To evaluate the postoperative outcome of percutaneous pedicle screw fixation (PPSF) using the proposed technique in the treatment of thoracolumbar spine fracture compared to an open long segment pedicle screw fixation technique (OPSF).*

Materials and Methods: *A retrospective review of 49 cases of unstable thoracolumbar spine fracture patients (Burst fracture 44 cases and flexion-distraction 5 cases) without neuro deficit that treated at Maharat Nakhon Ratchasima hospital from January 2015 - December 2017. Demographics data, postoperative visual analog scale, intraoperative blood loss and length of stay were collected from medical records. Postoperative radiographic parameters were collected from the CT scan.*

Results: *The mean kyphosis reduction was 11.2±4.6 degrees in the PPSF group and 11.5±4.8 degrees in the OPSF group. Mean canal diameter increase was 17.81±16.46 and 18.83±15.36 mm2 respectively. Mean VAS reduction was 4.55±1.87 and 4.63±2.16 respectively. There was no significant difference between the two groups in these three parameters (all P-values > .05). There was a statistically significant difference in intraoperative blood loss which was 56.36±36.64 ml in PPSF and 124.38±59.89 ml in OPSF (P < .05). Postoperative length of stay was no significantly difference between the both groups (PPSF 5.7±2.2 and OPSF5.8±2.1 respectively, P = .86).*

Conclusions: *In terms of postoperative outcome, there were lack of evidence to detect the difference between PPSF and OPSF in postoperative radiologic outcomes, VAS reduction, postoperative length of stay and complications, but PPSF could reduce intraoperative blood loss.*

Keywords: *Thoracolumbar spine; Spinal fractures; Minimal invasive surgery; Pedicle screws; Fracture reduction*

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Introduction

Thoracolumbar spine fractures are the most common spine injuries especially at the thoracolumbar junction (T10-L2) which is a biomechanical transitional zone[1,2]. The incidence in the North America had been reported at around 160,000 cases per year. The consequences of such injuries can be devastating and include neurological deficit and severe deformities.

The most popular classification scheme is the use of a 3-column concept proposed by Denis[3]. This classification divides such injuries into four groups: compression, burst, seat-belt type injuries, and fracture dislocation. In 2005, Vaccaro et al. proposed the Thoracolumbar Injury Classification and Severity Score (TLICs)[4], which captures fracture morphology, posterior ligamentous complex and neurological status. TLICs is used as a guide for treatment method.

For an unstable thoracolumbar fracture (TLICs ≥ 4) with a neurological deficit, an open pedicle screw fixation with direct reduction by an anterior or posterior approach is standard treatment[5,6]. In contrast, an unstable thoracolumbar fracture without a neurological deficit can be treated with a minimally invasive pedicle screw fixation or open conventional pedicle screw fixation. The advantage of a minimally invasive pedicle screw fixation is reduced operative time, lower surgical morbidity and improved postoperative recovery[7-13].

There are many percutaneous screw fixation systems. Most systems use a guide wire and cannulated screw to insert the pedicle screw. Due to limitations at our hospital, we applied a conventional mono-axial screw inserted with a percutaneous technique after using a cannulated tap and inserted sub muscular rods through a distal incision (Figure 1). For an open long-segment pedicle screw insertion, we used an open split muscle technique that inserted a screw through the intermuscular plane between the multifidus and the longissimus muscles (Wiltse's approach)[14-16]. We retrospectively compared the feasibility, safety, and efficacy of our technique and open long-segment pedicle screw fixation.

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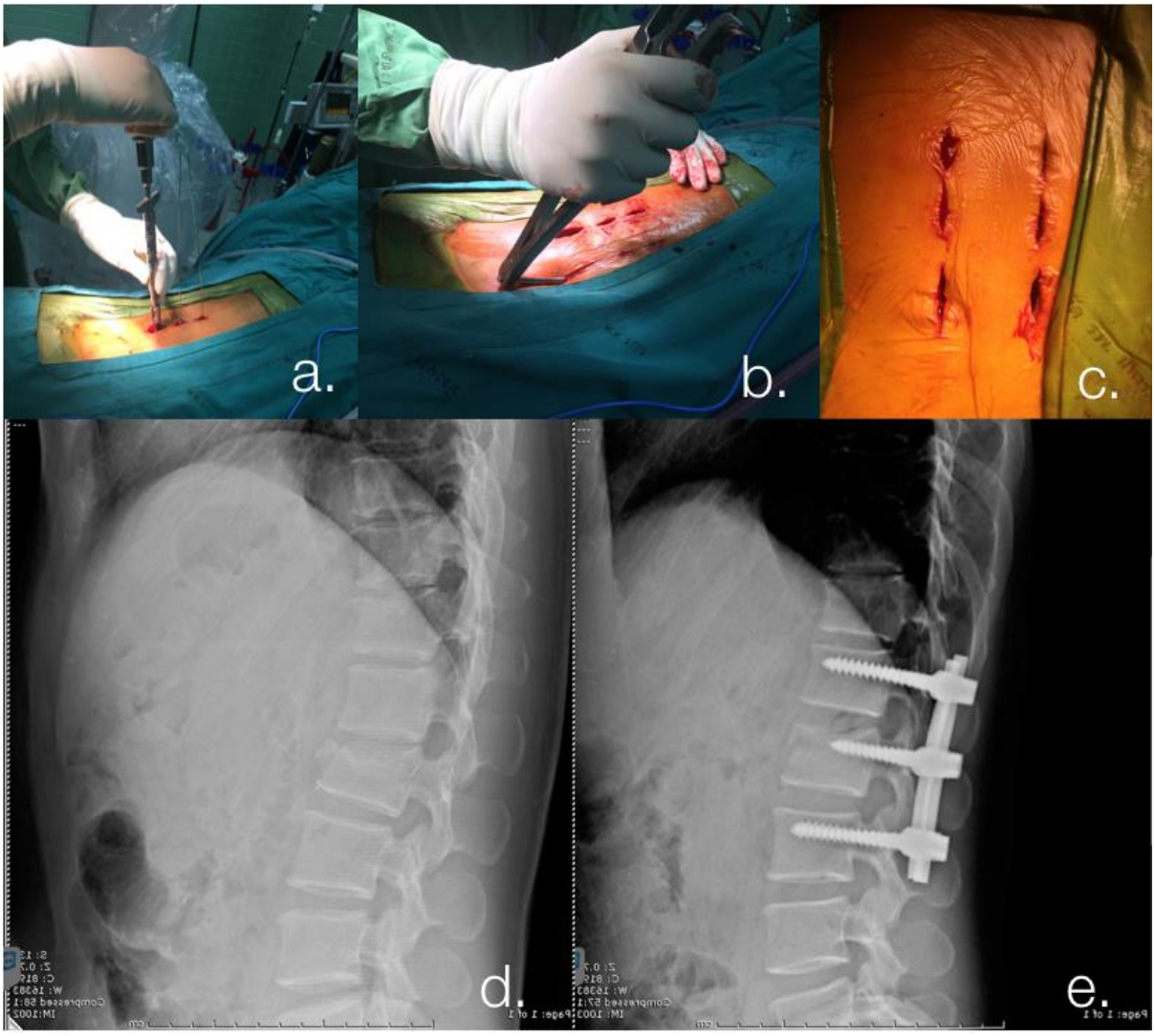

Fig.1 Our percutaneous screw fixation technique: a). mono-axial screw insertion after taping by cannulated tap. b). sub muscular rod insertion through distal skin incision. c). post-operative wound before skin closure. d). pre-operative radiograph e). post-operative radiograph.

Materials and Methods

This was a retrospective cohort study. We collected data on unstable thoracolumbar fracture (TLICs ≥ 4) without neurological deficit which underwent operation during January 2015 to December 2017. All patients underwent computed tomography (CT) scans to assess canal compromise, vertebral height loss, fracture configuration and the stability of the pedicles at the fracture. We excluded patients that had incomplete data from our hospital database.

Patients were divided into two groups: percutaneous pedicle screw fixation (PPSF) and open split muscle long-segment pedicle screw fixation group (OPSF). The procedures were performed by two experienced surgeons which surgeon choose technique depend on surgeon preference. The global standard screw (GSS, GS Medical Co., Ltd., Geumcheon-gu, Seoul, Korea) mono-axial pedicle screw system was used in both groups without decompression or posterior spinal fusion. Indirect reduction was performed by positioning a patient in the prone position. In our hospital, pure ligamentous flexion distraction injuries (Chance fracture of McAfee classification), long segment fixation should be use but in bony flexion distraction injury (Flexion distraction of McAfee classification) can treat with short segment fixation. Our technique uses intermediate screw to improve stability of construct and we reduced fixation segment to preserve motion of spine.

PPSF technique: Make a small longitudinal incision around 15 mm. The incision was slightly lateral to the pedicle on fluoroscopy depend on thickness of paraspinal muscles and soft tissue at back. The paraspinal muscle was split by blunt

dissection to identified facet joint. Used a standard awl to make bone opening. The pedicle probe was applied which also had manual sensation of pedicle screw tracking then monitoring position by the fluoroscope. A standard sounding probe was used to find pedicle penetration. A guide wire was inserted. Checked all guide wires in AP and lateral image. A cannulated tap was used followed well position guide wire and monitored tap depth by lateral fluoroscopic view. Removed tap and guide wire. Mono-axial long arm screw was inserted in the same direction as the tap which monitored by fluoroscopy. Checked positioned of all screws by AP and lateral fluoroscope. Pre-bended Rods were applied at the same incision of pedicle screw sub muscular fashioned. Check position of rod which proper in lordosis. Nut were inserted and tightened.

OPSF technique: Midline longitudinal incision was made. Wiltse's approach was use to split longissimus and multifidus muscle. Pedicle screw was inserted with conventional technique. Checked positioned of all screws by AP and lateral fluoroscope. Pre-bended rods were applied. Nut were inserted and tightened.

We collected demographic data such as age, sex, intraoperative blood loss and length of stay from the hospital database. Severity of pain was assessed using a visual analog scale (VAS) pre-operative and postoperative (Day 1, 3 and discharge). Intraoperative blood loss measured by a pictorial reference guide to aid visual estimation of blood loss which developed and used every case in our hospital. Radiographic parameters were measured pre- and postoperatively by a computer program called PAC to identify the radiographic outcomes. Supine CT scan was use to measurement Cobb angle, anterior vertebral and posterior vertebral height, canal diameter and screw malposition. We used supine CT scan in both pre- and postoperative because pre-operative we cannot have done upright radiograph which can cause further injury or pain. For preoperative patient underwent CT scan on admitted day and postoperative on first day after operation. Cobb angle (degrees) was defined as the angle between the upper end plate of a proximal adjacent and lower end plate of a distal adjacent point of the injured vertebra. A Cobb angle reduction was defined as the difference between pre- and postoperative Cobb angle. Canal area (mm^2) was the canal area diameter measured in a CT axial view at a mid-pedicle level of the injured vertebra. Canal compromise reduction was defined as the difference in the canal area between a pre- and postoperative CT scan. Anterior vertebral height (AVH) reduction was defined as the difference between pre- and postoperative AVH. Posterior vertebral height (PVH) reduction was defined as the difference between pre- and postoperative PVH.

All data are presented as frequencies and percentages, or means and standard deviations, as appropriate. Chi-square tests were used to test for relationships between categorical variables to examine proportional differences. Two sample t-tests were performed to examine mean differences between groups. All statistical analyses were conducted using SPSS software for Windows version 23.0 (SPSS, Inc., Chicago, IL). A *P*-value of less than .05 was considered statistically significant.

Ethics approval was obtained from the Institutional Review Board, Maharat Nakhon Ratchasima Hospital Ethics Committee: MNRH IRB 104/ 2017. The study was retrospectively registered at Clinicaltrials. in. th (Identifier: TCTR20180809001) on July 31st, 2018.

Results

In total, there were 49 patients that met the inclusion criteria from January 2015 to December 2017. There were 33 patients in the PPSF group and 16 patients in the OPSF group. Patient demographic data is shown in Table 1. There were no statistical significant differences in sex, type of fracture, level of fracture, cause of injury, pre-operative VAS, pre-operative kyphosis and pre-operative canal diameter, but there were significant difference between the two groups in age and day before surgery. The PPSF group was younger and operated on earlier than the OPSF group. Despite there were no significant statistical difference in type of fracture but flexion-distraction type found in PPSF group only (5 in 33 cases).

Radiological outcomes

A significant improvement of kyphosis deformities was found in both PPSF and OPSF, 11.2±4.6 and 11.5±4.8 degrees, respectively. There were no statistical significant differences between the two groups in post-operative kyphosis and kyphosis correction angle (P = .84). For canal diameter, there was a significant improvement between pre-operative and postoperative (17.81 mm^2 and 18.83 mm^2, respectively), but no statistical difference between the two groups (P = .84). For AVH and PVH, there were significant improvement between pre-operative and postoperative, but no statistical difference between the two groups (all *P*-value > .05) as shown in Table 2.

Table 1 Patient demographic data of PPSF and OPSF groups (N = 49)

Parameters	**PPSF (N=33)**	**OPSF (N=16)**	***P*-value**
Sex			.62
Male	21	9	
Female	12	7	
Age (yrs.)	43.2 ± 13.4	51.6 ± 14.0	.048
Diabetes	0	1	.33
Hypertension	2	1	1.00
Smoking	7	6	.30
Type of fracture			.10
Burst	28	16	
Flexion distraction	5	0	
Level of fracture			.10
T12	3	4	
L1	24	7	
L2	6	3	
L3	0	2	
Cause of injury			.43
Fall from height	20	9	
Traffic accident	12	5	
Direct injury	1	2	
Day before surgery	6.3 (3.5)	9.4 (3.6)	.01
Pre-op VAS	5.8 (1.4)	6.0 (1.7)	.69
Pre-op Kyphosis	13.2 (6.9)	12.1 (6.8)	.59
Pre-op AVH (% of prediction)	63.96 (12.63)	63.87 (9.71)	.98
Pre-op PVH (% of prediction)	97.27 (5.79)	90.70 (7.03)	.39
Pre-op canal diameter (mm^2)	190.52 (52.24)	171.82 (53.44)	.25

Abbreviations: VAS, visual analogue score; AVH, anterior vertebral height; PVH, posterior vertebral height

Table 2 Results of radiologic outcome comparing between PPSF and OPSF groups

Parameters	**PPSF (N=33)**	**OPSF (N=16)**	***P*-value**
Pre-operative kyphosis	13.2 ± 6.9	12.1 ± 6.8	.59
Postoperative kyphosis	2.0 ± 5.4	.6 ± 8.1	.46
Correction angle	11.2 ± 4.6	11.5 ± 4.8	.84
Pre-operative canal diameter (mm^2)	190.52 ± 52.24	171.82 ± 53.44	.25
Canal diameter increase (mm^2)	17.81 ± 16.46	18.83 ± 15.36	.84
AVH correction (% of prediction)	25.60 ± 9.77	26.27 ± 9.41	.82
PVH correction (% 0f prediction)	4.67 ± 6.56	3.19 ± 6.12	.45

Abbreviations: VAS, visual analogue score; AVH, anterior vertebral height; PVH, posterior vertebral height

Operative time, intraoperative blood loss and fluoroscopic time

The mean operative time in the PPSF and OPSF groups were 59.03±12.68 and 57.13±12.23 minutes, respectively. There was no significant difference between the two groups (P = .62). The mean intraoperative blood loss in the PPSF and OPSF groups were 56.36±36.64 and 124.38±59.89 milliliters, respectively, with a significant difference between the groups (P < .05). Fluoroscopic time was 2.10±.91 minutes in the PPSF group, but there was no record in OPSF group because the surgeons used only a few shots after the pedicle screw placement with an open technique, as shown in Table 3.

Hospital stay

The mean length of stay in the PPSF and OPSF groups were 12.0±4.0 and 15.2±5.0 days respectively, which was statistical significant (*P* = .02). The postoperative stays were 5.7±2.2 and 5.8±2.1 days, respectively. There was no statistical difference between the groups. This data is presented in Table 3.

Table 3 Others post-operative outcome comparing between PPSF and OPSF groups

Parameters	PPSF (N=33)	OPSF (N=16)	*P*-value
Operative time (minutes)	59.03 ± 12.68	57.13 ± 12.23	.62
Intraoperative blood loss (ml)	56.36 ± 36.64	124.38 ± 59.89	<.05
Length of stay (days)	12.0 ± 4.0	15.2 ± 5.0	.02
Post-operative stay (days)	5.7 ± 2.2	5.8 ± 2.1	.86
Fluoroscopic time (minutes)	2.10 ± .91	-	
Complication			
Number screw malposition/Screw inserted	13/181 screws (7.18%)	14/128 screws (10.94%)	.16
Type [a]			
1b	11	2	
2a	0	6	
2b	1	1	
3a	0	5	
3b	1	0	
Number of revision	0	0	
Others complication			.35
Urinary tract infection	1	1	
Pneumonia	0	1	
Alcohol withdrawal syndrome	2	0	

a. Type according to Zdichavsky's[17] screw malposition system

Table 4 Visual analogue pain score pre- and post-operative

Parameters	PPSF	OPSF	*P*-value
Pre-op VAS	5.82 ± 1.36	6.00 ± 1.67	.69
Post op			
Day 1	7.18 ± 1.93	6.88 ± 1.92	.60
Day 3	4.36 ± 2.55	4.19 ± 2.46	.82
Discharge VAS	1.27 ± 1.33	1.36 ± 1.15	.79
VAS reduction	4.55 ± 1.87	4.63 ± 2.16	.89

Abbreviations: VAS, visual analogue score

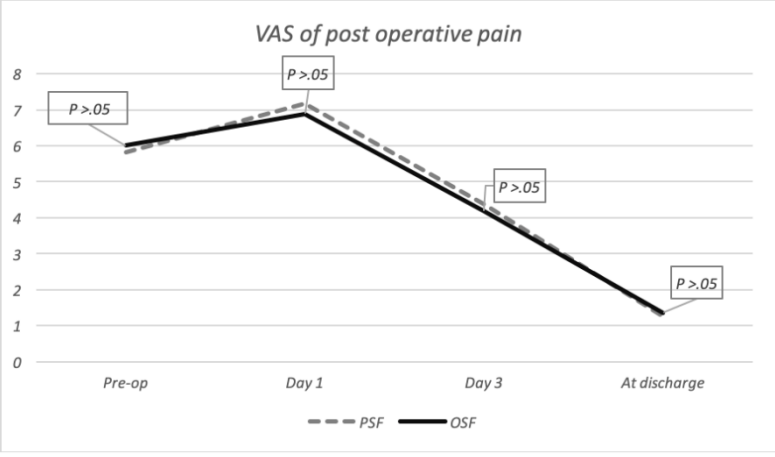

Fig.2 Postoperative VAS score. There was no statistical difference in all period. (*P*-value > 0.05)

Postoperative pain

There was no significant difference in pre-operative VAS between the groups. At the first day, postoperative VAS increased from 5.82 to 7.18 in the PPSF group and 6.00 to 6.88 in the OPSF group, with no significant differences between the groups ($P > .61$). The pain score decreased to 1.27 in the PPSF group and 1.36 in the OPSF group at discharge day, with no significant difference between the groups ($P = .79$). This data is shown in Table 4 and Figure 2.

Complication

Screw malposition occurred at 7.18% in PPSF and 10.94% in OPSF, with no significant difference between the groups ($P = .16$). According to Zdichavsky's[17] screw malposition system, we found most screw malpositions in PPSF were type 1b (11 screws) and in OPSF was 2a (6 screws). There was no revision needed in both groups. Other complications included urinary tract infection, pneumonia and alcohol withdrawal syndrome, with no significant differences between the groups ($P = .35$), as shown in Table 3.

Discussion

Traditional open pedicle screw fixation is a widely-accepted standard treatment for thoracolumbar spine fracture. After minimal invasive pedicle screw (MIS) fixation was reported by Magerl[18], the MIS technique become popular and widely used for many indications, including thoracolumbar fracture. The benefits of a MIS technique compared with traditional open methods included less muscle injury, decreased blood loss, reduced surgical time, and less postoperative pain[7-13].

In our study, the benefit of PPSF over OPSF was a significant decrease in intraoperative blood loss, which was 56.36 and 124.38, respectively ($P < .05$). The PPSF group also had significantly decreased overall length of stay, at 12 days compared to 15.2 days in the OPSF group ($P = .02$). These results concurred with previous studies[9,10,19,20]. However, when comparing only postoperative stays, there was no significant difference between the groups. As such, the difference in overall length of stay may be due to a significant difference in day before surgery in both groups (Table 1). In our hospital had limit operative room and also had other more urgency case that require operate before neurological intact thoracolumbar fracture that why we have longer preoperative period.

For the radiological outcomes in both groups, there was no significant difference in Cobb angle reduction, AVH, and PVH, which was similar to findings of other studies and a systematic review by Phan, K. and McAnany, S. J.[9,10,19-23]. Both techniques achieved correction of the kyphotic angle from 13.2 to 2.0 degrees in PPSF and 12.1 to .6 degrees in OPSF. Anterior vertebral height was also significantly reduced by both techniques, with 25.6 and 26.67 percent of prediction, respectively. Correction of local kyphotic deformities may prevent positive sagittal imbalance that leads to poor functional outcomes and a high-risk operation for correction in symptomatic patients[24]. There was a canal diameter increase in both groups, at 17.81 mm^2 and 18.83 mm^2, respectively. This supported indirect reduction that also reduced canal compression fragments.

Operative time showed no significant difference between the groups, which is in line with the study by Dong S.H. and Grossbach A.J.[21,25] and against other reports[9,19,26]. The mean operative time of the PPSF group was 59.03 minutes, which was shorter than the 68-195 minutes reported by others[22,25,27-29]. The fluoroscopic time in the PPSF group was 2.10 minutes, which was shorter than the 3-39 minutes reported by others[12,27,28]. The variations in operative time and fluoroscopic time may be due to differences in surgeon experience, the minimal invasive technique, and percutaneous screw systems.

Postoperative VAS increased in both groups in the first day after surgery and eventually decreased to 1.27 in the PPSF group and 1.36 in the OPSF group at discharge day. Total pain reduction was 4.55 and 4.63, respectively, with no significant difference between both groups. The results were different from that reported by others which favored the minimally invasive technique [10,12,19, 21]. There was one systematic review that selected only six studies to decrease heterogeneity by McAnany SJ.[9], which reported a similar finding as our study with no significant difference in postoperative pain. There are two possible explanations for such results. The first is that in trauma patients there are significant muscle injuries and significant pain from injuries that conceal the pain from the operation. Second, our sample size had insufficient power to show a difference in VAS between the groups.

For screw malposition, our results were 7.18% in the PPSF group and 10.94% in the OPSF group, with no significant difference between both groups. The screw malposition of PPSF in our study was higher than that reported by others (2.1-6.7%)[29,30], however, there were no cases that needed revision of the screw position in both groups. Most of the screw malposition in PPSF was a breached lateral cortex of the pedicle.

A strength of our study was our use of a computer tomography scan to measure pre- and postoperative outcome, which allowed for an accurate identification of a canal diameter increase after the procedures.

There were some limitations in our study. First our study had a small sample size that may not had enough power to identify some differences in

some parameters in both groups. Second, our study was a retrospective study, some bias could alter treatment outcomes. Selection bias due to incomplete data that had to exclude from our study and information bias such as diagnostic review bias may occur in our study such as intraoperative blood loss which we used local method may resulting in error when compare to previous studies that use different methods. Third, despite there were no statistical significant difference between in fracture type but flexion-distraction type found only PPSF group. Enrolled samples had different types that may lead to heterogeneity of the result. Fourth, we collected and present only intra and early post-operative outcomes. A further randomized control study is necessary to identify more exact results.

Conclusion

The outcomes of percutaneous screw fixation (PPSF) using our technique in the treatment of thoracolumbar spine fracture could reduce intraoperative blood loss compare to open split muscle long-segment pedicle screw fixation (OPSF). In terms of post-operative radiologic outcomes, VAS reduction, postoperative length of stay and complications were lack of evidence to detect the difference between the two techniques.

Declaration of Conflicting Interests

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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ผลการรักษาหลังผ่าตัดของผู้ป่วยกระดูกสันหลังหักโดยการผ่าตัดใส่เหล็กแบบแผลเล็กยึดกระดูกช่วงสั้น เทียบกับการผ่าตัดใส่เหล็กแบบปกติยึดกระดูกช่วงยาว

คงธัช ชูวงศ์โกมล, พบ, อุรวิศ ปิยพรมดี, พบ, เทอดพงษ์ ธนาวิริยะชัย, พบ, ศรุต จงกิจธนกุล, พบ, วีระ สุดประเสริฐ, พบ

วัตถุประสงค์: เพื่อศึกษาผลการรักษาหลังผ่าตัดของของผู้ป่วยกระดูกสันหลังหัก โดยการผ่าตัดใส่เหล็กแบบแผลเล็กยึดกระดูกช่วงสั้น (PPSF) เทียบกับการผ่าตัดใส่เหล็กแบบปกติยึดกระดูกช่วงยาว (OPSF)

วัสดุและวิธีการ: ศึกษาผลการรักษาผู้ป่วยกระดูกสันหลังหักที่ไม่มีภาวะอ่อนแรง ที่ได้รับการรักษาด้วยวิธีผ่าตัด ที่โรงพยาบาลมหาราชนครราชสีมา ระหว่างเดือน มกราคม พ.ศ.2559 ถึง ธันวาคม พ.ศ.2561 เปรียบเทียบกันระหว่างสองกลุ่ม โดยผลที่สนใจคือ ความปวดของผู้ป่วยหลังผ่าตัด (VAS), ปริมาณเลือดออกระหว่างผ่าตัด, ระยะเวลานอนรักษาที่โรงพยาบาล และผลการรักษาจากภาพฉายรังสี (radiographic parameters)

ผลการศึกษา: ผู้ป่วยหลังการผ่าตัดในกลุ่ม PPSF มีมุมค่อมที่หลังลดลง 11.21±4.61 องศา และ ในกลุ่ม OPSF ลดลง 11.50±4.77 องศา สำหรับขนาดของช่องกระดูกไขสันหลังเพิ่มขึ้น17.81±16.46 และ 18.83±15.36 ตารางมิลลิเมตร ตามลำดับ ความปวดของผู้ป่วย (VAS) 4.55±1.87 และ 4.63±2.16 ตามลำดับโดยไม่มีความแตกต่างกันนัยสำคัญทางสถิติทั้งหมด (all *P*-values > .05) ขณะที่ปริมาณเลือดออกระหว่างผ่าตัดและระยะเวลานอนโรงพยาบาลในกลุ่ม OPSF มากกว่ากลุ่ม PPSF อย่างมีนัยสำคัญทางสถิติ (124.38±59.89 มล. และ 56.36±36.64 มล.ตามลำดับ, $P < .05$) (15.19±4.98 วัน และ 12.00±4.0 วันตามลำดับ, $P = .02$)

สรุป: ผลการรักษาหลังการผ่าตัด การรักษาทั้งสองแบบให้ผลไม่ต่างกันในด้านความปวดหลังผ่าตัด มุมค่อมที่ลดลง และความกว้างของช่องกระดูกสันหลังที่เพิ่มขึ้น แต่การผ่าตัดใส่เหล็กแบบแผลเล็กยึดกระดูกช่วงสั้น ช่วยลดปริมาณเลือดออกระหว่างผ่าตัดและระยะเวลานอนโรงพยาบาลได้