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Safety and Efficacy of Percutaneous Non-Canulated Transpedicular Screws Fixation (TPSF) in the Management of Thoracolumbar Fractures

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Abstract

Background Data: The use of pedicle screws for spinal stabilization has become increasingly popular worldwide. Standard open techniques for pedicle screw placement, however, require extensive tissue dissection to expose entry points and to provide lateral to medial orientation for optimal screw trajectory. Minimal invasive techniques (MIT) are widely accepted as being the less aggressive procedure in any kind of surgery.

Purpose: The aim of this study was to describe and evaluate a new alternative percutaneous technique using the usual economic non-canulated screws in thoracolumbar fractures.

Study Design: A prospective clinical case study.

Patients and Methods: Between January 2007 and December 2012, 42 patients (31 males and 11 females) with thoracolumbar fractures were admitted to emergency department of Assiut University Hospital. The mean age of the patients was 37 years (range, 19 to 57). All fractures were classified according to Magerl's classification. According to American Spinal injury Association (ASIA) Impairment Scale (AIS), all patients were neurologically free (ASIA grade E) preoperatively. Surgery was done within 72 hours after injury. All patients underwent ligamentotaxis through percutaneous posterior approach using non-canulated transpedicle screws. The kyphotic angle was measured according to Cobb method preoperatively, postoperatively, and at latest follow up. Postoperative CT was done for all patients to verify screw position and recording of pedicle violations.

Results: The mean operative time was 65 minutes (range, 55 to 120). The mean operative blood loss was 54 ml (range, 35 to 90). The mean preoperative local kyphotic angle (LKA) improved from 12° to -2° postoperatively and 2° at latest follow up. Neurological deterioration occurred in one patient. The average hospital stay was 1.5 days (average, 1 to 3). Misplacement of the screws (3 screws violated the medial wall of the pedicle, 7 violated the lateral wall) was recorded in 10 of 186 screws (5.4%).

Conclusion: The percutaneous pedicle screw insertion using non-canulated technique in thoracolumbar spine fracture is safe, economic, and reliable minimal invasive technique. (2013ESA047)

Keywords: Thoracolumbar fracture, Percutaneous, Transpedicle, non-canulated screw.

Introduction

The use of pedicle screws for spinal stabilization has become increasingly popular worldwide. Pedicle screw systems engage all three columns of the spine and can resist motion in all planes. Several studies suggest that pedicle screw fixation is safe and effective treatment for many spinal disorders.[9,27]

Standard open techniques for pedicle screw placement, however, require extensive tissue dissection to expose entry points and to provide lateral to medial orientation for optimal screw trajectory.[24] Minimal invasive techniques (MIT) are widely accepted as being the less aggressive procedure in any kind of surgery, whenever they are applicable in the treatment of chosen cases.[8]

All published papers discussed the minimal invasive techniques using canulated screws which are expensive and need special instruments. Therefore, the purpose of this study was to describe and evaluate a new alternative percutaneous technique using the usual economic non-canulated screws in thoracolumbar fractures.

Patients and Methods

Between January 2007 and December 2012, 42 patients (31 males and 11 females) with thoracolumbar fractures were admitted to emergency department of Assiut University Hospital. The mean age of the patients was 37 years (range, 19 to 57). Reported levels of fractures in this study are shown in figure 1. All fractures were classified according to Magerl's classification[18,] where 35 patients were class A, and 5 were class B. (Figure 1) According to American Spinal injury Association (ASIA) Impairment Scale (AIS), all patients were neurologically free (ASIA grade E) preoperatively.[1] The kyphotic angle was measured according to Cobb method preoperatively, postoperatively, and at latest follow up.[4] Postoperative CT was done for all patients to verify screw position and recording of pedicle violations.

Surgical Technique:

The pedicle screws were non-canulated (Top-loading screws, Moss-Miami System™, Depuy). The screws were inserted in accordance with a modified technique proven experimentally and described by Wiesner et al,[26] A stepwise description of the technique follows:

Step 1: Percutaneous localization of the targeted pedicles:

The image intensifier is oriented in a perfect anteroposterior direction. A needle is inserted about one inch lateral to the midline (palpable spinous process) (Figure 3). A key hole (1.5 cm) skin incision is made opposite each pedicle. After cutting the dorsolumbar fascia, muscle dissection is made with blunt dilators.

Step 2: Drilling of the pedicle:

A 1.8 mm K-wire is positioned at the base of the transverse process and angled 10° to 20° medially with its tip lies exactly lateral to the true oval pedicle image. Under lateral fluoroscopic control, the wire is adjusted in a cephalocaudad direction and drilled forward through the entire pedicle until the dorsal wall of the vertebral body is reached. In the anteroposterior direction, the tip of the wire should now be in the center of the true oval pedicle image (Figure 4). Next, the wire is removed and hole is drilled in the pedicle with a 3.2 mm non-canulated drill bit.

Step 3: Insertion of the non-canulated pedicle screws and rods:

The crown head (long-head) screws are used (Figure 5). The crowns will ensure that the rod travels through the muscles in the direction of the muscle fibers and connect the two pedicle screws. With the rod in place, ligamentotaxis (reduction by distraction) can be done using a curved long-arm distractor applied directly to the crowns proximally and distally. The rod is then tightened in place and the crowns are cut (Figure 6).

Step 4: Closure of the mini-incision:

No suction drain was used. Every hole is closed with single deep fascia and skin suture (Figure 7).

Postoperative care and evaluation

One day analgesia was required in all patients. Postoperative anteroposterior and lateral roentgenograms were performed routinely in each patient. Also, postoperative CT scan was performed for all patients. Two-mm slices of all instrumented pedicles were analyzed. First, the cortical wall of the pedicles was examined for bone defects. To detect caudal and cranial screw penetration, the most superior and inferior slices of each pedicle were analyzed carefully. The direction of the pedicle violations was noted. Metal removal was done 3-6 months after healing of the injured segment which was ensured by CT scan. The average time for metal removal was 13 months (range, 9 to 18) postoperatively.

Results

Fourteen patients underwent fixation in the thoracic spine (from T8 to T12) and 28 in the lumbar spine (from L1 to L4). TPSF of one vertebra above and below the fractured level was done in 29 patients and additional screws in the fractured level in 13 (two screws in fractured level in 5 patients and one screw in 8 patients). The total number of screws inserted percutaneous was 186 screws. (Figure 8,9)

The mean operative time was 65 minutes (range, 55 to 120). The mean operative blood loss was 54 ml (range, 35 to 90). The average hospital stay was 1.5 days (average, 1 to 3).The mean preoperative local kyphotic angle (LKA) improved from 12° to -2° postoperatively and 2° at latest follow up. There was neurological deterioration in one patient occurred immediately postoperatively.

Complications:

One patient (2.4%) with L1 burst fracture developed incomplete paraplegia (ASIA grade C) postoperatively. Postoperative CT scan showed anterior bone fragments compressing the cord. Anterior corpectomy, decompression, and iliac grafting were done and the patient improved completely within 2 months. Superficial wound infection developed in one patient (2.4%) who improved completely within two weeks by daily dressing and appropriate antibiotics. Misplacement of the screws (3 screws violated the medial wall of the pedicle, 7 violated the lateral wall) was recorded in 10 of 186 screws (5.4%) (Figure 10). These violations had no neurological consequences postoperatively. Also, none of these patients required revision surgery.

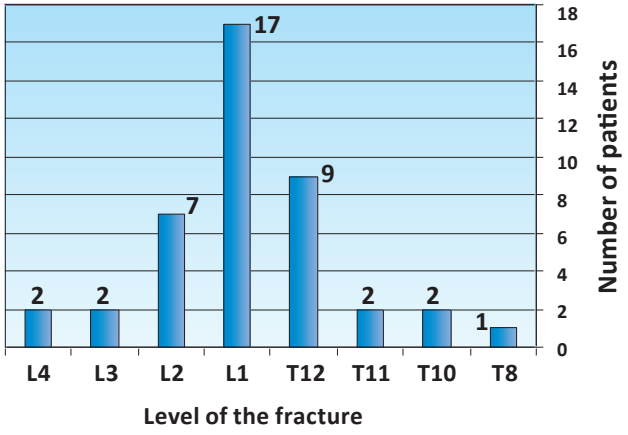

Figure 1: Distribution of the Reported Fractures in this Study

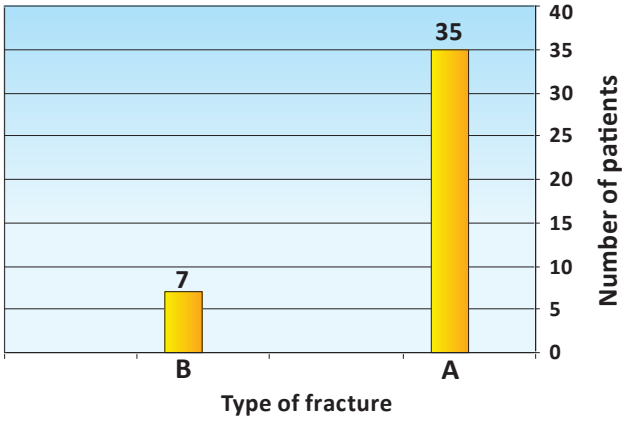

Figure 2: Types of Fracture According to Magerl's classification in this Study

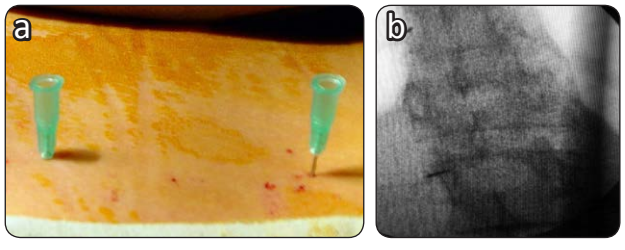

Figure 3 (a,b): Percutaneous localisation of the pedicles under image

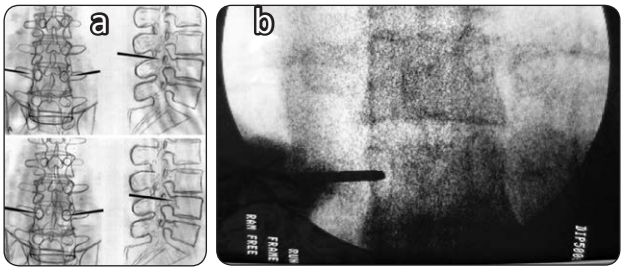

Figure 4 (a,b): Drilling of the pedicle

Figure 5 (a,b): Insertion of non-canulated screw

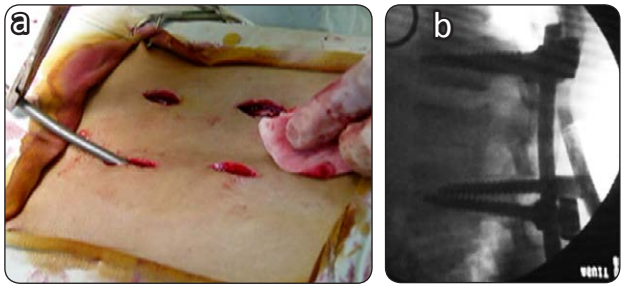

Figure 6 (a,b): Sliding the rods

Figure 7: Closure of the mini-incision

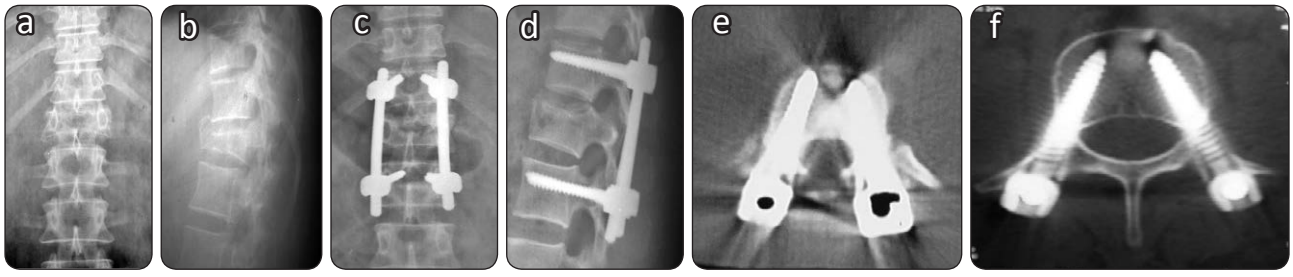

Figure 8: 28 years old male patient with fracutre LV1. The images demonstrate the preoperative plain X-ray anteroposterior (a) and lateral (b) views, plain X-ray postoperative anteroposterior(c) and lateral (d) views, CT scan postoperative showing upper level screws (e) and lower level screws (f).

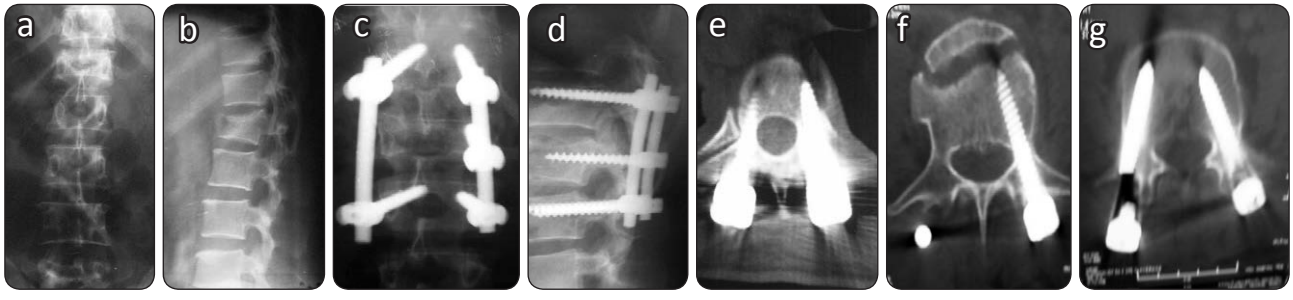

Figure 9: 18 years old, Female,Fr. L1, NF. Preoperative plain X-ray anteroposterior(a) and lateral (b) views. Postoperative plain X-ray anteroposterior (c) and lateral (d) views. Postoperative CT scan: upper level (e), fractured level (f), and lower level (g).

Figure 10: One screw violated the medial wall of the pedicle.

Discussion

Traditional open surgical technique for the insertion of pedicle screw requires incision and extensive dissection and retraction of para-spinal muscles in both sides to expose the roots of the pedicle and to identify the site of screw insertion. This may lead to muscular denervation and necrosis resulting in prolonged postoperative pain and disability.[14,23] The significant blood loss and the potential for serious infection are additional risk factors. For these reasons, the development of minimally invasive techniques to achieve spinal fixation would appear desirable.

Percutaneous fixation of the lumbar spine was first described by Magerl[17] who used an external fixator. Mathews and Long[19] first described and performed a wholly percutaneous lumbar pedicle fixation technique in which they used plates as the longitudinal connectors. Lowery and Kulkarni[16] subsequently described a similar technique in which rods were placed. Since 2000, the techniques of minimally invasive spinal fusion have expanded.

No published articles of high standard data show that minimal invasive surgery is superior to open surgery. However, there is a trend towards minimal invasive surgery of the spine due to lower complication rates and approach related morbidity with minimum soft tissue trauma.[15,13,12,22] Despite this, some reports believe that minimal exposure is associated with incomplete treatment of the pathology due to significantly decreased visualization with minimal invasive surgery.[3] Another potential limitation includes the use of imaging-guided pedicle screw placement. Imaging increases operative time and patient/ surgeon exposure to ionizing radiation. Non-radiological navigation methods, thus, need to be explored to further improve minimal invasive surgery.[3,11]

In most situations, the pedicle screws can be inserted through the skin and muscles via tubular retractors positioned opposite the pedicles. The rod that connects the screws is inserted through the muscles using special systems (e.g. Sextant™ Acromed, USA) that positioned the rod into the poly-axial screw heads. Each screw is connected to a tower that extends above the skin. The tower ensures that the rod travels through the muscles in the direction of the muscle fibers and connect the two pedicle screws. The rod is then tightened in place and tower is removed. This technique is complex and needs more operative time for instillation of the towers and connectors. Adding to that, it is expensive and needs special instruments.

In this study, percutaneous TPSF was done as alternative new idea that alleviated the need for towers and canulated screws. The crown-head (long head) non-canulated screws were used. The crown replaced the towers and ensured that the rod travels through muscles in the direction of the muscle fibers and connects the two pedicle screws. Also, the crowns facilitated the reduction of the fracture by distraction (ligamentotaxis). This could be done using a curved long arm distractor applied directly to the crowns proximally and distally. The rod is then tightened in place and the crowns are cut.

Ni et al,[21] who treated 36 patients with thoracolumbar burst fractures using percutaneous canulated screws reported an average operative time 78 minutes. Longer time was reported by Emad et al,[6] with an average 90 minutes. Shorter operative time was achieved in this study as it was 65 minutes ranged from 55 to 120 minutes. This may be attributed to the simpler technique of insertion of non-canulated screws done in this study. Similarly, blood loss in this study was negligible with an average 54 ml which is comparable with that of series of Emad et al,[6] who used percutanious canulated screws and reported negligible amount of blood loss.

Gowan et al,[20] reported an experimental pedicle violation rate 6% for 118 percutaneous screws inserted from T10 to S1 in a human cadaver model. In this study, the analysis of 186 percutaneous inserted non canulated pedicle screws; 5.4% (10 screws) misplacement rate (violation of medial and lateral pedicle wall) could be found. The misplacement rate of this study (5.4%) was less compared with that of Wineser et al,[26] who reported 10% misplacement rate found in a comparative cadaver study of 360 pedicle screws inserted with the standard Magerl's technique[22] or the author's technique[26]. Interestingly, the reported misplacement rate has been very different, ranging from 3% to 40%.[5,10] In addition to important factors such as different surgical experience and indications, this discrepancy may result from different methods of screw placement and assessment.

Weinstein et al,[25] showed that the simple

roentgenograms were insufficient for the evaluation of screw accuracy. This finding was confirmed by Farber et al,[7] who found that CT scan showed 10 times more pedicle violations than radiographs. However, even with postoperative CT examination, the accurate assessment of the pedicle wall integrity can be difficult because of image artifacts caused by implants. However, when a surgical technique such as the percutaneous insertion of pedicle screw is evaluated, clinical data on the screw accuracy must be considered. In this study, plain X-ray and CT scan were done preoperatively and postoperatively for all patients.

Removal of the instrumentation after healing of the injured segments serves to preserve the patient's motion segment. In this study, metal removal was done 3-6 months after healing of the injured segment which was ensured by CT scan. The average time was 13 months postoperatively. However, implant removal remains a controversy as it requires a second surgery and a general anesthesia adding risks for the patient and cost for the hospital. We recommend implant removal 3-6 months after healing of the injured segment guided with CT scan to ensure ligamentous injury healing in addition to osseous healing. Andrew et al,[2] reported that implant removal is not recommended prior to at least one year in case of ligamentous injury.

Conclusion

The percutaneous pedicle screw insertion using non-canulated technique in thoracolumbar spine fracture is safe, economic, and reliable minimal invasive technique.

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الملخص العربي

إستخدام مسامير عنق الفقرة (بيديكال) لتثبيت العمود الفقرى

البيانات الخلفية: أصبح لإستخدام مسامير عنق الفقرة (بيديكال) لتثبيت العمود الفقرى شعبية متزايدة فى جميع أنحاء العالم وبسبب أن إستخدام طريقه الفتح الكبير بالجلد لتركيب المسامير يحتاج إلى تشريح واسع للعضلات لكشف نقاط دخول المسامير وطريقة دخولها من الإتجاة الأفقى للإتجاة الأنسى تم إستحداث طريقه فتح بسيطة خلال الجلد لإدخال مسامير(بيديكال) مثقوبة جديدة خلال عنق الفقرة وأصبحت هذه الطريقه مقبولة على نطاق واسع فى كل أنواع جراحات العمود الفقرى .

الهدف: الهدف من هذه الدراسه هو وصف و تقييم تقنيه جديدة لطريقة الفتح البسيط بالجلد بإستخدام مسامير (بيديكال) غير مثقوبة إقتصادية عادية فى كسور الفقرات الصدرية القطنية للعمود الفقرى .

تصميم الدراسة: دراسة مستقبليه سريرية للمرضى

المرضى و الطريقه: إستقبل قسم الإصابات بمستشفى أسيوط الجامعى ٤٢ مصابا بكسور الفقرات الصدرية الفطنية فى الفترة من يناير ٢٠٠٧ إلى ديسمبر ٢٠١٠ وكان متوسط عمر المصابين ٣٧ سنه وتم تصنيف الكسور حسب (تصنيف ماجرل) وجميع المصابين لا يعانون من أى شلل نصفى حسب مقياس الضرر لرابطة إصابات العمود الفقرى الأمريكية وقد تم عمل جميع العمليات الجراحية خلال ٧٢ ساعة من الإصابة حيث تم عملها خلال طريقة الفتح البسيط بالجلد وتركيب مسامير غير مثقوبة خلال عنق الفترة . تم عمل أشعات عادية قبل وبعد العملية وقياس زاوية الحدب حسب طريقة كوب كما تم عمل أشعات مقطعية لكل المصابين قبل و بعد العملية لتحديد دقة دخول ووضع المسمار بعنق الفقرة.

النتائج: نتج عن هذه الدراسة مايلى: بلغ متوسط وقت العملية ٦٥ دقيقة و متوسط فقد الدم ٥٤ مل وقد تحسنت زاوية الحدب من ١٢ درجة إلى -٢ درجة بعد العملية و ٢ درجة فى اخر متابعة والحالة العصبية للأطراف السفلية لجميع المصابين بعد العملية جيدة ماعدا مصاب واحد حدث له شلل غير كامل وتم عمل جراحة أخرى أمامية لإزالة الضغط على الأعصاب وتحسنت الحالة تماما خلال شهرين . وبمتابعة الأشعات المقطعية بعد العملية تبين وجود عدد ١٠ مسامير من أصل ١٨٦ (٤,٥٪)فى وضع غير سليم .

الاستنتاج: أستنتج من هذه الدراسة أن إستخدام المسامير الغير مثقوبة خلال فتح بسيط بالجلد لتثبيت كسور الفقرات الصدرية القطنية طريقة امنة وموثوق بها.