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# Assessment of the outcome of percutaneous pedicle screws in management of degenerative and traumatic dorsal and lumbar pathologies

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## Abstract

**Background:** Percutaneous pedicle screw technique is relatively a recent technique that evolved the concept of posterior spinal instrumentation, utilizing familiar fluoroscopic landmarks to guide the procedure of screws insertion, which despite being technically demanding, it avoids the Musculo-ligamentous damage associated with the conventional posterior technique.

**Aim of the work:** This study aims to report our experience in managing traumatic and degenerative spine pathologies by the minimally invasive percutaneous technique and assessing its radiological and functional outcome.

**Materials and methods:** A prospective observational study that included the analysis of the functional, operative, biochemical, and radiological outcomes of 20 patients who underwent uniplanar fluoroscopic-guided dorsal and/or lumbar percutaneous pedicle screw fixation procedures with or without fusion using the sextant, longitude, and Spineart system and any reported complications between January 2018 and December 2019.

**Results:** The clinical and radiological analysis of 100 percutaneous pedicle screws in degenerative (n:11) and traumatic (n:9) dorsal and/or lumbar cases revealed that the biomechanical stabilizing characteristics are comparable to the conventional posterior approach with the added benefits of the paraspinal muscle-sparing. Satisfactory functional outcome represented in the improvement of the postoperative back pain visual analog score and Oswestry Disability Index Score with acceptable morbidity and complications rate was noticed.

**Conclusions:** Percutaneous pedicle screw fixation is a landmark in the evolution of the minimally invasive spine surgery which can be a safe alternative to the conventional posterior muscle stripping technique with a comparable functional and radiological outcome and good biomechanical profile and an acceptable morbidity rate.

**Keywords:** Percutaneous, Pedicular, Screw fixation, Minimally invasive, Spine surgery

## Introduction

Percutaneous pedicle screws are a relatively recent minimally invasive spine technique which was first innovated by Magerl et al. [1] in 1977 for the external fixation of the spine in the patients who required transient stability for

traumatic and infectious causes. Olerud et al. [2] in 1986 investigated the concept of the therapeutic testing of mechanical stabilization for possible lumbar segment instability as a postulated cause of debilitating back pain by a percutaneous external fixation system, but despite initial favorable results, that therapeutic test falls out of favor due to its invasiveness and the associated morbidity.

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Foley et al. [3] evolved the concept into an internal fixation technique which preserved the minimally invasive nature and the biomechanical properties of the external fixation systems, while avoiding its temporary nature and the associated high infection rate. Although the minimally invasive nature of the percutaneous pedicle screws helps in maintaining the integrity of the spinal musculo-ligamentous complex, but it poses a technical challenge with a steeper learning curve; as the lack of direct visualization of the anatomical landmarks for pedicle screw insertion and the dependence on the fluoroscopic landmarks and the tactile feedback for enhancing the accuracy of percutaneous applied pedicle screws.

Since the development of the Medtronic sextant system used by Foley in 2000, many percutaneous fixation systems were developed to address more complex spinal pathologies while enhancing the surgeon feedback by the integration of recent technological feats as intraoperative CT, robotic surgery, and neuronavigational modules that compensate for the loss of direct visualization of the anatomical landmarks [4].

This study aims for assessing the operative, radiological, and functional outcome of 20 patients who had been operated by three different systems (Medtronic sextant, Medtronic longitude, and Spineart ROMEO 2 MIS) for various degenerative and traumatic spinal pathologies using uniplanar fluoroscopy in a developing country educational institute. Technical considerations, midterm efficacy, and gained benefits will be mentioned, as well as the encountered challenges and limitations of this technique.

## Methods

This is a prospective observational study from January 2018 to December 2019 that included 20 consecutive patients with degenerative and traumatic dorsal and/or lumbar spine pathologies who were operated for percutaneous pedicle screws fixation with or without interbody cage fusion. Patients were followed-up for 12 months after the operation.

### Patient selection

Our study protocol was reviewed and approved by the ethical board of the neurosurgery department. Informed consent was taken from all the involved patients enrolled in our study. Twenty patients who had different dorsal or lumbar degenerative and traumatic pathologies were enrolled in the study as they did not experience adequate relieve of their symptoms with nonsurgical lines of management. Wedge fractures, spondylolisthesis, and disc prolapses were the most common indications.

### Inclusion criteria

- 1- Adult patients aged between 16 and 70 years old.
- 2- Back pain and/or radicular pain that failed to respond to conservative management.
- 3- Evident radiological traumatic or degenerative lumbar and/or dorsal pathologies which corresponds to the symptoms and signs of the patient.

### Exclusion criteria

- 1- Patients with spondylolisthesis grades III and IV.
- 2- Patient who had undergone previous spinal procedures.
- 3- Patients who had local or general contraindications for surgery.

### Preoperative data

**Clinical evaluation** This will include the following:

- 1- Patients' demographics (age, sex).
- 2- Relevant past medical and surgical history.
- 3- Patient's history and neurological examination and presentation and including the assessment of the visual analogue scale (VAS) for the back pain and the Oswestry disability index (ODI).

### Radiological investigation

#### Plain radiographs and computed topography (CT)

Anteroposterior, lateral, and dynamic X-ray views and computed topography (CT) dorsal and or lumbar spine were done when feasible to evaluate:

- 1- Anatomy of the dorsal and lumbar spines including the state of the facet joints and the presence of degenerative changes.
- 2- Type of fracture in the traumatic cases.
- 3- Stability of the spine on dynamic views.

*Magnetic resonance imaging (MRI)* of the dorsal and/or lumbar spine without Gadolinium enhancement which helps in the assessment of the related soft tissues (spinal canal, nerve roots, spinal musculo-ligamentous complex, and any compression pathologies).

### Patient population

Each involved patient underwent complete preoperative clinical and radiological assessment, recording of the operation duration, blood loss and hospital stay, and post-operative clinical, functional and radiological assessment (Table 1).

**Table 1** Demographic, clinical, and pathological properties of the included patients in our study

<i>Demographic parameters</i>		
Age	Mean	45.05
	SD	16.49
	Range	22–70
Sex	Females	11 (55%)
	Males	9 (45%)
Diagnosis	Fractures	9 (45%)
	Disc prolapse	3 (15%)
	Canal stenosis	4 (20%)
	Spondylolithesis	4 (20%)
Types of fractures	Wedge (A2)	8 (89%)
	Incomplete burst (A3)	1 (11%)
Operated levels	D11	2 (3.9%)
	D12	7 (13.7%)
	L1	4 (7.8%)
	L2	6 (11.7%)
	L3	6 (11.7%)
	L4	10 (19.6%)
	L5	11 (21.6%)
	S1	5 (10%)

### Equipment and instrumentation

The cases were operated in our operative rooms that are equipped by uniplanar fluoroscopic image intensifier and a standard operating table. The used percutaneous fixation systems are formed of a percutaneous retractor/sleeve which is introduced over a Jamshidi needle and anchored on the skin level after a series of tubular dilators displace the paraspinal muscles, and then, the screw tapping and the polyaxial cannulated screws are introduced via the sleeve over the K wire.

Finally, the pre-bent rods are applied by a special applicator from a separate cranial wound in the Sextant system and applied by freehand applicator from the upper most screw wound in the longitude and the Spineart system.

### Operative technique

#### Anaesthesia

The anaesthesia was induced by intravenous anaesthetics, and the procedure was maintained on general inhalational anaesthetic gases and intravenous muscle relaxants.

#### Procedure

After placing the patient on a radiolucent frame in a prone position and securing the pressure points by soft pads and then ensuring that the abdomen is not

compressed to avoid the increase in the intrabdominal pressure and the subsequent venous congestion.

Anteroposterior and lateral fluoroscopic images are taken by the fluoroscopy intensifier to ensure that the targeted vertebral level is neutral and that direct pedicular trajectory can be gained and reduction of pathological angles and steps can be done partially or totally by the positioning and it can be augmented later by the abilities of the used system and the use of interbody fusion prosthesis.

Subsequently, the planned skin incision line is marked; it is generally a paramedian incision that allows adequate inclination that matches the pedicle-body angle. By the anteroposterior fluoroscopic guidance, the Jamshidi needle is introduced in the vertebral pedicle in its upper and outer aspect and introduced gradually without breaching the medial aspect of the pedicle, then the C arm is rotated into the lateral position to confirm the cranio-caudal direction of the transpedicular tract created by the Jamshidi needle and then it is introduced deeper to cross the pedicle into the vertebral body.

Subsequently, a K wire is introduced into the pedicle and the vertebral body through the fenestrated Jamshidi needle and then serial muscle tubular dilators are applied over the K wire to create a potential corridor for introducing the instrumentation by muscle fibers displacement without destruction or damage.

Finally, the percutaneous sleeve is anchored in the created space and a cannulated tap is introduced over the K wire to create a tract in the pedicle and the vertebral body and then a screw is introduced over the K wire. That should be done while checking the trajectory in the anteroposterior and lateral fluoroscopic imaging alternately.

Finally, the pre bent rod is introduced by the special sextant introducer from a separate cranial stab wound in the Medtronic Horizon Sextant system or free handed in the Medtronic Horizon longitude and Spineart ROMEO 2 MIS systems from the upper most screw wound down through the screw sleeves extenders and then the screw plugs are applied and tightened after reduction, distraction, or compression if needed then the skin incision is closed in layers.

Augmentation of the fusion by interbody fusion prosthesis and/or minimally invasive neural structure decompression can be added to the previous procedure.

#### Postoperative considerations

No wound drains were needed except for cases that needed open neural decompression through conventional midline incision. The patients were advised to ambulate early as the acceptable postoperative pain after the minimally invasive approach encouraged for early ambulation.

## Evaluation follow-up

### Clinical outcome

The predischarge and the 6-month postoperative clinical outcome (hospital stay, visual analog score (VAS) [5], and the Oswestry Disability Index) [6] were recorded for each case and compared to the pre-operative values and to the results of the other comparable minimally invasive and conventional techniques series.

### Operative outcome

The operative parameters (operative time and blood loss) and the biochemical outcome analysed 24 h after the surgery (total creatine kinase and creatine kinase MB) were recorded for each case for assessment of the minimal invasiveness of the technique and comparison to other similar series and the series including cases operated by conventional technique.

### Radiological outcome

The 48 h and the 6-month postoperative radiological outcome (X-ray and computed topography when feasible) to assess the trajectory and possible violation of the pedicle screws or any possible complications and the 6-month radiological outcome to exclude any possible hardware failure were recorded for each case for assessment the accuracy of the percutaneous pedicle screw technique.

## Results

This observational study includes the prospective analysis of the perioperative data of the included cases. Eleven female and nine male patients with a mean age of  $45 \pm 16.5$  years (ranging from 22 to 70 years). Nine (45%) patients were operated for spinal fractures; 8 (40%) cases of wedge (A2) fracture and 1 (5%) case of incomplete burst (A3) fracture, 4 (20%) patients were operated spinal canal stenosis, 4 (20%) patients were operated for spondylolisthesis, and 3 (15%) patients were operated for management of prolapsed lumbar discs. Ten patients had an additional transforminal interbody fusion in the same procedure.

Using the Medtronic Horizon Sextant, Longitude or Spineart ROMEO 2 MIS systems and by the aid of uniplanar fluoroscopic image intensifier, the included subjects were operated between January 2018 and December 2019. There were different instrumented spinal levels ( $n=51$ ), D11 in 2 (4%) cases, D12 in 7 (14%) cases, L1 in 4 (8%) cases, L2 in 6 (12%) cases, L3 in 6 (12%) cases, L4 in 10 (20%) cases, L5 in 11 (22%) cases, and S1 in 5 (10%) cases. The average cost of the instrumentation ranged from 13000 to 25000 Egyptian pounds for Spineart ROMEO 2 MIS 4 percutaneous screws and 2 rods, in comparison to Spineart conventional open screws which ranged from 7200 to 15400 Egyptian pounds according to the payment method. On the other hand, Medtronic Sextant and longitude 4 percutaneous

screws and 2 rods cost ranged from 16000 to 22000 Egyptian pounds, in comparison to Medtronic conventional open screws which ranged from 10000 to 14000 Egyptian pounds according to the payment method.

### Operative results

The included cases were operated by the Spineart ROMEO 2 MIS ( $n= 9$ ), Medtronic Horizon Longitude ( $n= 9$ ), and Medtronic Horizon Sextant ( $n= 2$ ) by the aid of uniplanar fluoroscopic image intensifier. Our series involved 20 cases with mean operative time of  $139.35 \pm 63$  minutes: 9 (45%) cases of traumatic fractures with a mean operative time of  $87.3 \pm 24.3$  and 11 (55%) cases of degenerative pathologies with a mean operative time of  $181 \pm 52$  min. The average blood loss was  $168 \pm 141$  ml:  $95.5 \pm 28.7$  ml for the traumatic cases and  $227.3 \pm 168.8$  ml for the degenerative cases. The mean hospital stay duration was  $3.3 \pm 1.38$  days,  $3.7 \pm 1.64$  days in the trauma cases series and  $2.9 \pm 1$  days in the degenerative case series (Table 2).

### Clinical results

In our study, the clinical improvement was adequate and acceptable by all the patients and that was reflected in their early ambulation and the postoperative self-assessment by the visual analogue score (VAS) and the Oswestry Disability Index (ODI) before discharge from the hospital and 6 months after the operation in comparison to the preoperative values. It was found that the mean preoperative back VAS of pain of the included cohort was found to be  $9.05 \pm 1.05$ , ranged from 7 to 10 (Table 3).

The mean preoperative ODI score was  $29.6 \pm 6.5$ , ranging from 20 to 42. On the other hand, it was found that the mean post-operative back VAS of the included cohort 6 months after the operation was found to be  $2 \pm 1.21$ , ranging from 0 to 4, and the mean postoperative ODI score  $8 \pm 3.14$ , ranging from 4 to 14, both showing significant and satisfactory improvement in the self-expressed VAS and ODI pain scores of the included patients (Table 4).

### Radiological results

One hundred screws' placement and trajectory were analyzed by post-operative computed topography in our study according to Raley and Mobbs Screw Position

**Table 2** Operative parameters of the included patients in our study

Operative parameters	Mean	SD	Range
Operation time (min)	139.35	63.07	58–270
Blood loss (ml)	188	137.4	60–600
Hospital length of stay (days)	3.3	1.38	2–7

**Table 3** Pre- and post-operative visual analog score values of the included patients in our study

Visual analogue score (VAS)	Mean	SD	Range
Pre-operative	9.05	1.05	7–10
Post-operative 24 h later	7.3	1.38	5–10
Post-operative 6 months later	2	1.21	0–4

evaluation grading system [7] when feasible, 92 (92%) screws were graded as being totally within the pedicle with no misplacement, and 7 (7%) screws were found to be malpositioned but no pedicle breachment was found. Mild (G1) misplacement was found in 4 (4%) of the screws in our study and on the other hand moderate (G2) misplacement was found in 3 screws (3%) and there were no cases of severe (G3) misplacement and no cases were symptomatic or developed weakened construct stability, and no revision surgeries were required. Out of the 7 misplaced screws in our series, 4 (57%) screws were misplaced medially, and 3 (43%) screws were misplaced laterally.

#### Biochemical outcome

In our series, the mean pre-operative CK total was 48.5 U/L with a standard deviation value of 19.1 U/L ranging from 19 to 107 U/L, while the mean pre-operative CK MB was 16.6 U/L with a standard deviation value of 5.7 U/L ranging from 6 to 29 U/L. On the other hand, the mean post-operative CK total was 986 U/L with a standard deviation value of 345.4 U/L ranging from 208 to 1924 U/L, while the mean post-operative CK MB was 37.25 U/L with a standard deviation value of 13 U/L ranging from 9 to 55 U/L (Table 5)

#### Complications

Neither there were acquired neurological or vascular deficits in the post-operative state secondary to the operative procedure, nor there were structural instabilities that required a revision surgery despite having 7 screws with mild to moderate misplacement and the radiological assessment 6 months after the operation revealed no hardware failure. No cases required blood transfusion secondary to the intra or post-operative blood loss. There were no encountered superficial or deep operative site infections and no cerebrospinal fluid

**Table 4** Pre- and post-operative disability index score values of the included patients in our study

Oswestry disability index ODI	Mean	SD	Range
Pre-operative	29.7	6.7	20–42
Post-operative 1 month later	17.1	4.09	10–28
Post-operative 6 months later	8.2	3	4–14

**Table 5** Pre- and post-operative visual CK total and CK MB values of the included patients in our study

Creatine kinase parameters	Mean	SD	Range
Pre-operative CK total U/L	48.5	19.1	19–107
Pre-operative CK MB U/L	16.6	5.7	6–29
Post-operative CK total U/L	986	345.4	208–1924
Post-operative CK MB U/L	37.2	13	9–55

leak occurred as there were no cases of intraoperative unintended durotomy. There was a case of a percutaneous pedicle screw anterior breach of the body, the patient did not show any complications secondary to the anterior breach and no further intervention or revision surgery were required.

#### Discussion

The introduction of the spine pedicle screws by Roy-Camille in 1970 [8] and the subsequent development in the posterior segmental instrumentation systems have dramatically improved the outcomes of spinal fusion and guided the way to the current practices in the spine stabilization and fusion techniques. The need for accessing the anatomical entry points of the pedicle screws helped in the introduction of the relevant surgical exposure techniques. However, that required the stripping and vigorous retraction of the overlying paraspinal muscles from their anchoring points for the essential exposure with their subsequent mechanical, neural, and vascular damage. It was years later when the spine and paraspinal muscle biomechanic studies were well established, emphasizing the anchoring and stabilizing biomechanics of the paravertebral muscles and the subsequent sequels of their iatrogenic injury during the surgical techniques. Therefore, minimally invasive application techniques of screws were developed to avoid the collateral damage of the paraspinal muscles and the spinal biomechanics resulting in paraspinal muscle preservation and more rapid recovery. However, minimally invasive procedures also are not without additional shortcomings including a steep learning curve with a higher complication rate and long operation time during the learning period, along with additional surgical devices and costs.

Our cohort involved the insertion of 100 percutaneous pedicle screws in 51 vertebrae. The mean number of screws used per case was  $5 \pm 1.17$  screws.

Our series involved 20 cases with mean operative time of  $139.35 \pm 63$  min: 9 cases of traumatic fractures with a mean operative time of  $87.3 \pm 24.3$  and 11 cases of degenerative pathologies with a mean operative time of  $181 \pm 52$  min as that included the time required for neural tissue decompression and/or interbody prosthesis application, and by omitting the time of neural decompression and/or interbody fusion, the time of applying

the screws was comparable to the time needed in the traumatic cases who was operated for percutaneous pedicle screw fixation only. That was relatively similar to the operative time reported by the traumatic cases series managed by percutaneous pedicle screws fixation: Wild et al. [9] (87 minutes), Ni et al. [10] (78 min), Hong et al. [11] (97 min), Lee et al. [12] (83.2 min), and Tinelli et al. [13] (65–81 min). That mean was relatively longer than the trauma case series reported by Schmidt et al. [14] (47 min), Taha et al. [15] (70 min), and Gong et al. [16] (59.46 min) and the degenerative cases series Kim et al. [17] (150 min), Park et al. [18] (151 min), and Versteeg et al. [19] (122 min), which can be attributed to the higher experience of the operating surgeons (these series have an average number of 70 patients) and the use of advanced intraoperative imaging techniques.

On the other hand, the mean operative time was relatively shorter than the series reported by Pelegri et al. [20] (108 min), Palmisani et al. [21] (120 min), Fuentes et al. (100 min), Grossbach et al. [22] (195 min), and Elenany et al. [23] (154.5 min), and the degenerative case series; Raley et al. [7] (238 min) and Mobbs et al. [24] (272 min). That can be attributed to the more complex nature of the fractures involved in these series, while our study was dealing mainly with wedge (A2) fractures (89%).

Our series average blood loss was  $168 \pm 141$  ml:  $95.5 \pm 28.7$  ml for the traumatic cases and  $227.3 \pm 168.8$  ml for the degenerative cases. That was relatively similar to the results reported in the trauma cases series of Taha et al. [15] (100 ml) and Grossbach et al. [22] (93 min). However, it was less than the recorded blood loss that was reported in the trauma series reported by Wild et al. [9] (194 ml), Lee et al. [12] (262 ml), and Elenany et al. [23] (174 ml), and the degenerative pathologies series reported by Kim et al. [17] (402 ml) and Park et al. [18] (302 ml), which may be attributed to the complexity of the involved cases in these series. On the other hand, our recorded blood loss was more than that reported in the trauma series reported by Ni et al. [10] (75 ml), Hong et al. (83 ml) [11], and Gong et al. [16] (59.5 ml), and the degenerative pathologies series reported by Mobbs et al. [7] (180 ml) and Versteeg et al. [19] (100 ml) that can be attributed to the higher level of experience of the surgeon, the shorter duration of the operation and the general morbidities of the patient.

The mean hospital stay duration in our series was  $3.3 \pm 1.38$  days,  $3.7 \pm 1.64$  days in the trauma cases series, and  $2.9 \pm 1$  days in the degenerative case series. That was less than the average reported in the trauma series by Ni et al. [10] (5 days), Fuentes et al. [25] (4.5 days), Hong [11] et al. (11.1 days), Grossbach et al. [22] (7.6 days), Versteeg et al. [19] (7 days), Gong et al. [16] (5.28 days), and more than the average stay reported by

Elenany et al. [23] (1.2 days). That can be attributed to the severity of other system injuries and the general condition of the patient which is related to the duration of the hospital admission in the other series [1–7].

Our first day post-operative total creatine kinase mean value was  $986 \pm 345.4$  U/L ranging from 208 to 1924 U/L. Our tenth case has the highest postoperative CK total value (1924 U/L) and the second longest operative time (236 min) and had been operated for two levels percutaneous pedicle screw fixation, midline single-level laminectomy, discectomy, and posterior lumbar interbody fusion. That shows the possible direct relation between the post-operative creatine kinase level, the duration, and the extent of the operation, especially when a muscle stripping decompression technique was added to the procedure. The creatine kinase MB values showed mild post-operative elevation that ranged from 9 to 55 U/L and did not form more than 5.5% of the total post-operative creatine kinase value, indicating that the creatine kinase MM variance is responsible mainly for the elevation of post-operative value.

Our mean creatine kinase value was less than mean value reported by Lenke et al. [26] ( $2490 \pm 3196$  U/L), Iglesias et al. [27] ( $1185.8 \pm 1234.6$  U/L), and Linzer et al. [28] (1350 U/L) in their conventional surgery series; these augment the muscle sparing aim of this minimally invasive technique and correlated with the less muscle injury associated with the percutaneous pedicle screws fixation technique. Nevertheless, our study's results showed higher creatine values in comparison to other minimally invasive techniques series as Kim et al. [29] ( $299.4 \pm 48$  U/L), Fan et al. [30] ( $347.9 \pm 94.6$  U/L), Arts et al. [31] ( $255.7 \pm 209.8$  U/L), Park et al. [18] ( $299.4 \pm 54$  U/L), Uehara et al. [32] ( $176 \pm 104$  U/L), Ohba et al. [33] ( $866 \pm 503$  U/L), and Gong et al. [16] ( $201.3 \pm 45.9$  U/L). That can be attributed to the following:

- 1- The mixed population of our study, which not only included traumatic but also degenerative spine pathologies which necessitates multiple level instrumentation and additional procedures as TLIF application.
- 2- Longer operative time which is directly related to the creatine kinase elevation values that can be explained by the initial learning curve of our study in comparison to other studies with higher number of included cases and the use of uniplanar fluoroscopy which add to the time of the operation.
- 3- The ethnic variation may have a role as all the previous studies were done on European, American, or Asian population, while all the cases included in this study were Egyptian. This can be attributed to Griffith et al study in which 94 patients underwent

variable conventional spine surgery procedures and the first post-operative day mean total creatine kinase was  $1205 \pm 1727$  U/L, ranging from 196 to 8828 U/L in black population, which was more than the values found in the white population with a mean value of  $702 \pm 928$  U/L and ranging between 196 and 6514 U/L, denoting the possible variation between different ethnicities.

Our study has a total malpositioned screw ratio of 7% (7 screws), which was less than the ratio reported by Kim et al. [17] (11%), Mobbs et al. [7] (9.7%), Seok et al. [34] (14.3%), and Mohi et al. [35] (21.6%). On the other hand, it was more than the ratio reported by Wiesner et al. (6.6%), Ni et al. [10] (4%), Taha et al. [15] (5.45%), Tinelli et al. [13] (2.4%), and Phan et al. [36] (3%). When calculating the mean malpositioning ratio of the mentioned studies, it was found to be 7.15%, which is almost similar to our study's mean. Mild (G1) misplacement was found in 4 (4%) of the screws in our study which was less than the mild (G1) misplacement ratio reported by Wiesner et al. [37] (6.1%), Wild et al. [9] (4.8%), Kim et al. [17] (9.4%), Mobbs et al. [7] (5.7%), Seok et al. [34] (10.6%), and Mohi et al. [35] (19%). On the other hand, moderate (G2) misplacement in our series was 3%, which was more than the ratio reported by Ni et al. [10] (1.9%), Kim et al. [17] (1.4%), Taha et al. [15] (1.6%), Seok et al. [34] (2.6%), and Mohi et al. [35] (2.6%). There were no cases of severe (G3) misplacement and no cases were symptomatic or developed weakened construct stability, and no revision surgeries were required. Out of the 7 misplaced screws in our series, 4 (57%) screws were misplaced medially, and 3 (43%) screws were misplaced laterally which showed no significant difference to the mean medial misplacement ratio of the previous studies which was 49.4% for medial misplacement and 44.4% for the lateral misplacement of the screws. When compared to conventional pedicle screws surgical technique series, our study showed an accuracy rate of 93%, which was higher than the 84.7% accuracy rate of conventional pedicular screws reported by Verma et al. [38] in his systematic review involving 2437 screws, Oh et al. [34] comparative study which involved 483 conventional screws with an accuracy rate of 86.6%, and Gelalis et al. [39] systematic review with an accuracy rate of 69–94% in 2412 conventional screws applied by free hand technique and accuracy rate of 28–85% in 1902 conventional screws applied by the aid of fluoroscopy.

### Study limitations

This study has the following limitations:

- 1- Our study's sample size was relatively small (20 patients) when compared to some other studies in the literature.

- 2- Our follow-up duration was 6 months, which highlights the short and midterm outcome, but does not reveal the long-term outcome of the procedure.
- 3- Our study was prospective non-randomized non-blinded study, which may suffer from selection, classification, and confounding biases.

### Conclusion

Percutaneous pedicle screw fixation technique provides short- and mid-term adequate spinal biomechanical stabilization which can be compared to the conventional posterior muscle stripping techniques while drastically reduce the paraspinal musculoligamentous complex damage. It may have a longer learning curve, though, the gained benefits of less muscular damage, less intraoperative morbidities, comparable accuracy and complication rate, and more rapid recovery course are to be considered. Although a longer follow-up period, a higher number of participants with proper selection and randomization is required, the percutaneous pedicle screw technique has proved to be an alternative with possible benefits in comparison to the conventional muscle damaging pedicle screw approach.

### Abbreviations

CK: Creatine kinase; CK-BB: Creatine kinase brain brain (brain type); CK-MB: Creatine kinase muscle brain (cardiac type); CK-MM: Creatine kinase muscle muscle (skeletal muscle type); CT: Computed topography; G: Grade; K wire: Kirschner wire; MIS: Minimally invasive surgery; MRI: Magnetic resonance imaging; ODI: Oswestry back pain disability index; TLIF: Transforaminal lumbar interbody fusion; SD: Standard deviation; U/L: International unit per liter; VAS: Visual analog scale/score

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### Authors' contributions

AH, HI, HM, SH, and AG have contributed to the study design, implementation, data and results analysis, writing, and editing of the manuscript. The authors have agreed to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. The authors have read and approved the manuscript.

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### Availability of data and materials

All the aforementioned data and results of the statistical analysis are available with the authors and ready to be shared with approved personnel upon demand.

### Declarations

#### Ethics approval and consent to participate

This research was performed after the authorization of the ethical committee of the Faculty of Medicine, Ain Shams University, in November 2017 under federal wide assurance number FWA 000017585 and committee reference number FMASU MD 38/2018. This research included human patients;

therefore, a written informed consent was taken from all the participants or their legal guardians as required by the ethical committee recommendations.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare that they have no competing interests.

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