Assessment of percutaneous “K-wireless” pedicle screw fixation technique

Abstract

Percutaneous spinal pedicle screw fixation is a mini invasive technique initially described by Magerl in 1977 [1] using guide wires. The original technique is decribed with use of k-wires which is frequently associated with breakage or recoil during tapping which can extend operating time in often fragile patients and increase radiation exposure in the medical team. Faced with these challenges, we detail our experience with percutaneous k-wireless pedicle screw fixation.

We carried out a retrospective study from January 2018 to December 2020. We collected K-wireless percutaneous pedicle screw fixation performed between the thoracolumbar hinges including T11 up to L5. The positioning of the screws was judged by a postoperative CT scan with grades ranging from A to D: A = intra-pedicle path or "in out in" extra canal. B = Intra-canal path <2 mm, C = Intra-canal path between 2-4mm, and D = Intra-canal path> 4 mm. The operating time, the exposure dose of irradiation and the complications related to the path of the screws were also noted.

A total of 200 screws in 42 patients were collected. A postoperative CT scan was performed in all our patients. 188 screws were grade A. 9 screws were grade B. 2 screws were grade C without clinical consequences and 1grade D symptomatic by an irritation of the left L5 root having required a surgical resumption and the change of the path of the screw. The average time for screw placement was 5.62 minutes with an average exposure dose of 7.6 +/- 1.2 mRem and an irradiation time of 1.2 minutes.

Results of this study showed that lumbur percutaneous k-wireless pedicule screw fixation under fluoroscopic control is achievable with improved operating time and reduced exposure of the medical team.

Key words : Percutaneous pedicle screw - K-wireless - Technique

Introduction:

The percutaneous pedicle screwing technique was developed by Magerl in 1977. Since then, technological advances in instrumentation have made the minimally invasive technique much easier[1]. This technique is characterized by its multiple advantages: respect of the paravertebral muscles, reduced blood loss, reduced risk of infection and shorter hospital stay [2-3].

Initially, this technique was described under fluoroscopic control with the use of a guide wire to ensure the appropriate route. However, the learning curve of percutaneous screw fixation is fraught with difficulties, namely the handling of the wires with the risk of breakage, withdrawal during tapping or migration through the vertebral body, especially in osteoporotic patients, causing more serious complications such as cerebrospinal fluid (CSF) leakage or intracranial migration in already fragile patients [4-5].

The objective of this study is to evaluate the feasibility and results of lumbar pedicle screw fixation without a guide wire.

Materials and methods:

We performed a single-centre retrospective study from January 2018 to December 2020. We collected percutaneous pedicle screwing without a guide pin performed between the thoraco-lumbar hinges including T11 to L5 by the spineart ancillary. We included all traumatic or degenerative indications for percutaneous fixation. In each case, the duration of screw placement was recorded from the time of incision to the final check for proper screw placement. The time of compression, distraction and final bending was not included in our measurement. Radiation was measured by measuring the delivered dose and the duration of radiation.

Surgical technique: The patient was placed in the prone position, under general anaesthesia, on a radiolucent table with a thoracic block and two blocks under the iliac crests. Care must be taken to ensure that the eyeballs are free. The correct positioning of the support points is imperative. On a frontal view, the skin projection of the vertebral pedicles concerned is marked with a metal pin, and is generally located 3 - 4 cm from the midline. After brushing, a frame setup with two lateral and two upper and lower fields is performed. A wide lateral field on the opposite side of the image intensifier should be added, allowing the image intensifier to be tilted to obtain the profile view. The skin incision is made opposite the previously marked skin markers. Using a number 11 blade, the skin, the sub-skin, and the aponeurosis of the paravertebral muscles are successively incised. The fleshy body of the paraspinal muscles is dissected with dissecting scissors and the finger, in the direction of the muscle fibres, until bone contact is obtained. The path of the screw is prepared with the trocar, composed of a square tip, a needle, and a T-handle. The trocar **(Figure 1)** is inserted in the upper lateral part of the pedicle, in the groove between the transverse process and the articular mass, which can be identified by palpation, the trocar and the visual inspection. Using a hammer, the trocar is introduced into the pedicle, following its progress on a frontal scan. Care must be taken to ensure that the tip of the trocar remains in the middle of the pedicle, i.e. in the "safe zone", in order to avoid its passage into the intracanal or extra pedicle. When the trocar reaches the medial aspect of the pedicle on the frontal scan **(Figure 2)**, it should be opposite the posterior wall on the lateral view, to ensure the intra-pedicular path. The dilators of increasing size are inserted, up to the crenelated dilator, which is hammered in with a few blows of the hammer to ensure that it is anchored to the bony structures **(Figure 3)**. The crenelated dilator is grasped to immobilise it, and the trocar and all dilators are removed. If the crenelated dilator moves or slips due to poor anchoring, we will need to repeat the above steps [6]. The crenelated dilator is immobilised with one hand, the probe is removed with the other and the screw is inserted through the crenelated dilator tube **(Figure 4)**. The length of this screw will have been previously estimated by the operator. The screw will have been previously assembled on the open clip-on tube, and the whole inserted on the screwdriver. The correct positioning of the screw on the profile incidence is then checked with the help of the image intensifier [7]. This technique would be repeated for the remaining stages.

Post-operative evaluation was performed by CT scan. The location of the screws was graded from A to D: A = intra-pedicular or extra-canal "in-out" path. B= Intracanal pathway < 2 mm, C = Intracanal pathway between 2-4mm, and D= Intracanal pathway> 4 mm [7].

We used the Oswestry Disability Index (ODI) to quantify post operative disability for low back pain.

These data were entered and analysed using SPSS 25.0 software.

Results:

The placement of 200 pedicle screws without pins was collected in 42 patients with most frequently traumatic injuries 85% of the cases **(Figure5)**. The average age was 62.4 +/-3 years. The majority of our patients were men (69%). The most screwed floors were at the thoracolumbar hinge **(table I)**. 94% of the screws were grade A. 12 screws penetrated the spinal canal: 9 screws had a path of less than 2 mm, 2 screws between 2 and 4 mm and 1 screw had a path of more than 4 mm. The protruding grade D screw was the only one that was symptomatic postoperatively with sciatica requiring a revision and a change in the screw path. In our series, there were no other intraoperative complications, particularly a pedicle blow and we did not face difficulties forcing us to switch to the k-wire based technique.

Post-operative management of this patient was straightforward without sequelae deficit. The average time for screw placement from the skin incision to the last satisfactory check was 5.62+/- 2.2 min. The average radiation time was 1.2 +/- 0.8 min per patient. The average exposure dose was 7.6+/-1.2 mRem. The evaluation according to the ODI at the last follow-up found minimal disability in the majority of cases, i.e. 94%.

Discussion:

The biomechanical strength provided by transpedicular screws has led to their widespread use in lumbar spine instrumentation [8]. Initially, the placement of transpedicular screws was described as open until Magerl began to describe it percutaneously [8]. Percutaneous placement of pedicle screws has been shown to be both safe and effective while offering distinct advantages over the open technique [9]. The percutaneous screw technique requires a learning curve. The operator must learn to operate with minimal tactile feedback, while relying on radiological images to visualise the anatomical landmarks, which at the beginning of the experiment leads to longer operating times and greater exposure to ionising radiation [10]. The technique of percutaneous screw fixation has been described based on the placement of the Jamshidi intrapedicularly followed by the introduction of guide wires. Incidents related to these wires such as misplacement, migration or breakage are rare and probably underreported [11]. Few publications have described the pin less screwing technique. Spitz et al. reported the results of 100 screwing operations without a guide, emphasising the benefits of percutaneous screwing, avoiding complications and the increased operating time associated with pinning [7].

The literature review found intracanal paths ranging from 6% to 30% with open screw fixation and 19-28% with conventional percutaneous screw fixation [12-13]. Direct comparison with percutaneous screw fixation without a guide wire is difficult due to the limited number of published data with results ranging from 3.6 to 9.9% [14-15]. The clinical neurological complication rate is estimated to be 2-12.5% for screw fixation with a guide wire and 3.6% without a wire [16]. In our series, there were 12 intracanal screws, 9 of which were grade B, 2 grade C and 1 grade D. It has been shown that in the lumbar spine there is a 2 mm safety zone in relation to the epidural space [17]. Thus, there are 3 screws that exceeded the 02 mm limit that are at risk of neurotoxicity 02 grade C in L4, L5 and one grade D in L5. This shows the difficulty of percutaneous screwing without a pin at these levels. The image intensifier remains the most commonly used imaging modality to visualise our anatomical landmarks in screw fixation although various other navigation systems exist today [18]. The use of image intensifier in spinal surgery exposes the patient and the medical team to radiation dose rates 10 times higher than other extra-spinal surgeries [19]. The average exposure time described in series using guide wires has been 1.6-4.5 min [7-20]. Our series found a mean time of slightly less than 1.2 +/-0.8 min. The exposure dose in percutaneous pedicle screwing with pins was reported by Mroz et al. The dosimeter placed at waist level under the lead apron found an average of 10 mRem[21] with an average in our study of 7.6+/-1.2 mRem in our series.

Limitations of our study: data collection was performed prospectively in a single centre. Our two operators are both surgeons specialised in minimally invasive surgery and therefore our results may not be representative of a larger group. Screws placed by junior doctors were not recorded. A comparison with the result of percutaneous screwing with a pin was not performed as this technique has been abandoned in our practice.

The results of this study of pedicle screwing without guide wires at the lumbar level demonstrate that screws can be safely placed without wires with a radiological intracanal path rate equivalent to the use of guide wires with a low clinical translation evaluated at 0.5% in our series. With a clear advantage in terms of operative time and exposure to ionising radiation when comparing our results with the literature.

Conclusion

The K-wireless pedicle screwing is a technique that reproduces the results of screwing with guide. However, it is a technique that requires a long learning curve and mastery of the usual technique in order to be able to switch in case of intraoperative difficulties.

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

Table and figures List:

Table 1: Distribution of extra-pedicular paths according to the vertebral level

Vertebral level	Number of screws	Number of extra-pedicular paths	Grade	Percentage
T11	34	2	B	5.8%
T12	24	3	B	12 .5%
L1	42	2	B	4.7%
L2	56	1	B	1.7%
L3	18	0		0
L4	12	1 1	C B	8.3% 8.3%
L5	14	1 1	D C	7.1% 7.1%
Total	200	12		100%

Figure 1: Placement of the trocar on the frontal view

Figure 2 : placement of the trocar on the lateral view

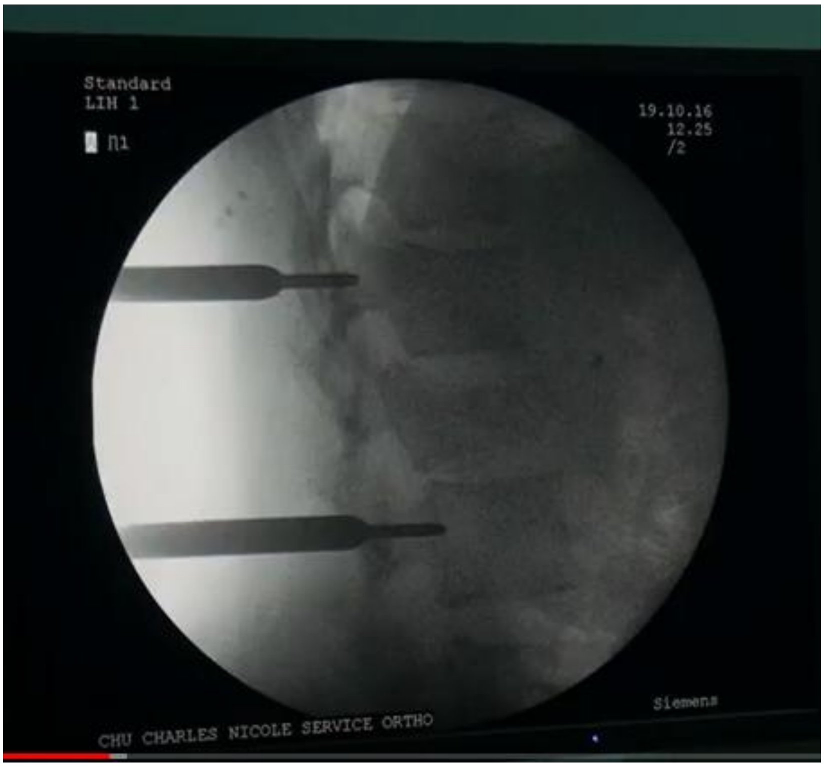


Figure 3 : Engaging the crenellated dilator with hammer

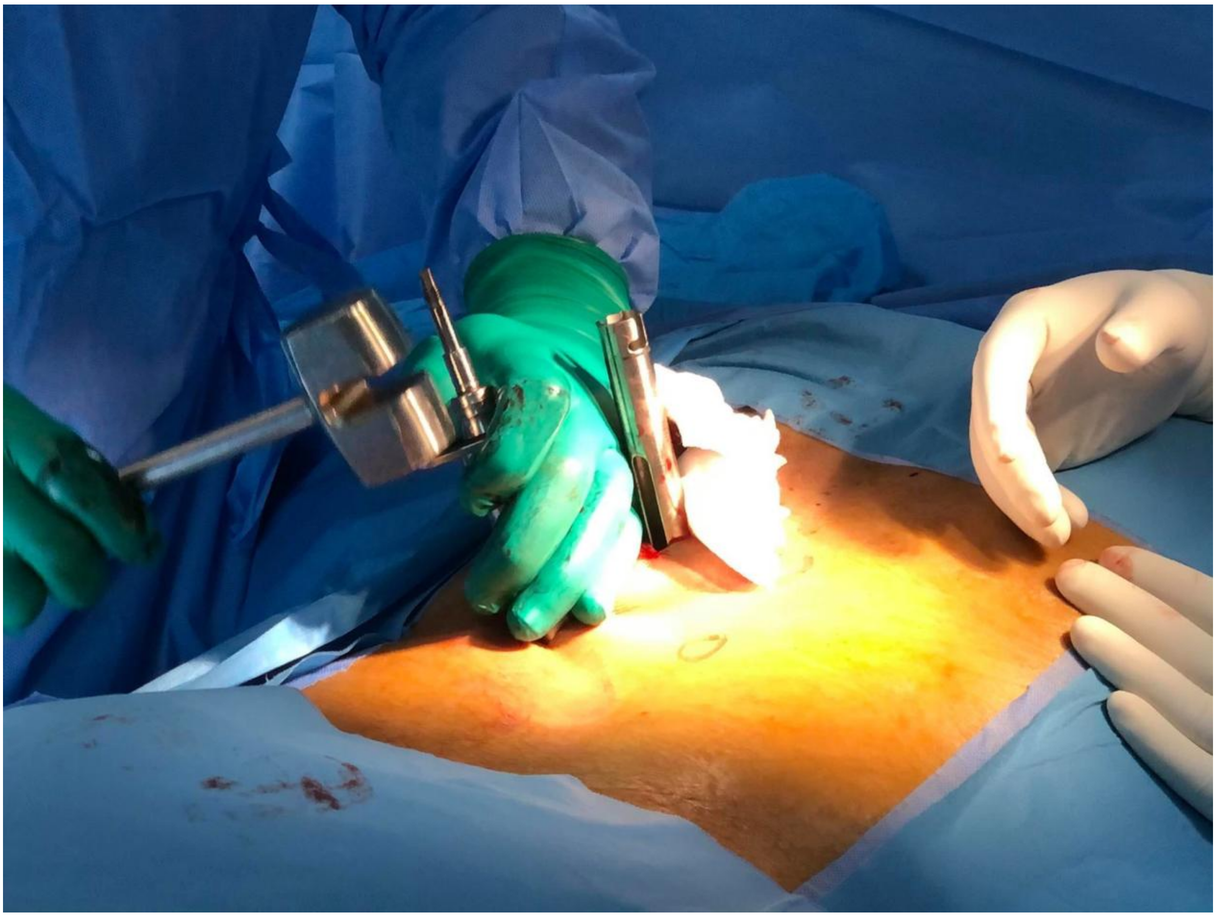


Figure 4 : Placement of the pedicular screw

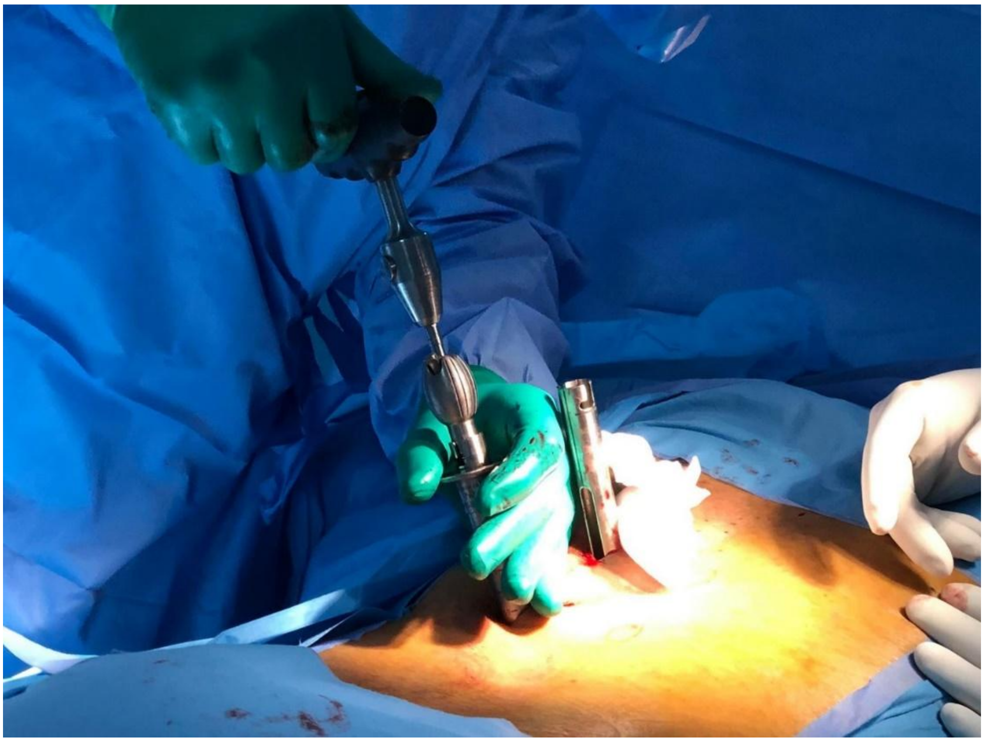
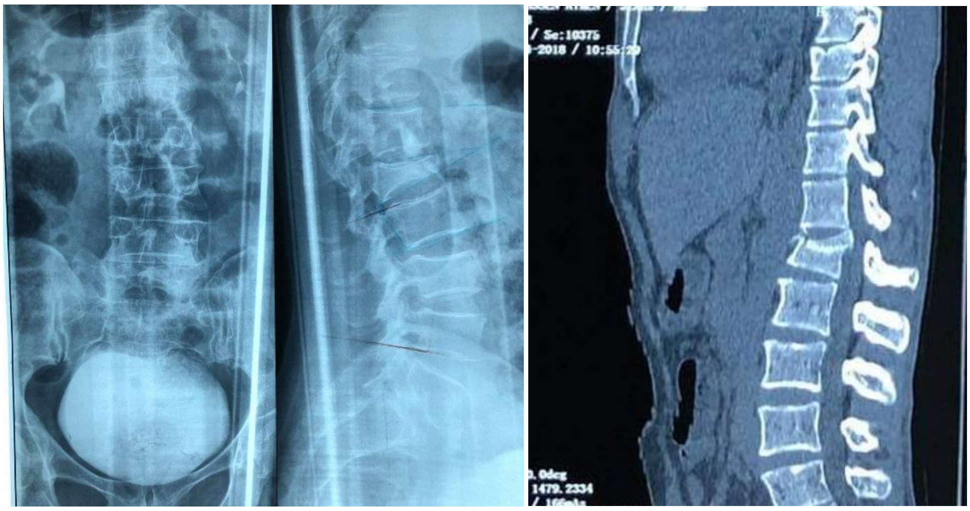
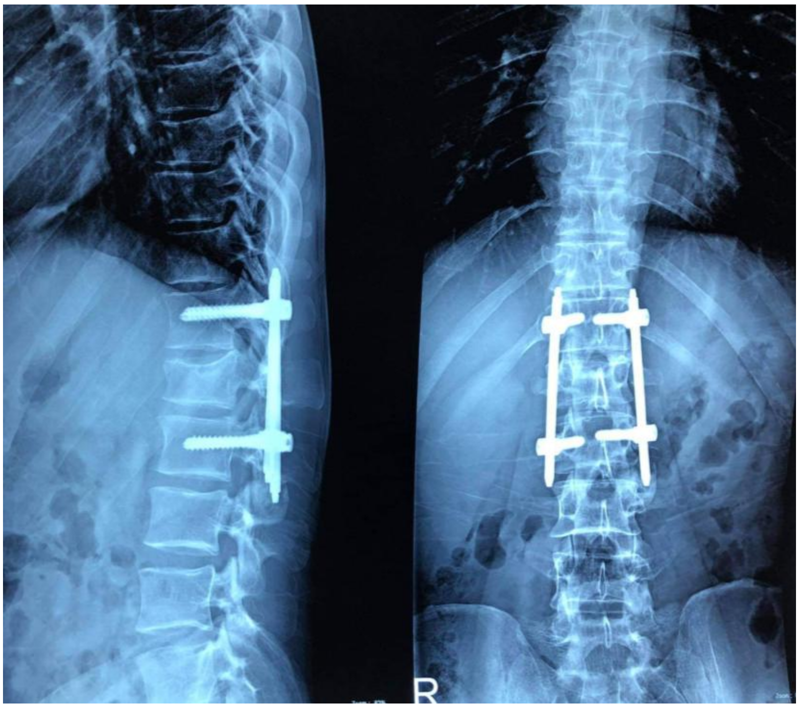


Figure 5: Clinical case of an incomplete burst fracture





References

1-F.P.Magerl. Stabilization of the lower thoracic and lumbar spine with external skeletal fixation. ClinOrthopRelat Res. 1984;(189):125-41.

2- A. Sebaaly, M.Rikallah,G.Riouallon,Z.Wang,P.Moreau,F.Bachour et al.Percutaneous fixation of thoracolumbar vertebral fractures. EFORT Open Rev. 2018;3(11):604-613

3- K.Phan, P.J.Rao, R.J.Mobbs. Percutaneous versus open pedicle screw fixation for treatment of thoracolumbar fractures: Systematic review and meta-analysis of comparative studies..ClinNeurolNeurosurg. 2015;135:85-92.

4-R.Furuhata, M.Nishida, M.Morishita, S.Yanagimoto, M.Tezuka, E.Okada.Migration of a Kirschner wire into the spinal cord: A case report and literature review. J Spinal Cord Med. 2020;43(2):272-275

5-Mobbs RJ: Raley DA: Complications with K-wire insertion for percutaneous pedicle screws. J Spinal Disord Tech 2014 ;27:390–394.

6- Kwan MK, Chiu CK, Chan CW, Zamani R, Hansen Algenstaedt, N. The use of fluoroscopic guided percutaneous pedicle screws in the upper thoracic spine (T1– T6): is it safe? J Orthop Surg. 2017;25(2):1–8

7- S.M.Spitz, F.A.Sandhu, J.M.Voyadzis. Percutaneous "K-wireless" pedicle screw fixation technique: an evaluation of the initial experience of 100 screws with assessment of accuracy, radiation exposure, and procedure time.J Neurosurg Spine. 2015; 22(4):422-31.

8-Y Shono , K Kaneda, K Abumi, P C McAfee, B W Cunningham.Stability of posterior spinal instrumentation and its effects on adjacent motion segments in the lumbosacral spine. Phila Pa. 1998;23(14):1550-1558.

9-Dirk H Alander , Shari Cui.Percutaneous Pedicle Screw Stabilization: Surgical Technique, Fracture Reduction, and Review of Current Spine Trauma Applications.J Am AcadOrthop Surg. 2018 ;26(7):231-240

10-Voyadzis JM: The learning curve in minimally invasive spine surgery. Semin Spine Surg.2011;23:9–13.

11-Mobbs RJ, Raley DA. Complications with K-wire insertion for percutaneous pedicle screws. J Spinal Disord Tech. 2014;27(7):390–394.

12-Gelalis ID, Paschos NK, Pakos EE, Politis AN, Arnaoutoglou CM, Karageorgos AC, et al: Accuracy of pedicle screw placement: a systematic review of prospective in vivo studies comparing free hand, fluoroscopy guidance and navigation techniques. Eur Spine J.2012; 21:247–255

13-Koichi Murata, Shunsuke Fujibayashi, BungoOtsuki, Takayoshi Shimizu, KazutakaMasamoto, Shuichi Matsuda. Accuracy of fluoroscopic guidance with the coaxial view of the pedicle for percutaneous insertion of lumbar pedicle screws and risk factors for pedicle breach. J Neurosurg Spine. 2020; 28:1-8.

14-Waschke A, Walter J, Duenisch P, Reichart R, Kalff R, Ewald C. CT-navigation versus fluoroscopy-guided placement of pedicle screws at the thoracolumbar spine: single center experience of 4, 500 screws. Eur Spine J. 2013;22(3):654–660.

15-SAEED S., RYAN J., BLAKE N., MAJDI R., PAUL J. H. Minimally Invasive, Stereotactic, Wireless, Percutaneous Pedicle Screw Placement in the Lumbar Spine: Accuracy Rates With 182 Consecutive Screws. Int J Spine Surg. 2018;12(6):650-658.

16-Wiesner L, Kothe R, Schulitz KP, Ruther W. Clinical ¨ evaluation and computed tomography scan analysis of screw tracts after percutaneous insertion of pedicle screws in the lumbar spine. Spine (Phila Pa 1976). 2000;25(5):615–621

17-Shiu-Bii Lien ,Nien-HsienLiou, Shing-Sheng Wu. Analysis of anatomic morphometry of the pedicles and the safe zone for through-pedicle procedures in the thoracic and lumbar spine. Eur Spine J. 2007 ;16(8):1215-22.

18- Pirateb P.M., Jacob Y., Mark T., Colum P., Chun S., Ji M. Accuracy of Thoracolumbar Pedicle Screw Insertion Based on Routine Use of Intraoperative Imaging and Navigation. Asian Spine J. 2021;15(4):491-497.

19- Rampersaud YR, Foley KT, Shen AC, Williams S, Solomito M: Radiation exposure to the spine surgeon during fluoroscopically assisted pedicle screw insertion. Spine (Phila Pa 1976).2000 ; 25:2637–2645.

20- Bindal RK, Glaze S, Ognoskie M, Tunner V, Malone R, Ghosh S: Surgeon and patient radiation exposure in minimally invasive transforaminal lumbar interbody fusion. J NeurosurgSpine.2008 ; 9:570–573.

21- Mroz TE, Abdullah KG, Steinmetz MP, Klineberg EO, Lieberman IH: Radiation exposure to the surgeon during percutaneous pedicle screw placement. J Spinal Disord Tech.2011 ; 24:264–267.