



EVALUATION OF SCREW MALPOSITION BY RADIOGRAPHY IN LENKE TYPE 1 ADOLESCENT IDIOPATHIC SCOLIOSIS PATIENTS HAVING UNDERGONE SELECTIVE FUSION

SELEKTİF FÜZYON YAPILAN LENKE TİP 1 ADÖLESAN İDİYOPATİK SKOLYOZLU HASTALARDA VİDA MALPOZİSYONUNUN DİREK RADYOGRAFİ İLE DEĞERLENDİRİLMESİ

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ABSTRACT:

Aim: In recent times, instrumentation with pedicle screw is a widely used method in vertebral surgery. In this study, we aimed to evaluate rate of the most common complication of this method, namely, pedicle screw malposition and its clinical implications in patients diagnosed as Lenke Type 1 idiopathic scoliosis and thus having undergone posterior intervention and instrumentation.

Patients and Method: Forty-nine patients have undergone posterior intervention and instrumentation because of Lenke Type 1 adolescent idiopathic scoliosis between 2005 and 2011 and 42 of them with continuous screw placement was included into the study (6 males; 36 females; mean age 13.8 years). Position of screws placed into thoracic and lumbar pedicles was evaluated by anteroposterior and lateral post-op radiographies by three orthopaedists.

Results: A total of 944 pedicle screws were found to be placed into thoracic and lumbar pedicles. Mean number of placed screws per patient was calculated as 22.5. Most of the screws were placed at T3-T4-T5-T6-T7-T8-T9-T10-T11-T12 (n:84) vertebra segments and L2 (n:2) segment was the lowest number of screws were placed. Rate of screws in normal position within the pedicles was 86.4% (n=816) and the rate of screws out of the pedicles was 13.6% (n=128). 74(57.8%) of the screw malposition were at lateral of the pedicle and 35 (27.3%) were at the inferior of the pedicles, 13 (10.2%) were at the superior of pedicle or at upper disc distance, 6 (4.7%) were at medial of the pedicle and 63% of these screws were at concave side and 37% were at convex side. Screw malposition was most commonly observed at T11 level. There was no screw malposition at L1-L2 levels. No complication with early symptoms was observed in any of the patients.

Conclusion: In this study; although rate of screw malposition was 13.6%, absence of any complication such as neurological deficit, pseudo-arthrosis, infection and pulmonary emboli at early stage has revealed that instrumentation by placing pedicle screws free hand in surgical treatment of adolescent idiopathic scoliosis is a safe and appropriate surgical method.

Key words: Adolescent idiopathic scoliosis, Lenke type 1 curve, posterior selective fusion, screw malposition

Level of evidence: Retrospective clinical study, Level III

ÖZET:

Amaç: Bu çalışmada vertebra cerrahilerinde yaygın bir şekilde kullanılmaya başlanan pedikül vidası ile enstrümantasyonun en sık komplikasyonu olan pedikül vida malpozisyonu oranlarını ve kliniğe yansımalarını Lenke tip 1 idiopatik skolyoz tanısıyla posterior girişim ve enstrümantasyon uygulanan hastalarda değerlendirmeyi amaçladık.

Hastalar ve yöntem: Çalışmaya 2005-2011 yılları arasında Lenke tip 1 adölesan idiopatik skolyoz tanısı ile posterior girişim ve enstrümantasyon uygulanan 49 hastanın boşluk bırakılmadan vida yerleştirilen 42'si çalışmaya dahil edildi (6 erkek; 36 kadın; ortalama yaş 13.8). Torakal ve lomber pediküllere yerleştirilen vidaların pozisyonları ameliyat sonrası çekilen ön-arka ve yan direk radyografiler ile üç ortopedist tarafından birlikte değerlendirildi.

Sonuçlar: Toplam 944 pedikül vidası torakal ve lomber pediküllere yerleştirildiği saptandı. Hasta başına yerleştirilen vida sayısı ortalama 22.5 olarak hesaplandı. En çok vida yerleştirilen seviyeler T3-T4-T5-T6-T7-T8-T9-T10-T11-T12 (n:84) vertebra segmentleri olurken, en az vida L2 (n:2) seviyesinde kullanıldı. Pedikül içinde normal yerleşim gösteren vidaların oranı %86.4 (n=816) iken pedikül dışında olanların oranı 13,6% (n=128) olarak saptandı. Hatalı vidaların 74'ü (%57.8) pedikül lateralinde, 35'inin (%27.3) pedikül inferiorunda, 13'ünün (%10.2) pedikül süperiorunda veya üst disk mesafesinde, 6'sının (%4.7) ise pedikül medialinde olduğu görülürken bu vidaların % 63'ü konkav, %37'sinin konveks yüzdeydi. Vida malpozisyonu en çok T11 seviyesinde görüldü. L1-L2 seviyelerinde malpozisyon saptanmadı. Hiçbir hastada erken dönemde klinik semptom veren bir komplikasyon saptanmadı.

Tartışma: Bu çalışma; %13,6 oranında vida malpozisyon görülmesine rağmen erken dönemde herhangi bir nörovasküler defisitinin saptanmaması, psödoartroz, enfeksiyon, pulmoner emboli gibi komplikasyonların görülmemesi adölesan idiopatik skolyoz cerrahi tedavisinde serbest uygulanan pedikül vidaları ile enstrümantasyonun güvenilir ve uygun bir cerrahi teknik olduğunu göstermektedir.

Anahtar kelimeler: Adölesan idiopatik skolyoz, Lenke tip 1 eğrilik, posterior selektif füzyon, vida malpozisyonu

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INTRODUCTION:

In spinal surgery, fusion instrumentation by using pedicle screws is widely used for correcting deformities such as traumatic, infective, degenerative and tumour deformities or deformities due to scoliosis. Biomechanically, pedicle screw is superior to sublaminar wires, hooks and laminar screws. Moreover, spinal segments may easily be controlled by pedicle screws and smaller number of vertebral segment fusion is adequate for stability. Thus, fusion instrumentation by using pedicle screw is frequently preferred⁴.

Scoliosis is a complex curvature of the spine occurring as a result of rotating of the spine around its own axis and leads to postural distortion not only at coronal plane but all of the three planes. The most common deformity of the spine is scoliosis and surgically most treated type of the scoliosis is Lenke type 1 adolescent idiopathic scoliosis. The most frequently encountered form of scoliosis is Lenke type 1 adolescent idiopathic scoliosis and those are the most treated patients^{2,5}.

To prevent heterogeneity in the study we evaluated pedicle screw malposition of patients having undergone posterior intervention and instrumentation because of Lenke type 1 idiopathic scoliosis between 2005–2011.

PATIENTS AND METHOD:

Forty-nine patients have undergone posterior intervention and instrumentation because of Lenke Type 1 adolescent idiopathic scoliosis between 2005 and 2011 and 42 of them with continuous screw placement was included into the study. Patients in whom bilateral pedicle screw was placed at all levels were evaluated. Seven patients were excluded because one or several screws were skipped. 6 of the patients were male and 36 of them were females; mean age of the patients was 13.8 years.

At the pre-op period anteroposterior, lateral and right and left bending radiographies of all patients were taken. Pedicle screws were placed in all of the subjects by using free-hand technique. Screws were placed in the cranio-caudal direction along the anatomic axis of the pedicle. C-arm radioscopy was used to check the rods before placement. In our subjects, usually polyaxial pedicle screws with a diameter of 4.0–4.5 mm were preferred for T1–T6 vertebrae, 5.5 mm for T7–T12 and 6.5 mm for L1–L2.

Pedicle screw position was evaluated by three orthopaedics specialists via anteroposterior and lateral plain radiographies taken post-operatively. Five criteria were used by three orthopaedics specialists during the evaluation of screw position via antero-posterior and lateral direct radiographies taken post-operatively:

1. In the anteroposterior radiography pedicle screw should be within the elliptic pedicle image.

2. Tip of the pedicle screws shouldn't exceed midpoint of the vertebral body in the anteroposterior radiography.

3. In the anteroposterior plain radiography tip of the pedicle screws should stay within the rectangle forming vertebral body and shouldn't deviate abnormally in the caudal and cranial direction.

4. In the lateral radiography screws should stay within the borders of rectangle forming vertebral body and tip of the screws shouldn't exceed anterior or posterior cortex of vertebral body.

5. In the lateral radiography screws should be within the pedicle and shouldn't reach to superior or inferior of vertebral foramina.

RESULTS

A total of 944 pedicle screws were found to be placed into thoracic and lumbar pedicles. Mean number of placed screws per patient was calculated as 22.5. Most of the screws were placed at T3–T4–T5–T6–T7–T8–T9–T10–T11–T12 (n:84) vertebra segments and L2 (n:2) segment was the level where the lowest number of screws were placed. Diameter of 368 (39 %) screws was 4.0 or 4.5 mm, diameter of 504 (53.4 %) screws was 5mm and diameter of 72 (7.6 %) screws was 6.5mm. Segmental distribution of placed pedicle screws is shown in Table-1.

Rate of screws in normal position within the pedicles was 86.4 % (n=816). Plain anteroposterior and lateral radiographies have revealed that 128 (% 13,6) of the pedicle screws were out of the pedicles. 74 (57.8 %) of the screw malposition were at lateral of the pedicle and 35 (27.3 %) were at the inferior of the pedicles, 13 (10.2 %) were at the superior of pedicle or at upper disc space, 6 (4.7 %) were exceeding medial wall of the pedicle. 63 % of malpositioned screws were at concave side and 37% were at convex side. Screw malposition was most commonly observed at T-11 level. There was no screw malposition at L1–L2 levels (Figure-1).

There was no neurovascular complication associated with pedicle screw malposition. There was no pleural injury, pneumothorax, pleural effusion, dural tear or CSF leakage due to screw placement during surgery. Coronal balance disturbance was detected in one study patient but since the patient wasn't complaining from the condition no surgical intervention was carried out. Likewise, in another patient shoulder asymmetry which doesn't disturb the patient was only clinically monitored. Both of these patients were surgically treated by advancing fusion up to L4 level which was previously left at distal T12 level. Superficial wound infection observed in one patient was treated by parenteral antibiotics. There was no death or complications such as deep vertebral infection and deep venous thrombus.

Table-1. Vertebral segment level of placed pedicle screws and inaccurate screws and their distribution according to side of the deformity

Vertebral level	All screws		Inaccurate screws		Side of misplaced screw areas	
	No.	percentage	No.	percentage	concave	convex
T2	32	3.4	1	0.8	1	0
T3	84	8.9	5	3.9	5	0
T4	84	8.9	2	1.6	1	1
T5	84	8.9	5	3.9	2	3
T6	84	8.9	9	7.0	1	8
T7	84	8.9	13	10.2	10	3
T8	84	8.9	16	12.5	12	4
T9	84	8.9	13	10.2	6	7
T10	84	8.9	15	11.8	7	8
T11	84	8.9	29	22.7	22	9
T12	84	8.9	20	15.7	14	4
L1	70	7.4	0	0	0	0
L2	2	0.2	0	0	0	0
Total	944		128		81	47

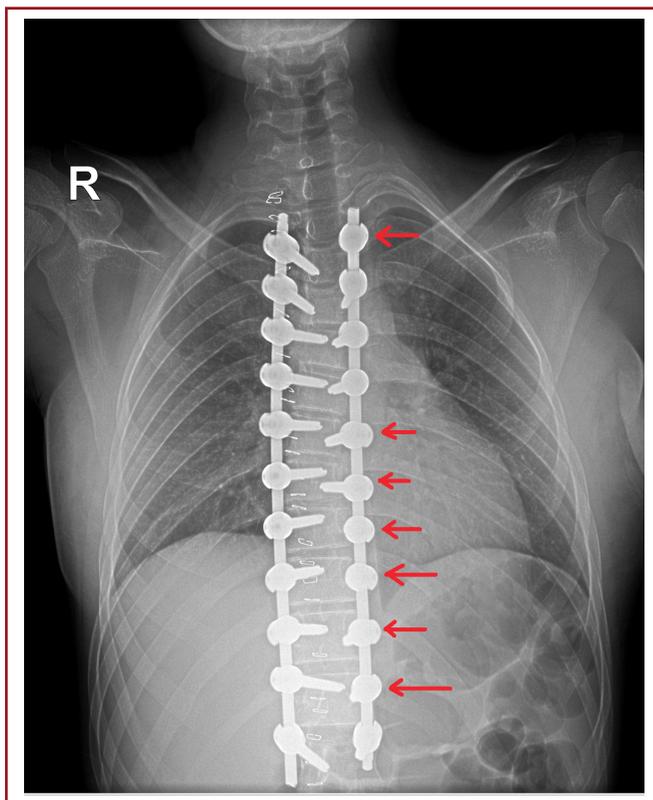


Figure-1. Image of screw malposition in plain posterior radiography.

DISCUSSION:

Scoliosis surgery requires a long learning curve and need for experience; however, despite its catastrophic complications instrumentation with pedicle screws is increasingly becoming popular in surgical treatment of adolescent idiopathic scoliosis. Even though it's a catastrophic and high risk surgery complications are rarely reported. We assume that low complication rate probably occurs because of the reason that scoliosis surgery usually carried out in experienced centres as a team work. In our clinic, pedicle screws are placed by an experienced operating team that has been dealing with scoliosis surgery nearly for 20 years and thus rate of screw malposition is 13.6 % in line with the literature. Despite the current rate of malposition, there was no clinically symptomatic complication at the early stage in any of the patient.

Studies have shown that pedicle screw malposition rate varies between 1.2 % and 40 % in scoliosis surgery and complications due to screw malposition vary between 0 % and 0.9 %^{6,7,9,18}. We assume that the probable reasons for the observed wide range in above mentioned rates are evaluation of patients who are in different scoliosis grades and more importantly employment of different evaluation methods. In our study, screw position was evaluated via anteroposterior and lateral radiographies. In our patients, we didn't use CT in evaluating pedicle screw position and this may be considered as one of the weaknesses

of our study. Although plain radiographies have been evaluated stringently through the eyes of three different orthopaedics specialists, the low rate of screw malposition may be due to non-use of CT in routine evaluation. Thus, screw malposition rate was found as 11 % by Hicks et al., in a literature review including 21 studies evaluating screw malposition by plain radiography; however, the rate increased to 15.7 % in the studies employing computerized tomography (CT) in post-op follow up⁷.

Various pedicle screw placement techniques such as several navigation systems, or robot or goniometry use were described because of high malposition risk during screw placement^{2-4,12-14}. However, high learning curve, high cost and long operation time and excessive blood loss have impeded widespread use of these techniques. In addition to pedicle screw malposition, inadequate correction of the curves, intraoperative pedicle fracture, screw loosening and retrieval, dural laceration, infection, pseudo arthrosis, pulmonary, neurological and vascular complications are rarely reported^{1,3,8,11,15-19}.

Free-hand technique described by Kim et al.⁹ is the most commonly used method in pedicle screw insertion to thoracolumbar spine. In their study, although they mentioned from free-hand technique as a safe method, they reported its main disadvantage as its total dependence to experience and competence of the surgeon. Suk et al.¹⁸ have described a novel technique called as "biplanar technique" for insertion of pedicle screw. A kirschner wire is placed into the presumed *pedicle entry point* along the appropriate axis and then appropriate entry point and screw axis is determined by taking anteroposterior and lateral plain radiographies. Medial pedicle wall penetration rate was 1.5 % after placement of 4604 thoracic pedicle screw by using this technique.

In Lenke type 1 scoliosis the highest numbers of screws are placed into thoracic spine. Malposition risk is higher during insertion of pedicle screws to thoracic spine compared to lumbar spine; because diameter of spinal canal and pedicle is relatively narrow and there is no anatomic structure indicating entry point unlike lumbar spine²¹. In addition, the pedicles at the concave side in scoliosis patients are thinner, anatomically dysmorphic and sclerotic and all these features increases malposition risk. In our study also rate of malposition was higher in the concave side in accordance with the literature (63 %). Also, since medulla spinalis is more rigid at the concave side, risk of neurological injury due to screw malposition at the concave side is found to be higher compared to the convex side²⁰. Most of the 128 malpositioned screws were observed to be at the lateral of pedicle. T11 level had the highest number of screw malposition and no screw malposition was observed at L1-L2 level.

According to numerous authors, trespassing medial wall by 2 mm of a pedicle screw is considered as in acceptable limits.

Moreover, Kim et al.¹⁰ considered medial wall trespassing by 2 mm-4 mm as safe. Papin et al.¹⁶ have found in a patient that 4 mm excess of 2 screws has led to epigastric pain, resting tremor at right leg and dysesthesia at the leg and the symptoms were relieved after changing the screws. Application side is also important for potential neurological complications in addition to medial wall penetration. We think that particularly in rigid curvatures we should be more careful at concave side while placing screws. We also think that spinal monetarisation during placement of each screw and anteroposterior, lateral and oblique fluoroscopic imaging during operation to confirm accurate screw axis are important in preventing potential neurological complications.

In scoliosis surgery, well apprehension of 3-dimensional anatomic structure of particularly the pedicle and spine and instrumentation with free-hand insertion of pedicle screws following a sound pre-op planning is a safe surgical method that shortens the duration of operation, reduces blood loss and increases stability.

We have found that 128 of the 944 screws placed to 42 adolescent idiopathic scoliosis patients were out of the pedicles. In this study, despite 13.6 % screw malposition, there was no early stage complication such as neurovascular deficit, pseudoarthrosis, infection or pulmonary emboli. However, that doesn't mean instrumentation by pedicle screws via free-hand technique is totally safe. Screw malposition should be minimized in order to avoid probable complications of malposition. We think that probable screw loosening and screw retrieval due to malposition should be radiologically and clinically monitored in late stage follow up of these patients.

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