Free hand insertion of pedicle screws in Dorsal / Lumbar / Sacral spine – Our experience

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ABSTRACT

BACKGROUND: Fluoroscopic guidance to put pedicle screws helps to confirm the accuracy of the screw in place; however, it is always not mandatory

METHODS: In 79 patients, 531 pedicle screws were inserted during a period between July 2006 and November 2009. There were 218 pedicle screws in trauma, 138 in TB spine, 107 in Scoliosis, 26 in Scheuermann's kyphosis, 18 in Spondylolysis / spondylolisthesis and 24 in tumors. In lumbar / sacral region total of 140 screws and in Dorsal region 391 screws were introduced. All screws were inserted free hand without fluoroscopic guidance. Accuracy of the placement was checked per operatively with pedicle probe by sounding technique. Before wound closure and whenever in doubt position of screws was checked under fluoroscope. Post operatively patients were subjected for CT scan to confirm the position of the screws. Seventeen patients with 107 screws were excluded from the study since they were not subjected for post-operative CT scan. The study consisted of 424 pedicle screws in 62 patients.

RESULTS: Out of 424 pedicle screws four screws (0.9%) were misplaced. Three patients complained of dysesthesia. Eleven screws (2.5%) were broken at last follow up of 12.6 months. The average surgical time for insertion of the screw without image intensifier is four minutes whereas with image intensifier was 7.5 minutes.

CONCLUSION: Free hand insertion of pedicle screws is safe and time saving.

KEY WORDS: *Free hand, Pedicle screw, image intensifier*

INTRODUCTION

Pedicle screw fixation has become a gold standard for any spinal reconstructive or stabilization procedures and is the integral part of the armamentarium for any spine surgeons. Its extension through three columns of the vertebrae improves load transfer across the spinal column by virtue of its load sharing capacity.[1] Pedicle screw insertion is relatively safe and it is very effective in providing stability in all planes of the spinal movements.

Pedicle screws can be applied in any vertebra where the pedicle can accommodate the screws. Exhaustive studies are available on anatomy of human pedicles. Wide variations have been identified within common patterns and pedicular anatomy unique to cervical, thoracic, lumbar and sacral spine do exist. [2,3,4,5,6]

Different techniques of insertion of the screws have been described. Roy-Camille et al.[12,13] recommended for drilling of the pedicular path and screw application. Many surgeons realized its risk of injuring neural structures and adopted blunt technique by using biplane image intensification during placement of the screws. [40] Accuracy of the placement of the screws can be assured by using sophisticated technologies like robots[7], navigators[8,9,10] or endoscopic visualization.[11] Some surgeons routinely use somato-sensory evoked potential[14] or dermatomal somato-sensory evoked potential [15] and

electromyography.[16,17,18,19,20] Japanese surgeons are using 3-D visual guidance or SEXTANT . Some authors have described an anterior approach[21] to the pedicle screw fixation while others do laminectomy to confirm the placement of the screws although this approach has not been widely adopted.

Free hand insertion, popularly known as Funnel technique, is a simple and widely accepted technique. In addition to its safety, it is cost effective and time effective. It is a blunt technique of identifying the pedicle isthmus and thus risk of injuring neural structures and misplacement of the pedicle screw is significantly less. Thus the objective of this study is to describe the accuracy of free hand technique for pedicle screw insertion.

MATERIALS AND METHODS

Between July 2006 and November 2009 total of 531 pedicle screws were inserted in thoracic, lumbar and sacral spines in 79 patients. Most of the screws were applied in traumatic spines (n=218) followed by in spine affected by infection (n= 138), scoliosis (n = 107), Scheuermann's Kyphosis (n = 26), spondylolisthesis / Spondylolysis (n= 18) and tumors (n= 24) (Chart 1). In dorsal spine total of 391 screws and in Lumbar and sacral spine 140 screws were inserted (Chart 2). Since the adequate data of 17 patients with 107 pedicle screws were not available the study population included 424 pedicle screws in 62 patients.

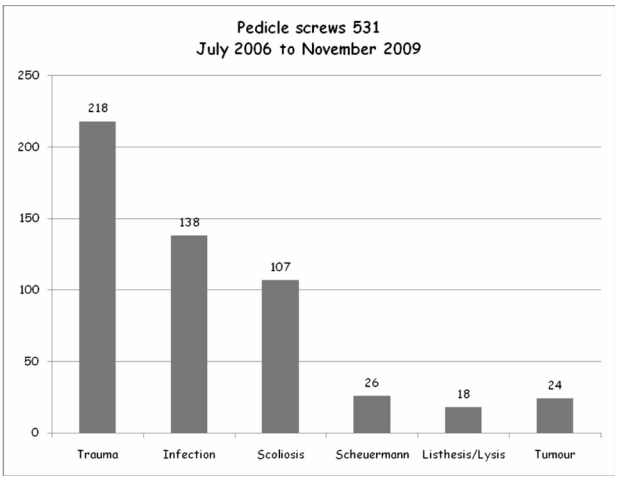

Chart 1: Showing number of screws used in various spinal conditions

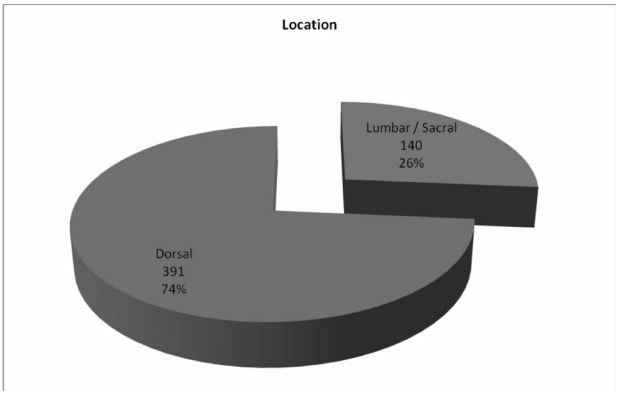

Chart 2: Number of screws used in Dorsal, Lumbar and Sacral spine

Technique of insertion of pedicle screw

Thorough knowledge of the anatomy of the vertebra is essential before attempting pedicle screw insertion (Figure 1).

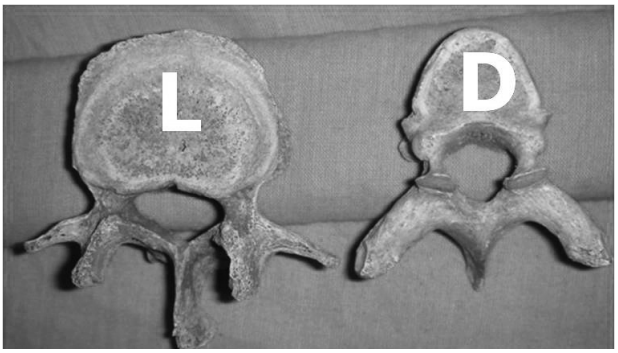

Fig 1. Anatomy of the Lumbar and Dorsal vertebrae. The pedicle is always at the confluence of the transverse process, articular facet and lamina.

The morphology and the size of the pedicle screw were evaluated before hand with the help of plain radiography and the axial cuts of the CT scan (Figure 2 & 3). The proper anatomy of the posterior elements of the vertebrae was studied after exposure right up to the tip of the transverse process. The pedicle is at the confluence of the transverse process, articular facets and the lamina. About 1 cm of bone was removed from the junction between lateral margin of the lamina, transverse process and superior articular process. The exposed cancellous portion of the bone was gently curetted out to visualize the isthmus of the pedicle. Two millimeter straight curette can be used to cannulate the isthmus. Blunt awl is used to drill a path along the pedicle into the vertebral body orienting

vertically down perpendicular to the lamina and directed medially. In between the procedure the sounding probe is used to make sure that all four quadrants of the pedicle are intact. The pedicle is tapped with appropriate sized pedicle tap. The pedicle is again probed with the sound and the tactile feel of step ladder pattern in all four cortices may confirm the position of the screw in the pedicle (Figure 4). The anterior cortex is palpated with the sounding probe. The Steinmann pin can be used to deliberately perforate the anterior cortex by gentle tapping to achieve bi-cortical purchase if the bone feels osteoporotic. The length of the screw is measured with depth gauge. Appropriate diameter and length pedicle screw is inserted.

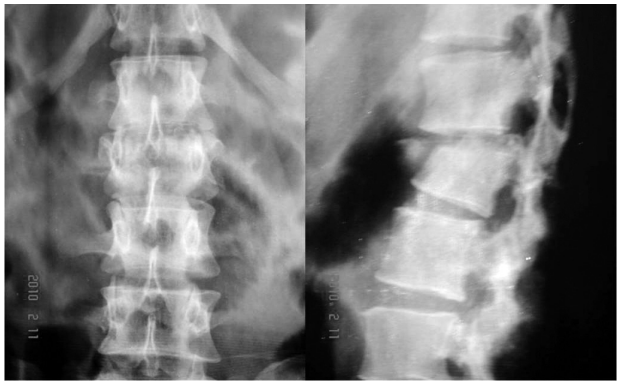

Fig 2. Plain radiograph gives the general anatomical feature of the vertebra but it is mandatory to have CT scan for measurement of the diameter, length and orientation of the pedicle screw.

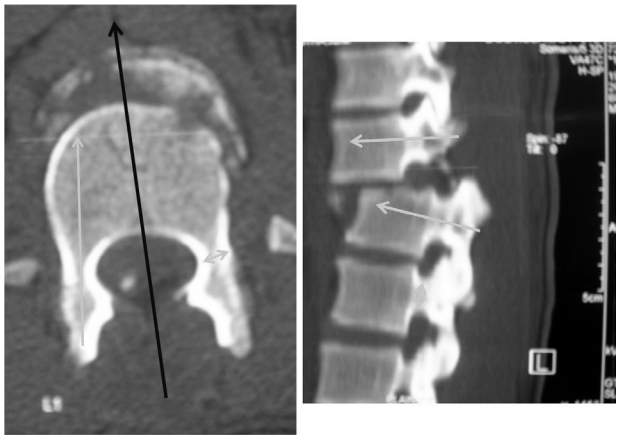

Fig 3. Plain radiograph gives the general anatomical feature of the vertebra but it is mandatory to have CT scan for measurement of the diameter, length and orientation of the pedicle screw.

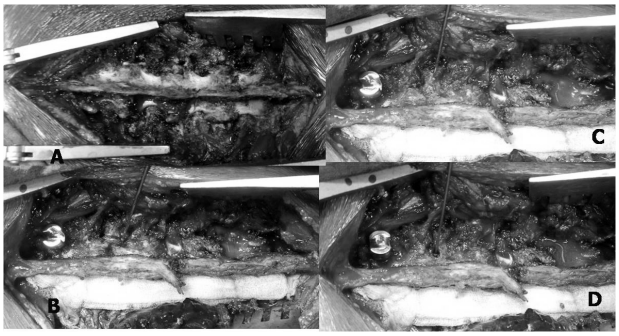

Fig 4. A. Posterior elements of the vertebrae exposed as far lateral as to the tip of the transverse process. B. Facet joint and lateral margin of the lamina exposed. C. About 1 cm of the bone from the facet joint was removed with rounger and the cancellous bone was curetted out to expose the isthmus of the pedicle. D. The pedicle path was gently awled and all four wall of the pedicle was sounded with flexible ball tipped probe.

Time taken for the insertion of each pedicle screw was recorded in the stopwatch by the circulating nurse right from the time of probing the pedicle to the end of its insertion, both during free hand technique and the technique using fluoroscope. The average time taken was calculated and recorded.

Evaluation of the placement of the pedicle screws

The proper positioning of the pedicle screws is assessed intraoperatively with the sounding technique which is done before and after taping the pedicle. The tactile feel of the bone in all the four cortices of the pedicle usually confirms the accurate placement of the screws which is further confirmed by sounding the pedicle after tapping is done, when the step ladder pattern is felt in all four quadrants.

We routinely use lateral view of the image intensifier at the end of the procedure after putting all pedicle screws. It further helps to assess the length and orientation of the pedicle screws (Figure 5).

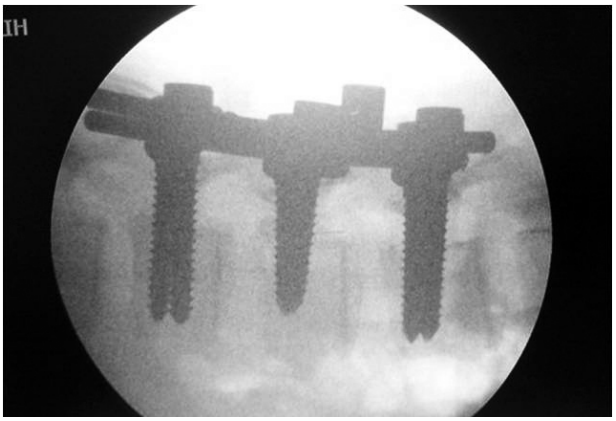

Fig 5. Length, orientation and placement of the pedicle screws was confirmed by image intensifier.

Post-operatively plain radiographs are usually adequate to assess the proper positioning of the screws. In antero-posterior view the pedicles are obliterated by the profiles of the screws and the screw tips should not cross the midline. The tip of the screw crossing the midline indicates then the screw passing through the spinal canal provided there is not much angular orientation of the pedicle as depicted by preoperative CT-Scan. In lateral view the shape of the intervertebral foramen can be a very good guide to assess the proper position. The well visualized oval shape of the foramen without disruption of its superior arch indicates the screw in place (Figure 6).

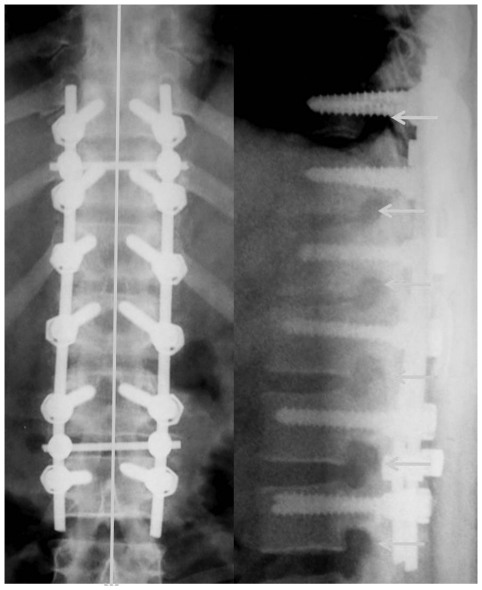

Fig 6. Post-operative plain x-rays are adequate to confirm the proper placement of the screws. In AP view the tip of the pedicle screws should remain lateral to midline. In lateral view the arch of the intervertebral foramen should be maintained. Thin cut CT-scan is the best way of confirming position of the pedicle screws.

Thin cut CT scan is the best way to evaluate the position of the pedicle screws (Figure 7), however, it is not mandatory.

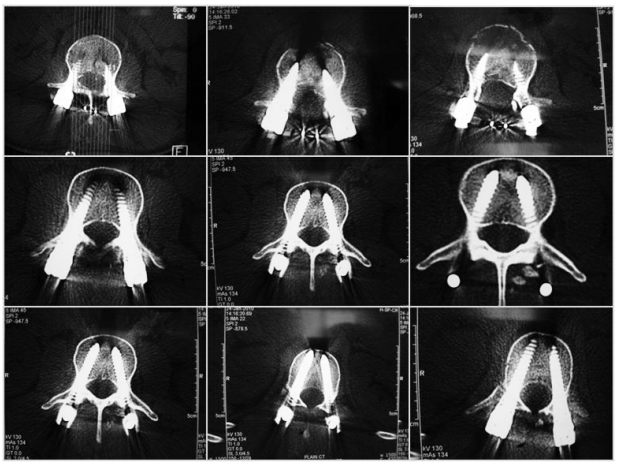

Fig 7. Post-operative plain x-rays are adequate to confirm the proper placement of the screws. In AP view the tip of the pedicle screws should remain lateral to midline. In lateral view the arch of the intervertebral foramen should be maintained. Thin cut CT-scan is the best way of confirming position of the pedicle screws.

RESULTS

The proper placement of the pedicle screws were evaluated on the basis of intra-operative tactile feeling, per-operative fluoroscopic visualization, post-operative plain radiographic criteria and post-operative clinical complaints.

Out of 424 pedicle screws, 4 (1 %) screws were misplaced (Figure 8, Chart 3). Three patients had complained of post-operative dysesthesias to specific dermatomes. Since there was no significant neurological weakness, all of them were managed symptomatically and all improved within 6 weeks of time.

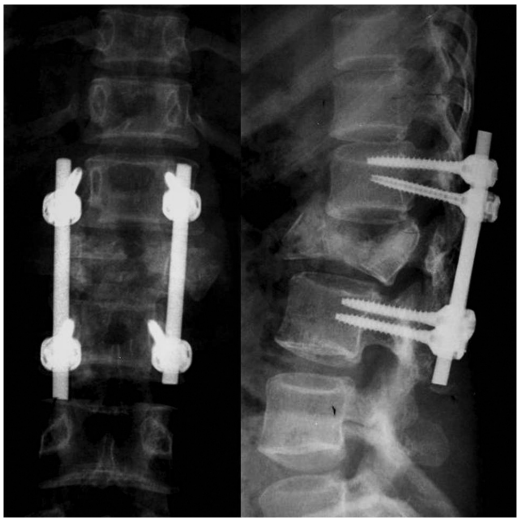

Fig 8. Misplaced pedicle screw. Please not the visible pedicle margin in AP view and obliterated arch of the intervertebral foramen.

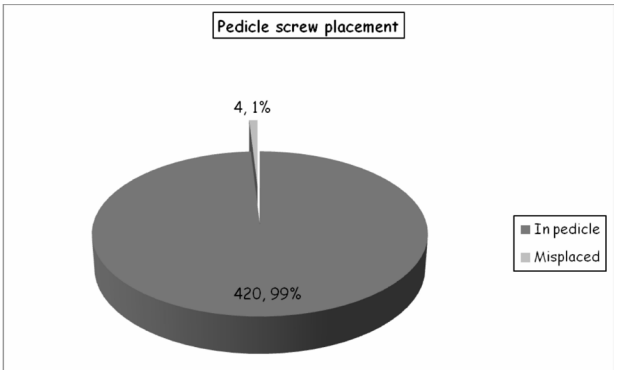

Chart 3: Showing number of misplaced screws.

At the last follow up of average 12.6 months 11 (2.5%) of the screws were broken (Figure 9). One of the patients with broken screw was complaining of pain and discomfort and thus the implants were removed. Asymptomatic broken screws were left alone.

We have not encountered deep infection in any of our patients. No patients had visceral or vascular injuries.

Till last follow up no patient had so far complained of pain attributable to instrumentation.

The time required for insertion of the pedicle screws ranged from 1 minute 38 seconds to 7 minutes 25 seconds depending upon the pedicle morphology. The average time taken for one pedicle screw insertion without fluoroscopic guidance was 4 minutes where as with fluoroscopic guidance was 7.5 minutes.

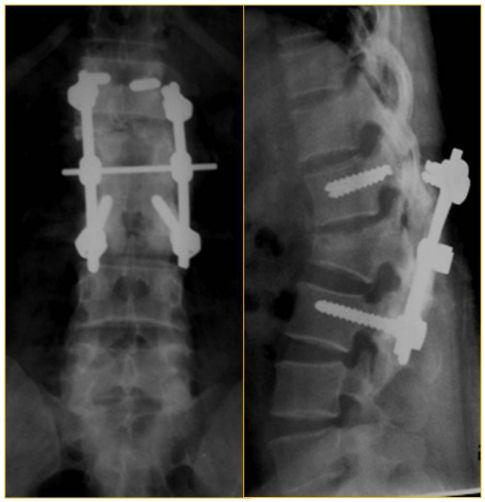

Figure 9: Broken pedicle screws.

DISCUSSION

Pedicle screw fixation for the spinal reconstructive procedure gives the excellent stability along with its ability to correct the deformity. Pedicle screw based construct has significantly improved the fusion rates.[22,23] In the places where the facilities are available and the patients are affordable sophisticated technologies can be used for accurate placement of the pedicle screws. For many centers in the world especially in developing countries like ours these sophisticated facilities may just be a luxury. In countries like ours where hospital facilities have to be customized according to the needs of the patients, the direct visualization of the pedicle and its insertion is the safest, cheapest and the most time effective technique. With the free hand technique pedicle screws can be inserted into any vertebra where pedicle can accommodate the screws, although we do not have experience of putting pedicle screws in the cervical spine.

Roy-Camille et al described the technique of inserting pedicle screw by drilling the isthmus of the pedicle.[12, 13] But the surgeons have found significant risk to neural injury with the technique and advocated blunt technique of identifying the pedicle.[12, 13]

We feel that it is much easier to put the pedicle screws with free hand technique in dorsal spine since the transverse process can be very easily followed up to the pedicle. The only criticism to this technique could be the lack of posterior cortical purchase but we do not think it

does matter since the screw is passing through the strong snugly fitting pedicle into the vertebral body. Although anterior cortical breach is the most common complication during insertion of the pedicle screws,[43] in osteoporotic bone, we always intentionally tend to purchase the anterior cortex of the vertebral body for better pull out strength and more stable fixation.[41] The anterior cortex can be perforated by gently tapping the vertebral body with the Steinmann pin. However, less common complications of injuries to lungs, azygous vein, thoracic duct, aorta, inferior vena cava and segmental artery, associated with anterior cortex perforation has been reported.[42] We have not so far encountered complications following anterior cortical perforation.

Proper judgment of the orientation of the pedicle screws is important. There are different parameters and anatomical variations described for orientation and diameter of the pedicle screws after exhaustive morphometric studies in human pedicles.[24, 25, 26] These studies can be a rough guideline but in practice the pedicle screw insertion has to be individualized. Direct visualization of the pedicle and soft hand drilling and revolving maneuver drives the pedicle probe along the path of the pedicle. The feel of the pedicle developed with the experience of putting screws drives the awl along the least resistant path.

In the deformed spine it has always been difficult for us to put pedicle screws. The thorough study of the vertebral anatomy and pedicle morphology is mandatory. Intra-operatively knowledge of orientation of the pedicle helps to reduce the risk of misplacement of the screws. Accurate placement of the screw is primarily assessed intra-operatively by sounding technique with the flexible ball tipped probe. The step ladder pattern of feel after tapping the pedicle usually confirms the accuracy of screw placement. This is the very useful and important tactile feeling for us. We always take a final look with the image intensifier. It is always advisable but with the experience gained in putting pedicle screws, the image intensifier is not always mandatory for us.

Use of biplane image intensification helps accurate placement of pedicle screws. However, the time taken for the surgery is as equally important as proper placement of the pedicle screws. Our average time taken for one pedicle screw insertion without image intensifier is 4 minutes whereas with image intensifier it is 7.5 minutes. Unless you have a good resolution image intensifier, even its use does not assure the accuracy of pedicle screw placement. Furthermore, sophisticated equipments like Computer based guidance does improve the placement of the screws but it has not proved to have improvement of quality of screw placement and rather it increases the operating time.[41]

Pre-operative evaluation and the study of the vertebral anatomy in plain radiographs and CT-scan of the spine give the clue about the diameter, length and orientation of the screw. The inner core diameter of the pedicle – the critical surgical dimension is measured in axial cuts of the CT scan.

Incidence of misplacement of pedicle screws varies from 0 to 2% and it significantly increases up to 25% if the spine is deformed.[27, 28, 29] In our study we have 4 out of 424 screws misplaced accounting to 1% of the total insertion. These misplaced screws were thought to be in place intra-operatively but seen breaching the pedicles in post-operative radiographs. These screws were not repositioned since they were not causing any symptoms. However, most misplaced screws do not create nerve root injury.[28, 30, 31]

Reported incidences of nerve root and cauda equine injuries vary from 1 to 11%.[32, 33] In our group of patients three patients (3.4%) had complained of severe post-operative dysesthesias specific to certain dermatome. We assume that nerve roots are irritated with the pedicle screws. They all were managed symptomatically and all recovered within 6 weeks of time. The most common reason for the nerve root irritation and injury is breaching of the medial and the inferior cortex of the pedicle.[43]

We have not so far come across dural injury and cerebrospinal Fluid (CSF) leakage following pedicle screw insertion. However, the risk of having dural injury is as high as 5%.[34, 35] The condition is difficult to diagnose unless the CSF leaks through the pedicle track. The patient may complain of post-operative headache and may develop CSF leakage.

Breakage of the screws is the most common complication after pedicle screw fixation. The reported incidence ranges from 2.6% to as high as 36%.[32, 36] We have 11 (2.5%) screws were broken. The screw breakage was observed between 9 and 12 months. High rates of screw breakage were reported when it is used in comminuted spinal

fractures with short segment fusion.[32, 37] In our cases also screws were broken after short segment instrumentation. Asymptomatic broken screws were left alone where as symptomatic screws were removed. We had to remove implants in one patient with burst fracture of L 1 vertebra since she was complaining of pain and discomfort. However, the part of the screws inside the pedicle and vertebral bodies were not removed. All the broken screws were made of stainless steel.

Deep infection rates have been reported to be between 1.1% to as high as 4.2%.[22, 36, 38] We have not so far come across this complication. However, prompt and thorough wound debridement along with administration of intravenous antibiotics has been routinely adopted for acceptable clinical outcome.[39]

Pain has been reported to be one of the complications in long term following pedicle screw instrumentation. However, it requires long time follow up to decided whether the pain is attributable to the pedicle screws or pseudoarthrosis.[43]

CONCLUSION

Direct visualization of the pedicles by funnel technique is safe and very effective technique. It is very cost effective and learning curve is steep. With the experience this technique is very time effective and it can be very safely inserted into any pedicles in the vertebrae. However, the technique does have complications if not executed properly.

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