Original Article

Free hand technique of cervical lateral mass screw fixation

ABSTRACT

Study Design: We introduce a simple free hand technique with great ease of application, without angles, measures or degrees, and without any fluoroscopic guidance. It is a safe and reproducible technique. We present our preliminary experience with the use this technique, with inimitable simplicity.

Purpose: The primary aim of the procedure was to achieve adequate screw trajectory in an apparent challenging ease which is reproducible with a good outcome.

Overview of Literature: Lateral mass screw fixation is used for posterior subaxial cervical fixation. It was described by Louis and Magerl, then by Anderson, An, and Ebraheim *et al*. Each one described the procedure with a unique screw entrance point and trajectory.

Technical Note: This study is a prospective case study of 45 patients who underwent subaxial cervical lateral mass screw fixation. The screws were inserted using a free hand method. The described free hand technique was found to minimize the morbidity associated with other techniques without compromising the quality of fixation.

Conclusions: Surgical experiences with this technique found it equally safe, rapid, easy, and reproducible.

Keywords: Cervical degenerative disease, free hand technique, instability, lateral mass screw fixation

INTRODUCTION

Posterior cervical fixation techniques are commonly selected procedures in the surgical management of subaxial cervical spine diseases. Various screw fixation techniques using the lateral mass screw, pedicle screw, and transarticular screw are being used. Lateral mass screw fixation became the standard method for posterior cervical spine fixation. It is especially optimum for cervical stability reconstruction following posterior cervical decompression. Unlike posterior wiring, lateral mass screws do not require the presence of the posterior elements. Now, lateral mass rods and screws are also optimal for use in degenerative spondylosis with abnormal curvatures because the rods could be contoured and the presence of polyaxial screws solves previous alignment problems. Moreover, it is now easily possible to extend fusion up to the occiput and down to the thoracic spine.[1,2]

Lateral mass screw fixation as an option for posterior subaxial cervical fixation was first introduced in 1964 and initially proposed in 1972 by Roy-Camille. Then, the procedure was further developed and described by Louis and Magerl, then by Anderson, An, and Ebraheim *et al*. Each one described the procedure with a unique screw entrance point and trajectory. The screw trajectories in most techniques are directed superiorly and laterally; except for the Roy-Camille and Louis techniques. The literature from that time on is full of articles stating that the technique is simple, safe, and effective. The need for intraoperative fluoroscopy is also eliminated.[3-8]

Lateral mass screw fixation became one of the most common procedures of posterior cervical fixation worldwide. Despite reported success, lateral mass screw fixation is not free of complications. Injury or violation of adjacent

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structures (vertebral artery [VA], facet joint, and/or nerve root) and lateral mass fracture are potential reported complications. The key risk factor of most, if not all, of those complications is the screw trajectory (direction, angle, and length) which is totally dependent on the operative technique of screw insertion. All described techniques may result in different complications, depending on the surgeon's perfection of the technique. All described techniques describe the screw direction and trajectory by angles, degrees, and directions which are practically impossible to be perfect and exact.[9-14]

We introduce a simple free hand technique with great ease of application, without angles, measures or degrees, and without any fluoroscopic guidance. It is a safe and reproducible technique. We present our preliminary experience with the use this technique, with inimitable simplicity. The primary aim of the procedure was to achieve adequate screw trajectory in an apparent challenging ease which is reproducible with a great outcome. In this study, the screw trajectory was evaluated on early postoperative computed tomography (CT) images. The purpose of this study was to describe a free hand technique of subaxial cervical lateral mass screw fixation with apparent challenging ease, focusing on the analysis of screw trajectory on early postoperative CT images.

TECHNICAL NOTE

Patients

This study is a prospective case study of 45 patients (30 males and 15 females) to describe a free hand technique of cervical lateral mass screw fixation (C3–C7). Those patients underwent the procedure at two centers, namely, Neurosurgery Department of Cairo University and Neurosurgery Department of Naser Institute Hospital of Ministry of Health, from 2010 to 2016. Screw placement and trajectory were assessed on early postoperative CT images, while clinical outcomes were assessed within 1 month after surgery. In total, 370 lateral mass screws were used and subject to analysis. The screws were inserted using the described free hand method. The average age at surgery was 50.4 years (range 35–72 years). The preoperative diagnoses were spondylostenosis (cervical canal stenosis with the loss of lordosis or focal kyphosis) in 15, cervical spondylotic myelopathy in 10, cervical chronic degenerative multi-level instability in 10, kyphosis in 6, ankylosing spondylitis in 3, and rheumatoid arthritis in 1. Vertex reconstruction system (Medtronic) was mainly used for fixation [Figure 1]. Traumatic cases with lateral mass comminution or deficiency were excluded from the study because it is a contraindication for lateral mass fixation.

Preoperatively all patients were subjected to clinical history, examination and routine laboratory investigations.

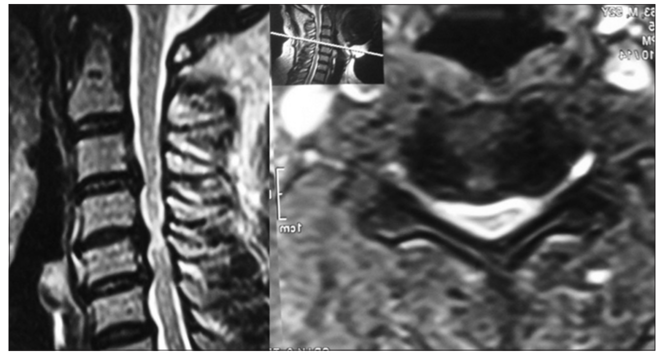

Figure 1: One of the preoperative images with degenerative multilevel cervical canal stenosis. Note the loss of cervical lordosis

Radiological assessment included plain X-rays (lateral, anteroposterior, flexion, and extension views), magnetic resonance imaging in all cases; and occasionally CT in some cases in which details of bony anatomy were needed. Decompressed levels, fixed levels, and number of screws were reported. An informed consent was obtained from each patient. Follow-up period was up to 12 months.

Loss of normal cervical lordosis [Figure 1] was an important finding and selection criterion in most of our nontraumatic patients. It has been our policy to perform posterior decompression laminectomy combined with fusion if normal cervical lordosis is lost, and in patients with severe spondylotic radiculopathy with segmental instability on dynamic films.

Description of the technique

Under general endotracheal intubation, the patient is placed in the prone position with the chest elevated about 15° to reduce venous bleeding. The neck of the patient and hence the cervical spine is maintained in the neutral position either using simple head rest or Mayfield pin skull fixation. A standard midline posterior approach is used. Subperiosteal muscle dissection is done and self-retaining retractors put in place. Lateral X-ray is done to confirm the level. The exposure is usually extended for at least one level below the inferior end of the targeted fusion to allow for easy screw placement. The spinous processes, the laminae and the lateral masses are fully exposed, extending to the lateral edges of the lateral mass and the facet joint at each fusion level [Figure 2].

Lateral dissection is stopped at the lateral border of the lateral mass to avoid unnecessary bleeding. In the presence of degenerative posterior facet osteophytes, those osteophytes should be removed to help the boundaries of the facets and to provide a surface for rotation of the polyaxial screw heads. The facet joints in-between fused levels are decorticated, leaving the facet joint above and below the instrumented levels intact.

Because we do not use fluoroscopy, attention to the patient's unique anatomy is very important. Identify the lateral mass itself first. The lateral mass is divided into four quadrants by drawing two imaginary cross lines with a monopolar diathermy, and center point is identified. The superolateral quadrant is considered the "safe quadrant".

According to our free hand technique, the entry point is 1 mm below and 1 mm medial to the midpoint of the lateral mass [Figure 3].

An awl (sharp trocar) or a high-speed drill used to decorticate the bone at the entry point and create the starting hole. The hole should be made perpendicular at first to preserve the posterior cortex of the lateral mass. Due to the relatively small size of the lateral mass and its cortical bone, any attempt to make it in the targeted upward and lateral direction from the start will end in violation of the superior cortex of the lateral mass. As in most cases, the cord is already compromised, no force is needed during the creation of entry holes to avoid unnecessary iatrogenic cord trauma. Care to be taken not to push downward to avoid cord injury in an already narrow canal.

After entering into the lateral mass, tapping is then directed toward upward and lateral ventral corner toward the so-called "safe quadrant", with no fluoroscopic guidance. The direction is not guided by mathematical angles or degrees. It is simply guided by two landmarks [Figures 3 and 4]:

1. Adopting facet joints' space as a reference to determine the craniocaudal angulation trajectory: insert the straight end of the McDonald dissector instrument or any other straight instrument into the facet joint space. This will dictate the upward and ventral angulation which is parallel to the superior facet joint endplate
2. Adopting the spinous process as a reference point to determine the lateral angulation trajectory: the screw trial instrument and the screw assembly are inclined medially to rest on the tip of the spinous process of the vertebra all through the screw advancement process. This inclination will dictate the needed lateral direction.

After a 3.5 mm tap is used, a probe is inserted before the screw to confirm that the lateral mass walls have not been violated. A depth gauge is inserted to measure the screw length, and the appropriate size screw is inserted the same way [Figure 5]. A 4 mm diameter polyaxial screw is inserted.

The usual length ranges from 12 to 18 mm. Rods of appropriate length were selected and bent to match the contour of the cervical spine, and secured to the screws by screw head nuts. Care is taken not to make the rods too long [Figure 6]. The rod should not come into contact of bony structures of adjacent levels otherwise is will be a source of pain and future erosion of adjacent bony structures. Before final tightening of the screw head nuts, each segment is compressed, distracted, or laterally rotated if needed. Wound closure is done in layers.

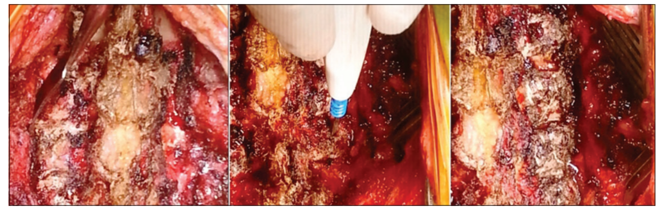

Figure 2: The spinous processes, the laminae and the lateral masses are fully exposed, extending to the lateral edges of the lateral mass and the facet joint at each fusion level. The boundaries of each lateral mass are identified

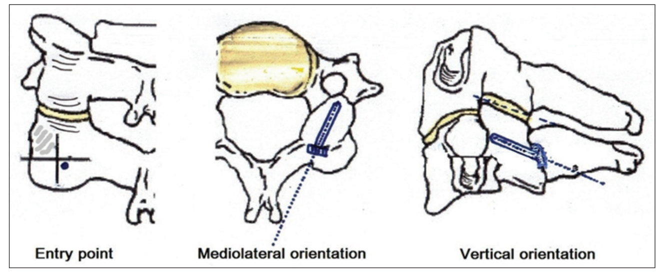

Figure 3: The entry point is 1 mm below and 1 mm medial to the midpoint of the lateral mass directed to the upper outer quadrant of the lateral mass. The facet joints' space is adopted as reference to determine the craniocaudal angulation trajectory, and the spinous process as a reference point to determine the lateral angulation trajectory

Figure 4: Operative picture is showing that the direction is not guided by mathematical angles or degrees. It is simply guided by two landmarks: The facet joints' space for craniocaudal orientation, and the spinous process for mediolateral orientation

In most cases, to preserve the normal anatomical landmarks, screw insertion is performed before posterior decompression procedures (laminectomy or laminoplasty). The presence of lamina also protects the dural canal during the preparation of entry holes. Foraminotomy was required in cases with brachialgia. Bone grafts from dissected spinous processes and lamina were placed into the facet joints after curettage of its joint surfaces, and also laterally on both sides of joints.

Computed tomography evaluation for screw trajectory

For all patients, CT thin cuts (slice thickness of 3 mm) with bone window and three-dimensional reconstruction were done within 2 weeks postoperatively. The screw trajectory angle was assessed. Screw trajectory was measured using goniometry ruler on the CT images.

Screw assessment

The location of the screw in relation to the edge of the root foramen and to the facet joint was assessed.

Results of the technique

In total of 45 patients (30 males and 15 females) underwent subaxial cervical lateral mass screw fixation (C3–C7), equal to 370 lateral mass screws used and were subject to analysis. The screws were inserted using the described free hand method. The average age at surgery was 50.4 years (range 35–72 years). The preoperative diagnoses were spondylostenosis (cervical canal stenosis with the loss of lordosis or focal kyphosis), cervical spondylotic myelopathy, cervical chronic degenerative multi-level instability, kyphosis, ankylosing spondylitis, and rheumatoid arthritis. Vertex reconstruction system (Medtronic) was mainly used for fixation.

Median surgical time was 65 ± 25 min and blood loss 120 ± 50 ml. None of the patients developed additional neurological deficits related to the instrumentation. A total of 370 screws were inserted. Three hundred fifty screws were placed completely within the lateral mass unit. Twenty screws penetrated the border of the lateral mass without neurological consequences for the patient [Figure 1]. No wound infections occurred. No further complications were detected during the reported follow-up period (6–12 months). Only two of the patients required revision surgery as a result of instrumentation failure in one case and redirection of the screw in another case. CT evaluation for screw length and trajectory [Figure 7].

A total of 370 lateral mass screws comprising 70 at C3, 120 at C4, 120 at C5, and 60 screws at C6 level. Only one screw was in direct contact with the root causing radicular pain that necessitates revision and reinsertion in the better trajectory.

The mean screw length at each level was 16.2 mm. There was no significant difference in screw length among the levels. The mean screw trajectory angles were within the acceptable range both on axial and sagittal planes in 358 of 370 screws.

Facet violation (FV) was identified for three screws [Figure 4]. No significant correlation between the occurrences of violation of the VA foramen and the FV was detected.

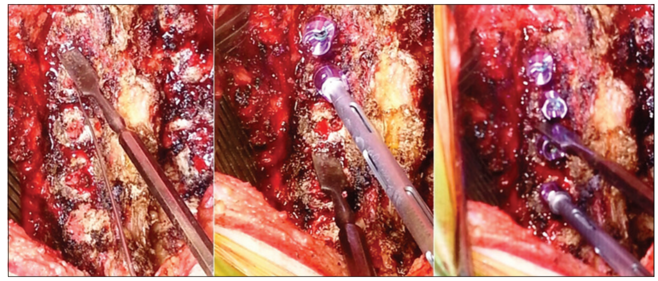

Figure 5: Operative picture showing that the direction of screw insertion by our technique

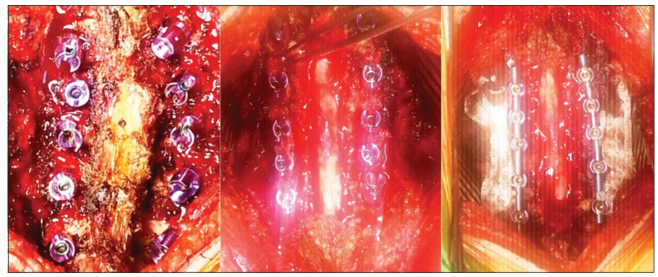

Figure 6: Operative picture is showing that the screws in place before decompression. The rods should not be too long, not to come into contact of bony structures of adjacent levels

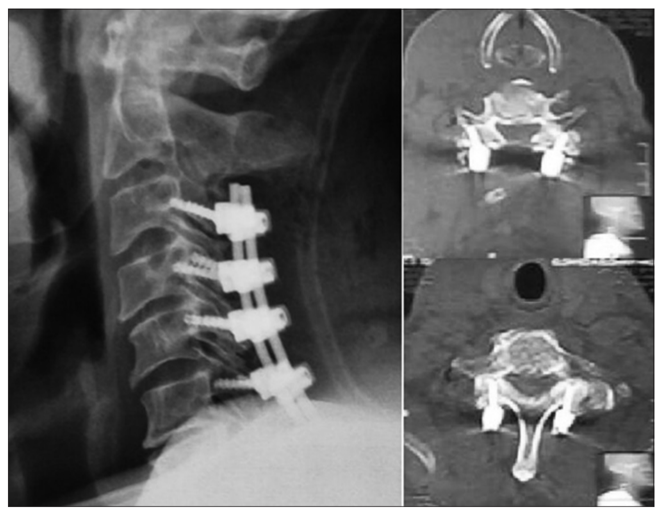

Figure 7: Postoperative X-ray and computed tomography images showing that the direction of screw insertion by our technique is good in the setting of the lateral mass without any radiological guidance

Intraoperative lateral mass fractures were identified in 4 of the 370 lateral masses. When this complication occurred, the screw was reinserted with a different trajectory angle in two lateral masses. In the remaining two cases, screw reinsertion was impossible, and the site was skipped for screwing. Therefore, the relationship between the occurrence of this complication and the screw trajectory was not analyzed in this group.

DISCUSSION

This study addresses the issues of “safety and efficacy” of our described free hand lateral mass screw insertion which have been described in detail. The results suggest that depending on the spinous processes and the facet joint space as guidelines to anatomical insertion of screws is easy, feasible, accurate, and safe.

When placing screws in such an easy anatomical guidance into the small area of the lateral mass, without any fluoroscopic guidance, screw malposition could be avoided.[9,15-18] Choosing the entry point, 1 mm medial and 1 mm inferior to the central point of the lateral mass, in the projection of the targeted trajectory, added to the safety and good trajectory results. That is why it is essential that the initial screw placement be as accurate as possible to be safe as needed. In this study, there were no injuries with screws, even when they inadvertently deviated from the planned trajectory. This free hand technique also plays a direct role in the safety of placing lateral mass screws.

Twenty screws were placed by the senior resident under supervision. The learning curve of this free hand technique is rapid and usually safe. In addition, without radiological exposure, the accurate and safe placement of these screws is significantly improved with small experience and rapid educational training in the technique. The procedure training is easily reproducible by fellows.

The lateral mass is rectangular‑shaped when viewed from behind (posteriorly). A vertical line can be drawn connecting the facet joints at the midline, and a horizontal line can be drawn dividing the lateral mass into equal upper and lower halves. The screw entry point for the Roy‑Camille’s technique is at the midpoint of the lateral mass (intersection of these lines). The Magerl’s starting point is 1 mm medial and 1 mm superior to the Roy‑Camille’s entry point. The trajectory is angled at 45–60° anterosuperiorly and 25° lateral to the sagittal plane. In Anderson technique, the entry point for screw insertion is located 1 mm medial to the midpoint of the lateral mass. The direction of the screw is 30–40° superiorly and 10° laterally. In a technique, the entry point for screw insertion is located 1 mm medial to the midpoint of the lateral mass. The direction of the screw is 15° superiorly and 30° laterally for C3–C6.[5-9] How could any one measure these angles accurately intraoperatively. With our free hand technique, we choose our entry point followed by no angles or degrees.

Revising the literature, we found that the Roy‑Camille screws were associated with less risk of nerve root injury, but more chance of facet joint violation. In contrast, the Magerl screws were associated with more risk of nerve root injury, but less chance of facet joint violation. In this study, we had no neurological or vascular injuries. It was interesting to note that the anatomic location of screw trajectory greatly lessens nerve root violation in contrast to all other different techniques.[5-9,19]

It should be mentioned that all screw placements in this study were performed by surgeons who are familiar with the cervical anatomy and lateral mass screw insertion techniques. Each step of screw placement was done as accurately as possible to avoid or minimize technical deviation.

CONCLUSIONS

This study indicates that lateral mass screw fixation without intraoperative fluoroscopic images can be performed without serious complications. The Medtronic posterior polyaxial cervical screw and rod system with its unique design together with our described free hand technique made the procedure so easy, rapid, and safe. In addition, it allows for lateral mass fixation from C3 to C7. We have successfully used this technique in 45 patients to achieve posterior cervical arthrodesis, with minimal complications.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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