ORIGINAL STUDY

Efficacy and Safety of Free-hand Technique in Posterior Cervical Lateral Mass Fixation: Radiological and Clinical Outcome in 42 Patients

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Abstract

Background data: **Posterior cervical lateral mass fixation is a widely used technique for the management of subaxial cervical spine diseases. Recently, the free-hand technique (FHT) was proposed as an effective, easy-to-operate, and safe technique.**

Purpose: **This study aims to evaluate the efficacy and safety of FHT posterior cervical lateral mass fixation.**

Study design: **A retrospective chart review study.**

Patients and methods: **The data of 27 males and 15 females with a mean age of 56.09 ± 8.78 years who were operated on at the Department of Neurosurgery, Alexandria University, between June 2019 and May 2021, using the FHT for posterior cervical lateral mass screw fixation were retrieved and reported. Outcome parameters include axial and sagittal screw angles, facet violation, and invasion of the vertebral foramen.**

Results: **A total of 326 lateral mass screws were used in 42 patients using FHT. The mean operative time, blood loss, and hospital stay were 60.26 ± 11.46 (range, 45−80) minutes, 124.76 ± 27.38 (range, 80−160) cc, and 6.28 ± 3.58 (range, 2−14) days, respectively. The mean axial and sagittal screw angles were 26 ± 6.4 (range, 23−31) degrees and 29.5 ± 5.3 (range, 27−35) degrees, respectively. The mean screw length was 14.66 ± 1.30 (range, 12−18) mm. Facet violation was reported in (7.6%) 25/326 screws, with radicular pain occurring in one case, which required redo surgery to redirect the screw. Invasion of the vertebral foramen was reported in (14.7%) 48/326 screws with no operative or postoperative sequela.**

Conclusion: **FHT posterior cervical lateral mass fixation is safe and effective with low incidence violation of facet joints, vertebral artery, and intervertebral foramen. Metacentric RCT studies are required to further evaluate the safety and efficacy.**

Keywords: Cervical fixations, Degenerative cervical myelopathy, Free-hand technique, Lateral mass screw

Introduction

Subaxial cervical spine disorders are usually treated surgically using posterior cervical fixation methods [1]. The pedicle screw and the lateral mass screw (LMS) are utilized in numerous screw fixation procedures [2−4]. The use of LMS for posterior cervical spine fixation became a standard technique. It is ideal for reestablishing cervical stability after a posterior cervical decompression procedure [5,6]. The use of contoured rods and polyaxial screws makes its use in degenerative spondylosis with irregular curvatures feasible [7,8]. Furthermore, fusion can be extended up to the occiput and down to the thoracic spine, making it easier than ever to treat a wide range of spinal disorders [9,10]. LMSs are known to be safer compared to pedicle screws [11,12], and many investigators have achieved excellent results utilizing the free-

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hand technique (FHT) without image guidance [13−15]. Posterior cervical fixation without the aid of anatomical landmarks of the lamina or spinous process (SP) and superior biomechanical stability to wiring techniques are among the advantages of LMS [16]. Complications, including damage or violation to the surrounding facet joint, nerve root, vertebral artery (VA), and spinal cord, may occur when the surgeon chooses the screw entry location and angle based on his/her experience [17]. FHT can be made safer and easier to conduct by utilizing the surrounding anatomical landmarks such as lamina and SP [3,18].

This study aims to evaluate the safety and efficacy of FHT LMS in subaxial spine disorders at our institution.

Patients and methods

The study was approved by the IRB committee of Alexandria University Hospital, Egypt. Written informed consent was waived by the IRB committee due to the retrospective nature of the study. The study's procedure complies with the Declaration of Helsinki principles. We followed the STROBE guidelines while drafting this manuscript [19].

In this retrospective study, all our institution's medical charts were reviewed for patients who were operated on using the FHT LMS fixation over three years (June 2019 to May 2021). All patients were operated on at the Neurosurgery Department of Alexandria University Hospitals, Egypt.

Inclusion criteria were patients of any age or sex with complete data and 12-month follow-up. Those suffering from radiographically proved degenerative cervical myelopathy (DCM) and did not respond to adequate conservative therapy, and those with cervical spine trauma were reported. Exclusion criteria were redo surgery, osteoporosis, neurodegenerative disorders, neoplasm, and general contraindication to surgery.

This study included 42 patients, including 27 males and 15 females, with a mean age of 56.09 ± 8.78 (range, 38−68) years. According to the mJOA score, 20 cases (47.6%) had mild myelopathy with a score range of 15−17, 15 cases (35.7%) had moderate myelopathy with a score range of 12−14, and only seven cases (16.6%) had severe myelopathy with a score range of 0−11.

All patients underwent routine preoperative preparation according to the institution's protocol, including radiological and laboratory assessment. The radiological assessment included plain X-rays cervical spine (AP, lateral, and dynamic views) and magnetic resonance imaging (MRI), while patients with suspected abnormalities of bone anatomy underwent multisliced computed tomography (MSCT).

Surgical technique

All patients underwent posterior cervical FHT LMS fixation under general anesthesia. With the patient in a prone position with an elevated chest and maintained neutral neck position, a posterior midline incision was performed, followed by subperiosteal dissection of muscles and placement of retractors to ensure. Exposure was at least one level below the targeted fusion segments. Exposure should ensure full visualization of the spinous processes and the lateral masses up to the lateral edge and the facet joints. Facet joints were gently decorticated to preserve facet joints intact. The boundaries of the lateral masses were identified by drawing two cross lines with mono-polar diathermy. This divided the lateral masses into four quadrants; the superiorlateral quadrant was chosen as the safest entry point.

We then identified the entry point of the FHT, which was 1 mm inferomedial to the midpoint of the lateral mass. A high-speed drill was employed to make an entry point hole perpendicular to the bone surface. The tapping was then directed toward the superior quadrant. A 3.5 mm tap was continued and was tested by a probe to ensure no violation of the lateral mass walls. Two 4 mm screws were then inserted at each level, and rods were inserted and secured to the screws by screw headsets. Additional decompression laminectomy and/or foraminotomy were indicated in case of lost cervical lordosis or spondylotic radiculopathy. The segment was compressed, and the screw headsets were subjected to final tightening. After meticulous hemostasis, a multilayer wound closure was conducted.

Postoperative care

All patients received routine postoperative care, including prophylactic antibiotics. Hard collars were used for all patients for three months. All patients were evaluated using three-dimensional multislice CT to assess the adequacy of screw purchase and screw location in relation to the root foramen, the facet joint edges, and the foramen of the VA.

Data collection and follow-up

All patients were analyzed for assessment of operative time, intraoperative blood loss, hospital stay, intraoperative VA injury, and intraoperative facet violations. All patients were clinically assessed postoperatively for manifestations of neurovascular injuries resulting from invasion of the vertebral foramen or facet violations with subsequent nerve root injury. Postoperative radiological evaluation was done using thin-cut bone window MSCT scans within two weeks after surgery. Outpatient clinic routine follow-up was reported at three-month, six-month, and one-year visits for all patients.

Statistical analysis

Data were analyzed using the SPSS V0.25 software for Windows. Data were statistically described in terms of mean ± standard deviation (SD), range, frequencies (number of cases), and percentages when appropriate.

Results

Overall, 55 patients' charts were retrieved from our hospital's medical records during this study period. Thirteen patients were excluded because of lack of complete data and/or follow-up period. In total, 42 patients who met our inclusion criteria were reported (Table 1). Twenty (47.6%) patients had cervical canal stenosis and reversed cervical lordosis, 18 (42.8%) patients had DCM with preserved cervical curves, and four (9.5%) patients had cervical spinal trauma.

The mean operative time was 60.26 ± 11.46 (range, 45–80) minutes. The mean blood loss was 124.76 ± 27.38 (range, 80–160) cc. The mean hospital stay was 6.28 ± 3.58 (range, 2–14) days.

Thirty-four patients have been operated on from C3 to C6, four patients from C3 to C7 (using C7 LMSs), one patient from C3 to C5, and three patients from C3 to C4. In four different patients, four out of total 330 lateral masses (1.2%) were damaged intraoperatively and thus escaped from fixation. In total, we inserted 326 screws in 42 patients (Table 2).

Postoperative radiological evaluation showed that the mean screw length was 14.66 ± 1.30 (range, 12–18) mm. The mean axial and sagittal screw's angles were 26 ± 6.4 (range, 23–31) degrees, and 29.5 ± 5.3 (range, 27–35) degrees, respectively. Overall, 25 LMS (7.6%) penetrated the lateral mass, causing facet violation (FV) with radicular pain occurring only in one case, which required redo surgery to redirect the screw. Invasion of the vertebral foramen was detected postoperatively in 48 LMS (14.7%) with no intraoperative massive bleeding or postoperative neurological deterioration. No other complications were detected during the 12-month follow-up period (Figs. 1 and 2).

Table 1. Summary of epidemiological data in study patients (n = 42).

Parameters	Results
Age/years	56.09 ± 8.78 (38–68)
Sex	
Males	27 (47.6%)
Females	15 (42.8%)
Pathological diagnosis	
Cervical canal stenosis/kyphosis	20 (47.6%)
Degenerative cervical myelopathy	18 (42.8%)
Cervical trauma	4 (9.5%)

Table 2. Summary of perioperative data in study patients (n = 42).

Parameters	Results
Operative time/minute	60.26 ± 11.46 (45–80)
Blood loss/ml	124.76 ± 27.38 (80–160)
Operated levels	
C3–C6	34 (80.9%)
C3–C7	4 (9.5%)
C3–C5	1 (2.3%)
C3–C4	3 (7.1%)
Total number of screw	326
Screw length/mm	14.66 ± 1.30 (12–18)
Axial angle/degree	26 ± 6.4 (23–31)
Sagittal angle/degree	29.5 ± 5.3 (27–35)
Facet violation	25 (7.6%)
Vertebral artery foramen invasion	48 (14.7%)
Hospital stay/day	6.28 ± 3.58 (2–14)

Discussion

This study discusses the safety and efficacy of FHT in LMS insertion. This FHT may be unfamiliar for many spine and neurosurgeons who prefer to depend on fluoroscopic guided technique while inserting cervical LMSs. It is well known that surgeons and patients are exposed to severe hazardous radiation exposure while doing cervical lateral mass fixation under fluoroscopic guidance. The most crucial step that guarantees the safety of this technique is accuracy while you are selecting your starting point. The learning curve seemed easier than expected. This can encourage other colleagues concerned with radiation risk to consider the FHT as an ordinary technique in lateral mass fixation. Our findings suggest that the application of FHT, depending on the normal anatomy landmarks of adjacent cervical spine structures in posterior cervical lateral mass fixation, is safe and feasible.

Our findings showed that the mean operative time was 60.26 ± 11.46 (range, 45–80) minutes. The mean blood loss was 124.76 ± 27.38 (range, 80–160) cc. The mean hospital stay was 6.28 ± 3.58 (range, 2–14) days. A total of 326 LMSs were inserted in 42 patients. FHT was associated with a low incidence (7.6%) of FV, with radicular pain occurring only in

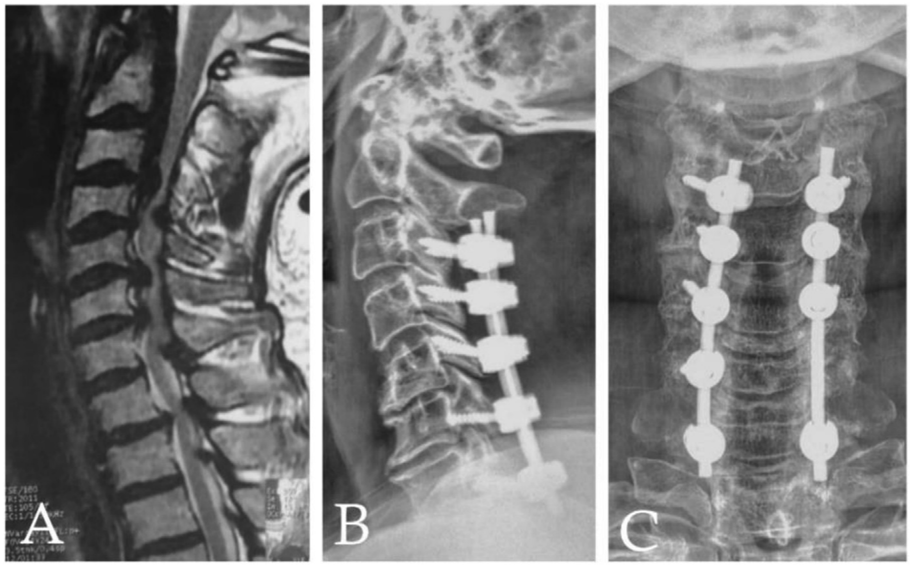

Fig. 1. (A) Preoperative MRI of a 66-year-old male patient presented with degenerative cervical myelopathy and operated for posterior cervical laminectomy and lateral mass fixation using free-hand technique; (B) postoperative plain X-ray showing facet violation at the level of C6; (C) AP view of X-ray showing the skipped level of fixation at the left lateral mass of C6, which has been fractured intraoperatively.

one case, which required redo surgery for redirection of the screw. Invasion of the vertebral foramen was detected postoperatively in 48 screws with no intraoperative massive bleeding or postoperative neurological deterioration. These findings suggest that the application of FHT in posterior cervical lateral mass fixation is safe and feasible.

It has been reported that LMS fixation can cause damage to the facet joints, nerve roots, and VA [20,21]. As a result, many surgeons now choose to

Fig. 2. (A) Preoperative MRI of a 58-year-male patient presented with cervical myelopathy due to cervical canal stenosis with lost cervical lordosis; (B) well-inserted lateral mass screws using free-hand technique with no violation of the vertebral artery or its foramen.

utilize a C-arm to ensure the safe placement of screws during surgery. In addition, patients and surgeons are concerned about radiation risk [22]. Therefore, many investigators recommended the FHT for this group of patients [23,24]. Although it has been performed in many studies, the safety is still debatable. The FHT was shown to have low accuracy even among specialists when utilizing the normal insertion angles; the authors advocated using the lamina and surrounding constructions as a reference point [25]. Screws should be placed parallel to the ipsilateral lamina, according to Bayley E et al.'s examination of CT images [26]. To determine the lateral trajectory angle, Cho et al. [3] suggested leaning to SP with the cranial trajectory angle parallel to the same level SP. Promising findings were reported by Roche S et al. [15], utilizing the sagittal angle parallel to the SP without establishing any lateral angle. Thus, findings of FHT based on the surrounding structures vary widely from study to study.

Similar to these findings, Kim et al. [16] prospectively evaluated the safety outcomes of FHT in 178 patients who underwent LMS fixation. They highlighted that FHT was associated with a low risk of injury of foramen transversarium (FT) and a low risk of FV. It's possible that the divergent angle might be narrow enough to violate the FT. At C6, FT violations were most prevalent. At C3, facets were most often violated as the authors did not expose C3 lateral mass sufficiently. The increased risk for injury of FT in C6 was believed to be due to the preservation of C7 lamina and SP in most cases. Using the Roy-Camille or Magerl approach, Ebrahim et al. [27] reported that the angle of angulation required to prevent VA damage must be at least 15° lateral.

Likewise, in the Ra et al. [28] study, the facet was violated by eight screws (6.0%), and the mean sagittal angle was substantially less than that in the group without FVs. C6 had the highest average difference in the angle between the actual joint surface and the screw ($P = 0.0472$). Therefore, they suggested that further studies should focus on the increased risks of this technique at C6.

A comparison of LMSs and cervical pedicle screws was carried out by Yoshihara et al. [22], and they reported that cervical pedicle screw fixation resulted in a higher rate of VA lesions. They also concluded that the FHT should only be utilized by surgeons who are experienced with the anatomy of the cervical spine or who have performed numerous procedures on cadavers in a cadaver lab. FV in our study was higher than that reported in the study of Ra et al. [28], who reported a 6% incidence, and lower than FV reported in the study by Kim et al. [16], who reported a 9% incidence.

A screw inserted parallel to the SP would likely elevate the risk of FV due to the irregular angle at the facet joint surface. A substantial association was found between this FV and the low sagittal plane angle described in the investigation by Inoue S et al. [14].

Feng et al. [17] conducted a clinical study that compared the safety and efficacy of FHT and 3-Dimensional printing templates guiding patients with cervical LMS fixation. All patients experienced modified posterior surgery (C4–C6) with cervical LMSs. Blood loss and operative time were comparable in both groups. On the other hand, three-dimensional templates were more effective in terms of the acceptability of screws based on Bayard's criteria. Coe et al. [3] conducted a meta-analysis of the safety of FHT in LMS fixation on 20 studies. They reported that the risks of complications, such as nerve root injury, were low (1%), and the fusion rate was high (97%). In addition, there were no cases of VA injury in 758 patients.

We acknowledge that this study has some limitations, including the small sample size and the single-center setting of this study, which may hinder the generalizability of the data. In addition, we did not evaluate the difference between the safety profile at C3 and C6. Subgroup analysis was not available due to the lack of sufficient data.

Conclusion

FHT in posterior cervical lateral mass fixation is safe and effective with a low incidence of violation of facet joints, VA, and intervertebral foramen. Further multicentric studies are required to evaluate the difference between using FHT at C3 and C6 in terms of safety and efficacy.

Ethics Information

The article does not contain information about medical device(s)/drug(s).

Conflicts of interest

The authors report no conflicts of interest.

Author declaration of funding statement

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Abbreviations

DCM	Degenerative cervical myelopathy
FHT	Free-hand technique

FT Foramen transversarium
FV Facet violation
LMS Lateral mass screwm
JOA Modified Japanese orthopedic association score
SP Spinous process
VA Vertebral artery.

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