Evaluation of lateral mass fixation of the cervical spine

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Background
Many techniques for cervical stabilization have been evaluated in the management of cervical disorders. Anterior fixation generally has a limited role and is used for anterior column disorders or in addition to posterior fixation in certain situations; however, several complications have been associated with this technique. Posterior fixation and fusion may be the approach of choice in cases that require multilevel decompression, particularly if extension to upper cervical, occiput, or upper thoracic is required.

Patients and methods
A prospective study of 200 lateral mass screws which have been placed in 25 (eight women and 17 men) patients aged 20–76 years. All cases were performed with a polyaxial screw–rod system. Harms technique was used in the upper cervical spine, and Magerl technique in the subaxial spine. Screw location was assessed by intraoperative fluoroscopy and was confirmed postoperatively using plain radiograph and computed tomography (in some cases).

Results
No patients experienced iatrogenic neural or vascular injury. Four patients experienced superficial wound infection. Three patients had pain around the shoulder of C5 distribution which subsided over time. No patients developed screw pullouts or symptomatic adjacent segment disease within the period of follow-up. The mean follow-up period was 1.5 years.

Conclusion
Posterior cervical fixation with a screw–rod system is a safe and efficient method of treatment that can be used for a variety of cervical spine pathologies.

Keywords:
cervical vertebrae, lateral mass screw, Magerl technique, Roy-Camille technique

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Introduction

In current attempts to attain posterior fixation of the middle and lower cervical spine, posterior cervical lateral mass screw fixation has been widely used. For example, cervical instabilities due to trauma, degenerative diseases, infections, or tumors are indications for cervical fixation [1–3]. Lateral mass screw fixation has advantages over standard posterior wiring techniques; it can be done easily for many levels on patients with laminectomy and it can preserve biomechanical forces [4,5]. The screw–rod system is superior to the plating system; screw–rod systems are easily to contour; screw position is not constrained by the plate's entry holes; screw back-out is difficult to occur; and screw–rod systems are easily adapted for extension to the occiput or thoracic spine [6,7]. Ever since Roy-Camille first introduced posterior cervical lateral mass screw fixation in 1972, numerous authors developed and modified it. Anderson, and An were representatives of these authors [1,8–11]. The Harms technique of stabilizing C1–C2 by fixation with polyaxial screws is another attractive option since the risk of vertebral artery injury is lower and posterior reduction and fixation of C1 and C2 can be achieved.

This study evaluates the outcome and complications of posterior lateral mass cervical fixation with the screw–rod system in 25 cases treated for variable cervical spine pathologies that included degenerative disease, neoplastic disease, and trauma.

Patients and methods

Using a prospectively acquired database, data were obtained from 25 (17 men and eight women, aged from 20 to 76 years with a mean age of 51.96 years) patients from March 2011 to April 2014. The duration of symptoms ranged from 1 week to 2 years with a mean duration of 11.9 months. The cases underwent posterior lateral mass cervical fixation and fusion using a polyaxial screw–rod implant system. All patients were evaluated clinically and radiologically preoperatively. Neck disability scale and Nurick's myelopathy grade were used for assessments in this series.

Surgical technique

In this procedure under general anesthesia, the patients were placed in a prone position using a Mayfield skull clamp and the alignment of the cervical spine was verified using a C-arm fluoroscope. A skin incision was made through the midline to expose the outer edge of the lateral mass to the extent of the area of fixation after periosteal dissection.

In subaxial cervical spine from C3 to C7, the entry point is 1–2 mm superior and medially to the midpoint of the posterior surface of the rectangular lateral mass. The technique described by Magerl [9] with 20°–25° lateral and cranial angulations parallel to the joint line of the adjacent facet was used to avoid injury to the vertebral artery and spinal nerve root.

In C1 according to Harms technique [12,13], the C1–C2 joint is exposed and opened by dissection over the superior surface of the C2 pars interarticularis. This joint is a key anatomic landmark for accurate placement of the C1 lateral mass screw. The dorsal root ganglion of C2 is retracted in a caudal direction to expose the entry point for the C1 screw, which is in the middle of the junction of the C1 posterior arch and the midpoint of the posterior inferior part of the C1 lateral mass. This entry point is marked with a 1–2-mm high-speed drill to prevent slippage of the drill point. The pilot hole is then drilled in a straight or slightly convergent trajectory in an anterior–posterior direction and parallel to the plane of the C1 posterior arch in the sagittal direction, with the tip of the drill directed toward the anterior arch of C1, the hole is tapped, and a 3.5 mm polyaxial screw of an appropriate length is inserted.

The usual screws used measure 3.5 mm width and 18–30 mm in length. In C2 pedicles screw fixation according to Harms technique [12], the entry point is 5 mm superior and lateral to the medial aspect of the C2–C3 facet joint. The screw trajectory was 15°–25° medial and 20° cephalic. We typically used 4 mm wide and 18–30 mm long screws for the C2 pedicles.

For pedicle screw placement at C7 (used in one patient) the entry point is 1 mm below the center of the facet joint and followed a trajectory 25°–30° medial while maintaining a perpendicular angle in the sagittal plane. In two patients the level of fixation reaches the T1 vertebra, a drill bit of 3.2 mm was used to make a hole at the point at the superior border of the transverse process, a 3 mm lateral to the middle of the inferior facet and drilling was directed about 25° anteromedially and 10° caudally.

In patients who need decompression laminectomy we do this after putting the screws and rods to avoid injury to the spinal cord.

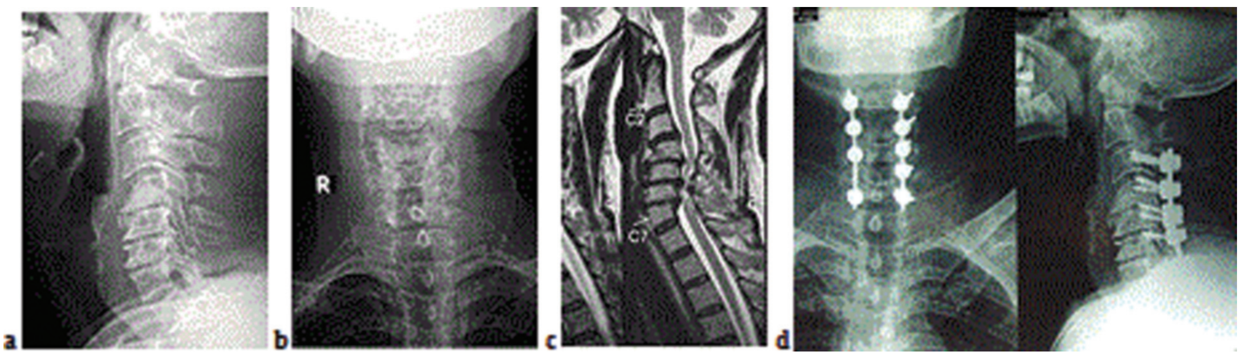
Intraoperatively fluoroscopy was used, chips of autograft bone were placed over the decorticated lateral masses and into the appropriate facet joints after its decortication. Postoperatively, all patients were placed into a hard neck collar and plain radiograph was done on the second postoperative day.

Results

The majority of patients were men (17 men and eight women), with a mean age of 52 years (ranged from 20 to 76 years). Different pathologies were included in this study; symptomatic degenerative cervical spine disease (cervical spondylosis) were 16 cases (Figs 1 and 2), neoplastic were three cases [two cases of thyroid metastases (Figs 3–5) and one case of chordoma] and traumatic were six cases (one case of C4 fracture, two cases of C5 fracture, and three cases of C6 fracture; Table 1).

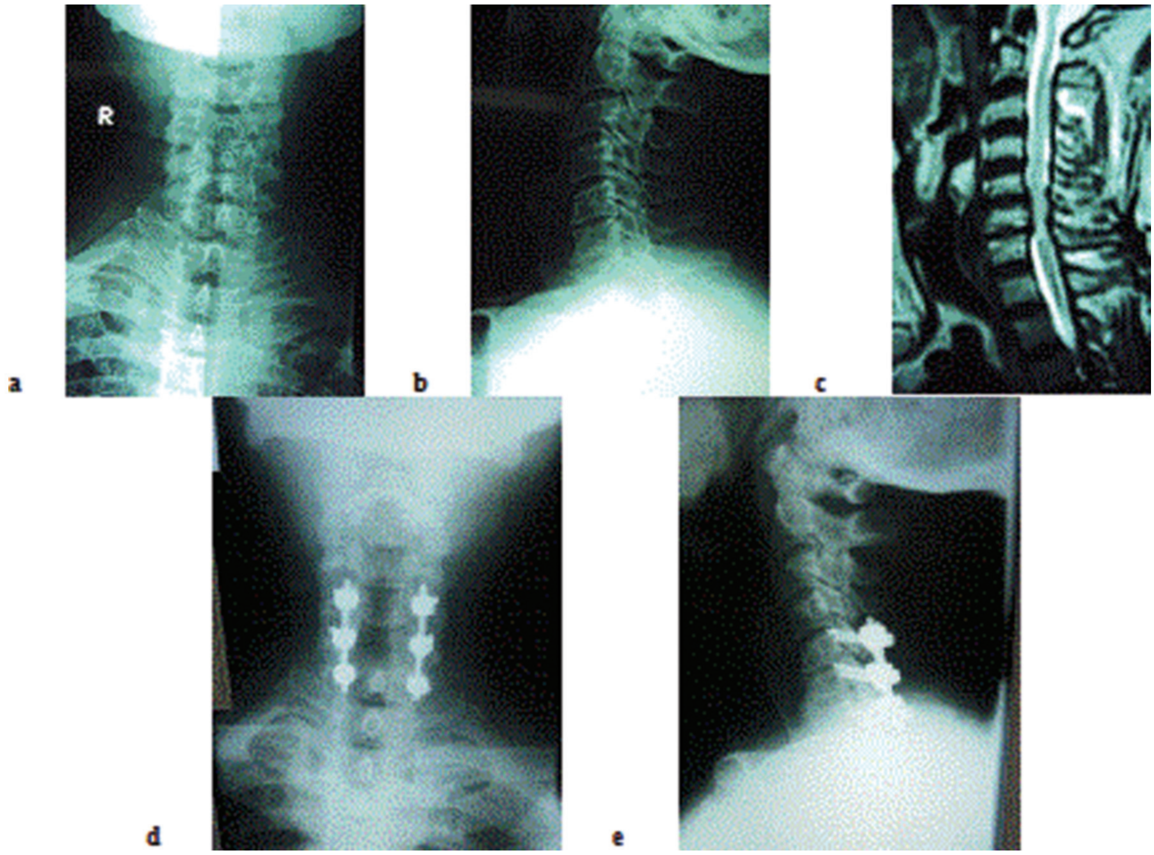
Preoperatively, brachialgia was the most common presenting symptom occurring in 25 patients

Figure 1



(a, b) Preoperative radiograph, (c) MRI of a cervical spondylotic myelopathy patient with three-level stenosis, (d) postoperative radiograph.

Figure 2



(a, b) Preoperative radiograph, (c) MRI of a cervical spondylotic myelopathy patient with two-level stenosis, (d, e) postoperative 2-year follow-up radiograph.

followed by heaviness in lower limbs in 19 patients (Table 2). Motor deficits involving both upper and lower limbs in 14 patients and unilateral upper limb deficits were detected in only two patients (Table 3).

Patient disabilities were classified according to the neck disability index (Table 4) and Nurick's grading system (Table 5).

There was no case of vertebral artery injury, nerve root damage, or cerebrospinal fluid (CSF) leakage. Two cases of lateral mass breakout in patients with osteoporotic bone were recorded that required bypass of this level.

Postoperative clinical assessment

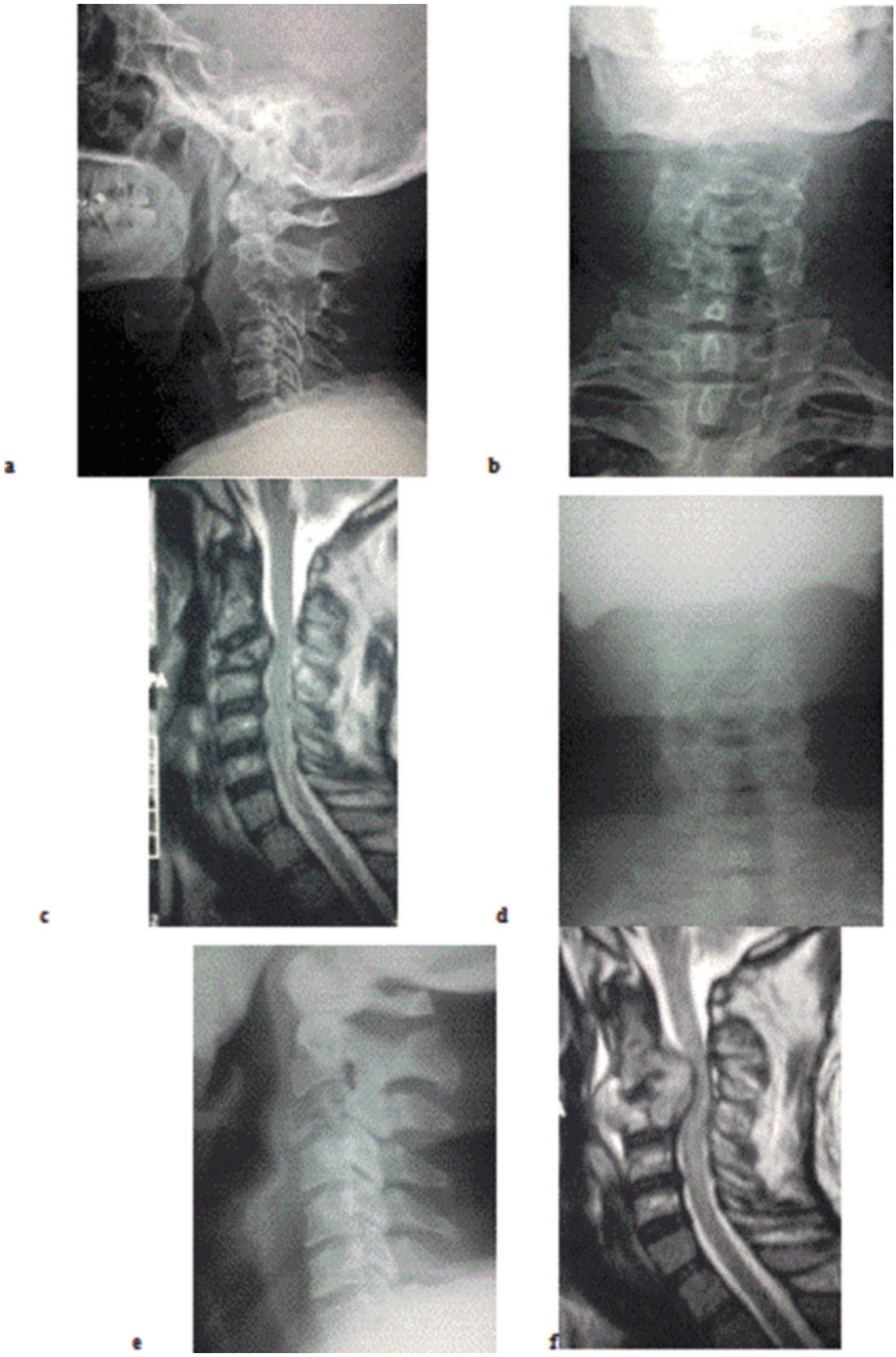
Analysis of Neck Disability Index (NDI) scores showed preoperative scores mean of 34.44±7.86 points, whereas at final follow-up, scores mean of 13.52±9.69 points (significant difference $P<0.003$). There is improvement in Nurick's grading of disability, the postoperative relief of brachialgia was achieved in 84% patients, and only 86.6% of those having neck pain improved and the remaining patients were the same, numbness improved in 85.7%, and gait heaviness improved in 84.2% and sphincteric manifestation improved only in 37.5% of patients; no patient showed deterioration in postoperative symptoms (Tables 6–8); three patients had pain around the shoulder of C5 distribution that subsided over time with a satisfactory postoperative computed tomography (CT) scan showing no violation by screws of the C4–C5 neural foramen. There were four cases with superficial infection but no deep infection was encountered. No patient experienced screw or rod pullouts. During our period of follow-up (minimum 6 months ≤ 2 years), all patients were stable in flexion–extension films.

According to the results showed in Tables 9 and 10, the age of patients and the duration of symptoms greatly affected the final outcomes.

Discussion

Over the last 15 years, lateral mass fixation had become the procedure of choice, especially when the posterior elements are deficient. This technique involves the use of screws and rod system, which are attached to the lateral masses of the subaxial cervical spine and the pedicle of C2, using polyaxial screws [14,15].

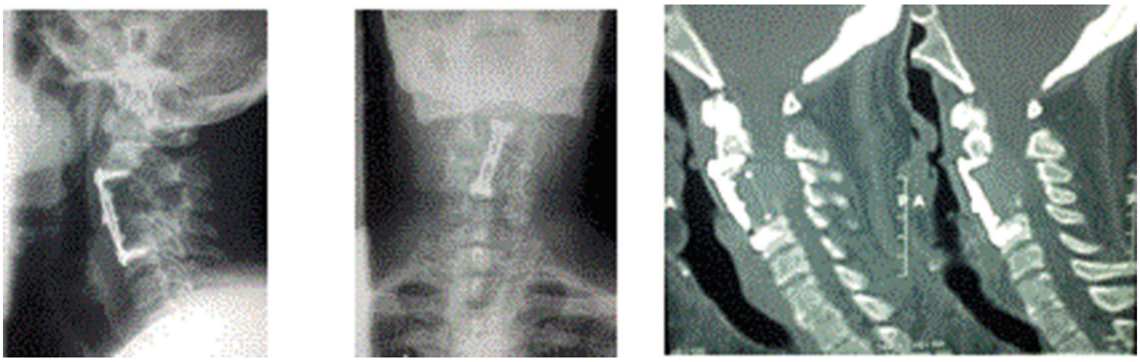
Figure 3



(a, b) Thyroid metastases; radiograph (c) MRI for early complaint (d–f); 2 years after initial complaint.

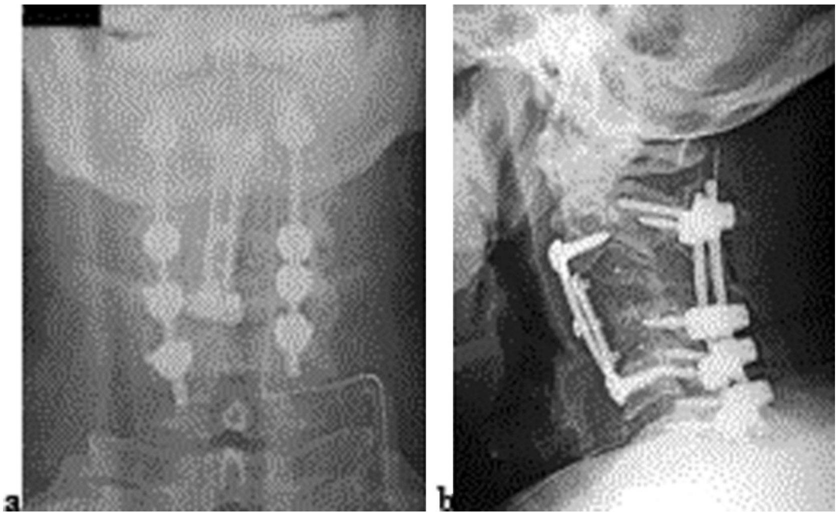
In comparison with other fixation techniques such as cervical pedicle screws, lateral mass fixation is safer, has higher success rate, and low comorbidities. In early studies, the failure rate was high in patients who underwent screw–plate constructs compared with the newer polyaxial screw–rod systems. The former systems were semiconstricted with no cross-link, which augment the stability of the system. In general, the newer polyaxial screw–rod systems are more constrained and essentially avoid screw pullout [16–18].

Figure 4



Radiograph and computed tomography after anterior corpectomy and fixation.

Figure 5



(a) Postoperative radiograph for laminectomy, (b) posterior fixation after 45 days of anterior surgery.

Table 1 Different cervical pathology and its levels

Cause	Degenerative 16 cases							Traumatic six cases			Neoplastic three cases		
Level	C3–C6	C4–C6	C3–C7	C5–C7	C2–C4	C3–C4	C2–C6	C4	C5	C6	C6–T1	C2–C5	C2–C6
n (%)	6 (24)	3 (12)	2 (8)	2 (8)	1 (4)	1 (4)	1 (4)	1 (4)	2 (8)	3 (12)	1 (4)	1 (4)	1 (4)

Table 2 Presenting symptoms in 25 patients

Symptoms	Heaviness in LL	Neck pain	Limitation of neck movement	Numbness	Brachialgia	Sphincters disturbance
n (%)	19 (76)	15 (60)	7 (28)	14 (56)	25 (100)	8 (32)

LL, lower limb.

Table 3 Clinical signs in 25 patients

Signs	UL weakness	UL and LL weakness	Independent ambulation	Hyperreflexia	Babnski sign	Hoffmann reflex	Ankle clonus
n (%)	2 (8)	14 (56)	20 (80)	18 (72)	12 (48)	12 (48)	5 (20)

LL, lower limb; UL, upper limb.

Table 4 Preoperative neck disability score

Raw score	0–4	5–14	15–24	25–34	35–50
Level of disability	No disability	Mild disability	Moderate disability	Sever disability	Completely disabled
n (%)	0	7 (28)	12 (48)	6 (24)	0

Many screw entry points and directions have been described since this technique was first introduced. Roy-Camille *et al.* [19] advocated the entry point of the screw is the midpoint of the lateral mass and the direction of the screw is to be perpendicular to the posterior aspect of the cervical spine and 10° outwards. While Magerl [9] proposed that the starting point is 2–3 mm medial and superior to the midpoint of the lateral mass and angling 30° superiorly and 25° laterally. Anderson *et al.* [1] recommended that the drilling point is 1 mm medial to the midpoint of the lateral mass and that the screw be angled at 30°–40° up and 10° lateral. An *et al.* [8] suggested angling 15°–18° superiorly and 30°–33° laterally, with a starting point of 1 mm medial to the center of the lateral mass. Pait *et al.* [3] divided the lateral mass into four quadrants with the upper outer quadrant being the intention for screw insertion; in this way, it is highly likely to evade neurovascular injury.

Our results agreed with the study conducted by Kim *et al.* [20] in which 39 patients underwent posterior cervical lateral mass screw fixation; there were 32 male and seven female patients with ages ranging from 27 to 79 years with a mean age of 54.26 years. In Al Barbarawi *et al.* [21] which was a retrospective review of 110 patients their ages ranged from 16 to 68 years (40 women and 70 men). The male predominance attributed to the fact that men have a higher incidence in degenerative cervical spondylosis and are more at risk for trauma. The extremes of young age and short duration of symptoms is due to traumatic cases. Concerning the age and outcome relationship in the study done by Naderi *et al.* [22], there was no relation between age and surgical outcome. In the study by Epstein [23], it was found that the cutoff age at the time of operation is 72 years; age above this is considered one of the bad prognostic factors. And we agreed with this, an increase in age is a bad prognostic factor, both clinically and radiologically. The duration of symptoms in our cases ranged from 1 week to 2 years with a mean duration of 11.9 months. In the study published in May 2008 by Fehlings *et al.* [24] it was concluded that there is no correlation between duration of symptoms and the surgical

Table 5 Nurick's grading of disability in myelopathy

Grade	Description	*n* (%)
Grade 0	Root symptoms No evidence of cord affection	6 (24)
Grade 1	Symptom(s) of cord affection Normal gait	0
Grade 2	Mild gait impairment Employable	11 (44)
Grade 3	Gait abnormality prevents employment	3 (12)
Grade 4	Ambulatory only with assistance	5 (20)
Grade 5	Chair or bed ridden	0

Table 8 Preoperative and postoperative Nurick's myelopathy grade

Grade	Preoperative [*n* (%)]	Postoperative [*n* (%)]
Grade 0	6 (24)	1 (4)
Grade 1	0	8 (32)
Grade 2	11 (44)	5 (20)
Grade 3	3 (12)	3 (12)
Grade 4	5 (20)	3 (12)
Grade 5	0	0

Table 9 The age improvement relation

Age (years)	<60	>60
Number of patients	17	8
Nurick's grade postoperative [*n* (%)]	13 (76.5)	4 (50)
Neck disability index postoperative *n* (%)	14 (82.3)	2 (25)
Preoperative (mean±SD)	26.4±8.80	22.6±5.4
Postoperative (mean±SD)	12.11±10.47	17±7.78

Table 6 Improvement in postoperative symptoms

Symptoms	Heaviness in LL	Neck pain	Limitation of neck movement	Numbness	Brachialgia	Sphincter disturbance
N	19	15	7	14	25	8
Improved	16 (84.2)	13 (86.6)	7 (100)	12 (85.7)	21 (84)	3 (37.5)
Worsened	–	–	–	–	–	–
No change	3 (15.8)	2 (13.4)	–	2 (14.3)	4(16)	5 (62.5)

LL, lower limb.

Table 7 Preoperative and postoperative neck disability score

Raw score	0–4	5–14	15–24	25–34	35–50
Level of disability	No disability	Mild disability	Moderate disability	Severe disability	Completely disabled
Preoperative (*N*)	0	7	12	6	0
Postoperative (*N*)	7	6	8	4	0
Preoperative (%)	0	28	48	24	0
Postoperative (%)	28	24	32	16	0

Table 10 Duration improvement relation

Duration	From 1 week to 12 months	From 13 to 24 months
Number of patients	13	12
Nurick's grade postoperative [*n* (%)]	10 (76.9)	6 (50)
Neck disability index postoperative		
n (%)	11 (84.6)	3 (25)
Preoperative (mean±SD)	23.3±9.7	22.75±5.23
Postoperative (mean±SD)	10.8±20.9	16.75±8.54

outcome. But in our study, we found that the duration of symptoms affect negatively the outcome in cervical spondylotic myelopathy. In this study, the main pathology was cervical myelopathy due to cervical canal stenosis reflecting the increase in the incidence of degenerative cervical spondylosis in our country due to the nature of heavy work.

Al Barbarawi *et al.* [21] and Kim *et al.* [20] agreed with us that there is no active bleeding as a result of vertebral artery injury as was noted in any case intraoperatively. There was no nerve root injury due to screws after lateral mass screw fixation for subaxial cervical spine. Postoperatively, there was no clinical evidence of vertebral artery injury as all patients were observed for local neck hematomas, vertebrobasilar stroke and for any further neurological deterioration. In Califianeller *et al.* [25] using the Harms technique in C1–C2 fixation by the polyaxial screw–rod system he found that the risk of vertebral artery and spinal cord injury is minimized. Integrity of C1 or C2 posterior elements is not necessary for a stable fixation, there is no need for postoperative Halo vest immobilization, and intraoperative bleeding from the venous plexus is profuse.

We did not observe any spinal cord, vertebral artery, or C2 nerve root injuries. There was a lot of bleeding from the vertebral venous plexus that prolongs the surgery.

In this study, postoperative relief of brachialgia was achieved in 84% patients, and only 86.6% of those having neck pain improved and the remaining patients were the same. Numbness improved in 85.7% and gait heaviness improved in 84.2% and sphincteric manifestation improved only in 37.5% of patients; no patient showed deterioration in postoperative symptoms. So our results agreed with the study conducted by Houten and Cooper [26] which did laminectomy from C3 to C7 with immediate stabilization with lateral mass fixation for spondylotic degenerative cervical disease. Numbness improved in 91% and the remaining patients were the same as the preoperative; gait heaviness improved in 93% and remains the same in the rest of patients; sphincteric manifestation improved in only 57%.

In the study conducted by Al Barbarawi *et al.* [21] 15 patients of total 110 cases experienced a persistent C5 palsy with a satisfactory postoperative CT scan showing no violation by screws of the C4–C5 neural foramen except in one female patient who required revision and her symptoms improved after revision. There were six cases with superficial infection but no deep infection was encountered. Only one case had CSF leak from the wound that was treated successfully with reinforcement sutures and lumbar drain for 3 days. No patients developed screw pullouts or symptomatic adjacent segment disease within the period of follow-up. Comparable to our study we found three cases of postoperative C5 nerve palsy and with further investigation by CT cervical spine there was no screw encroachment in the C4–C5 neural foramen. Three cases respond to medical treatment and four cases with superficial infection and the wound improved within 3 weeks postoperatively without the need of any debridement.Two cases in our series have lateral mass fracture during surgery and we bypass this level at one side. There is no record for deep wound infection or CSF leak. Kim *et al.* [27] showed one case of dural tearing and two cases of screw-induced lateral mass fracture during surgery.

We agreed with Al Barbarawi *et al.* [21] and Kim *et al.* [27] based on dynamic radiographs, no pseudarthrosis was noted and no symptomatic adjacent segment angulations have been revealed to date.

The risk of postoperative radiculopathy was not eliminated, and the incidence of this complication was 1.5% per screw placed. Iatrogenic foraminal stenosis effect was possibly a contributing factor. It can be difficult to determine radiographically whether a fusion is solid or not. All patients in this series were thought to be stable, based on the absence of motion on lateral flexion–extension radiographs and an absence of hardware breakage or migration, coupled with maintenance of alignment up to 2 years (with minimum 6 months) follow-up.

In the series of Kim *et al*. [20] bone fusion was achieved in all cases that undertook lateral mass screw fixation of the posterior cervical vertebrae. There were no cases with screws pulled out or broken, while Wu *et al*. [18]

found that good bony fusion was observed in all patients except in one (99.1%). The mean follow-up period was 14 months (4–35 months). Follow-up radiologic examinations found that the screw placements were well positioned.

None of our patients showed any deterioration of their achieved functional grade after a 6-month follow-up which confirms the importance of cervical fixation using lateral mass fixation in resolving the dynamic compressive factors, whose role as the main etiology for the progressive neurological deterioration in long-term follow-up of patients with cervical spondylotic myelopathy, whose preoperative assessment showed straightened or unstable curve. There was no increased morbidity due to added instrumentation.

It is obvious that posterior cervical fixation will prevent the development of kyphotic deformity in patients who had straight alignment preoperatively. Besides that the lateral mass screws were placed, and the rod or the plate was contoured before the laminectomy was performed. This sequence maximizes protection of the spinal cord throughout the majority of the instrumentation and fusion portion of the procedure. Bicortical fixation is not mandatory, and with the use of 14-mm screws, this minimizes the likelihood of postoperative radiculopathy owing to screw compression.

Conclusion

Lateral mass fixation by using Magerl's trajectory is a safe and reliable surgical technique for posterior stabilization and proper for a wide range of cervical pathologies. With a long-term follow-up satisfactory results can be achieved. Neurovascular complication is usually low and is avoidable when using this trajectory.

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Conflicts of interest

Declaration of Conflicting Interests The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

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