Roy-Camille Technique for Traumatic Instability of the Lower Cervical Spine

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Abstract

This study is a retrospective review of the charts and radiographs of sixty-seven patients treated with posterior lateral mass plating and iliac crest bone grafting in the cervical spine with the Roy-Camille technique.

The goal of the study is to determine the safety and efficacy of the Roy-Camille technique for screw placement in the cervical spine. All patients went on to develop a solid fusion. Sixty-one patients out of 67 (91.0%) with incomplete cord injuries improved at least one Frankel grade. Complications consisted of 3/67 wound infections, 1/67 deep wound infection and 2/67 superficial wound infection; neither requiring hardware removal. One patient with osteoporosis developed a loose screw. There were no patients with neurologic compromise or vascular injury related to the Roy-Camille technique. This study supports the Roy-Camille technique as being a safe and effective method of acquiring posterior cervical fusion.

INTRODUCTION

Posterior plate-screw fixation with or without supplemental bone grafting is being employed for treating an unstable cervical spine caused by various disorders since Roy-Camille first introduced screws into the lateral masses of the cervical spine to stabilize the unstable spine in 1964 [1,2,3,4,5,6,7,8,9,10]. The major advantage of posterior plating using lateral mass screws is that it provides equal or greater biomechanica1 stability than anterior plating or traditional interspinous wiring technique [11,12,13,14].

It is particularly useful for patients who have had extensive, multiple-level laminectomies because the screw placement involves only the lateral masses. It is also very useful in patients whose spinous processes, laminae, and facets are injured or deficient. The most frequently used indication for posterior lateral mass fixation is acute traumatic instability of the cervical spine, including significant bony or ligamentous injuries. Chronic instability with or without neurologic deficits secondary to unrecognized ligamentous injuries or significant degenerative diseases such as spondylosis could be stabilized with lateral mass plate fixation. Correction of kyphotic deformity of the cervical spine caused by multiple laminectomies has been successfully maintained by lateral mass plate-screw construct following anterior discectomies and strut bone grafting. Posterior lateral mass plating is effective for reconstruction of the cervical spine following bony tumor resection as it provides rigid stabilization. Posterior plating with bone grafting may also be used for patients who have had a failed anterior cervical fusion or a nonunion. The purpose of this retrospective study is to assess the safety, effectiveness, and complications of the Roy-Camille technique in the management of traumatic instability of the lower cervical spine.

SUBJECTS AND METHODS

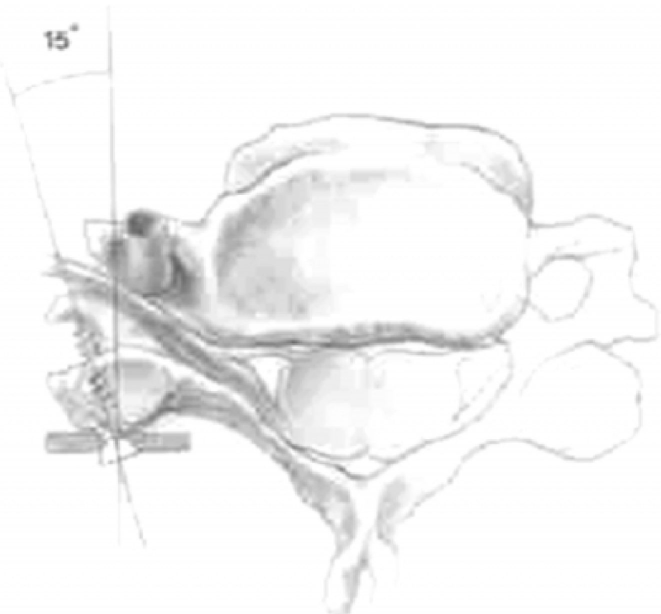
Sixty-seven patients (44 males and 23 females between ages 18 and 80 years) sustaining a traumatic cervical spine injury were treated using posterior lateral mass plating and iliac bone grafting. The surgical indications in this series included ligamentous or bony instability of the lower cervical spine. Pre-operative halo traction was used to reduce the malalignment. The Roy-Camille technique was used for all the patients.

The procedure was performed prone with SSEP monitoring under general anesthesia. A midline vertical incision was made and all of the soft tissues dissected from the spinous processes and lamina in order to expose the entire posterior aspect of the lateral mass. Exposure was limited to the desired fusion levels; the facet joint capsules and interspinous ligaments above and below the fusion site were preserved.

The spine alignment and appropriate level were identified anatomically. The attention was then turned to lateral mass screw placement. The midpoint of the lateral mass was identified and pierced with an awl. This point was drilled free hand with a 2-mm drill bit perpendicular to the posterior vertebral plane and 10-15° lateral to the sagittal plane (Fig. 1).

Figure 1

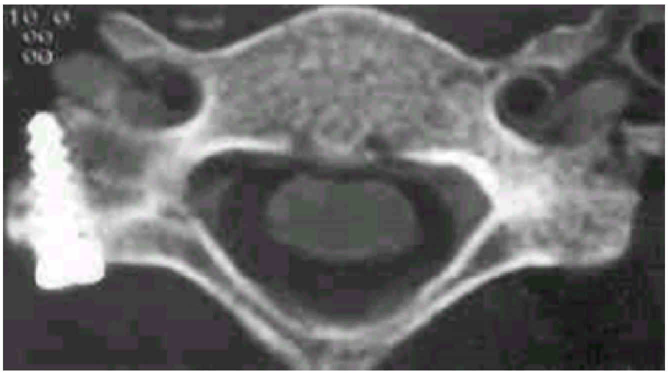
Figure 1: Illustration of Roy-Camille screw placement in relation to the nerve root and the vertebral artery.



The drill hole was further tapped with a 3.5mm tap, and its depth was measured with a calibrated depth gauge. Two contoured Roy-Camille cervical plates of appropriate length were placed and cortical screws of 3.5mm diameter and from 14 to 16mm length were inserted bi-cortical. During the procedure, fluoroscopic lateral and oblique projections were routinely used to assess the position of screws. Finally, the posterior elements adjacent to the plates were decorticated and the autogenous bone grafts from the posterior iliac crest were added. None of the included patients required decompression. Patients were placed in a hard cervical collar for six to twelve weeks postoperatively. Routine follow-up was scheduled at two weeks, three months, six months, and nine months after surgery. At each clinic visit, a detailed neurologic examination was performed and plain radiographs including anteroposterior and flexion-extension lateral radiographs were obtained and evaluated.

Figure 2

Figure 2: CT scan of the cervical vertebra with the lateral mass screw. The direction of the screw is 15 degrees laterally.



All the surgical procedures were performed by one surgeon. Data was compiled from patient files and follow-up notes by independent observers to eliminate operator and observer biases. The radiographs were re-evaluated by an independent radiologist and orthopaedic fellow and then results were compared with earlier (retrospective) radiology reports for confirmation.

RESULTS

A total of 328 screws were placed into the lateral masses of the cervical spine in 67 patients using Roy-Camille technique. The mean follow-up was 27.8 months ranging from 13 to 75 months. More than 85% enrolled patients had at least 22 months of follow-up. All patients maintained or improved their neurological status. Sixty-one patients (90.4%) with incomplete spinal cord injuries had an improvement of at least one Frankel grade. We had a 100% fusion rate, at an average of 22.13 weeks (range 16.0 to 28.2 weeks). A solid fusion was determined by lateral radiographs, which showed formation of bone or trabeculae across the facet joints. None of the patients required supplemental anterior or posterior surgery.

Screw loosening was noted in one patient with osteoporosis, however the fusion was solid. Three patients developed wound infections following surgery, one superficial, and two deep. Both were managed with antibiotics and without the removal of plates and screws; their symptoms resolved completely without adverse sequel.

DISCUSSION

Injury to the cervical spinal nerve associated with lateral mass screw insertion is a more common complication than spinal cord or vertebral artery injury. The reported incidence of spinal nerve injury with lateral mass screw insertion varies greatly between individuals. Levine and Roy-Camille [18] noted that 6 out of 24 patients developed radicular symptoms following posterior lateral mass screw fixation. Heller et al [15] reviewed 78 consecutive patients who underwent posterior lateral mass plating and reported an incidence of 0.6% for nerve injury. Graham et al [16] recently reported a higher incidence (14%) of nerve root injury associated with lateral mass screw fixation in 21 patients.

Nerve root compromise has been attributed to placement of excessively long screws. In the current series, 328 screws utilizing Roy-Camille technique were safely placed into the lateral masses of the cervical spine in 67 patients without any neurologic complications.

In addition to correct determination of the anatomic landmarks, screw orientation, and screw length, we felt that the lateral and oblique projections obtained with intraoperative fluoroscopy were very helpful in determining screw placement. If any screw is seen directed towards intervertebral foramen on oblique views and the patient has signs or symptoms of nerve compression or injury then removal of that screw must be considered as soon as possible. Adherence to the operative technique has been found to be the best method for avoiding nerve injury.

Plate-screw failure has been described by other authors including Anderson et al [1] who identified single screw loosening in three patients with no consequences. Fehlings and Cooper [4] reported screw loosening in 5 patients and screw pull-out in 3 of their 44 patients. Wellman et al [10] described one patient in his series of 43 patients with plate-screw failure which he attributed to an undiagnosed, unstable, adjacent level. Heller et al [15] reported an incidence of 0.3% for screw breakage, 0.2% for screw pull-out, and 1.1 % for screw loosening. Screw loosening in our series was observed in one patient with severely osteoporotic bone. Our fusion rate is higher than that of Heller et al [15], Cooper et al [2], Fehlings et al [4], and Wellman et al [10]; but similar to that of Nazarian and Louis [7], Jeanneret and Magerl [5], Anderson et al [1], and Graham et al [16]. The current and previous clinical investigation indicates that a higher fusion rate can be achieved by use of posterior plate-screw fixation.

TECHNICAL CONSIDERATIONS

Several techniques of lateral mass screw insertion have been proposed by Roy-Camille, Louis, Magerl, Anderson and An [1, 5, 7, 9, 17]. Each has its unique screw entrance point and trajectory. Roy-Camille [9] advocated that the screw entrance point is located at the center of the lateral mass, and the orientation of screw is perpendicular to the posterior vertebral plane and 10° lateral to the sagittal plane. Louis recommended [7] that the starting point for screw insertion be situated at the intersection of a vertical line 5 mm medial to the lateral margin of the inferior facet and a horizontal line 3 mm below the inferior margin of the inferior facet. The screw is directed strictly parallel to both sagittal and axial planes of the vertebra.

Magerl[5] favored that the entrance point for screw insertion is slightly medial and cranial to the posterior midpoint of the lateral mass, and the orientation of the screw is 20°-30° laterally and parallel to the adjacent facet. Anderson et al [1] modified Magerl's technique and changed the lateral angle of the screw to 10°. They also recommended that screw hole tapping be limited to the dorsal cortex to achieve sound bicortical bony purchase. Bicortical screw insertion has been shown to be resulted in better outcome of patients than unicortical screws [27]. However, few biomechanical studies have not shown significant difference between bicortical and unicortical screw insertion [28, 29, 30]. In our experience, the risk of vertebral artery or nerve injury is minimal if the technique is thoroughly followed.

An et al suggested that the screw orientation is approximately 30° lateral and 15° cephalad, starting at 1mm medial to the center of the lateral mass for C3-C6 [17]. We favor the use of Roy-Camille technique for posterior lateral mass screw insertion since it is easy to perform and biomechanically sound [9]. We feel that the Roy-Camille screws have less risk of spinal nerve compromise when compared to the Magerl screws. The length of screws is critical while using Roy-Camille technique. Ebraheim et al [25] reported that additional attention should be paid to the screw orientation for the Megeral technique and to the screw length for Roy-Camille technique. The safe screw length was found to be 14-15 mm for Roy-Camille technique as the mean screw path length in Roy-Camille technique decreased consistently from C3 (15.7 +/- 1.7mm) to C7 (11.3 +/- 0.8mm) [26]. However, the exact measurements may vary in individual patients. Anatomically, the exiting point for a Roy-Camille screw is situated posterior to the posterior ridge of the transverse process and close to the junction between the transverse process and lateral mass. A Roy-Camille's screw with bicortical purchase is away from the cervical nerve and separated from the nerve by the posterior ridge of the transverse process. Therefore, the chance of nerve root injury would be rare if the Roy Camille screws are correctly inserted into the lateral masses.

RADIOLOGICAL CONSIDERATIONS

Intraoperative fluoroscopy is a commonly used radiological modality in assisting lateral mass screw placement. The lateral projection of fluoroscopy may be the most convenient view to direct each screw insertion or evaluate the screw position after screw placement. This projection displays the facet joints and the posterior borders of the vertebral bodies. Facet joint violation, a possible complication in wrongly directed screws or in difficult cases with degenerative changes may occur. The lateral view of radiographs may help in diagnosis of this iatrogenic injury. However, the anterior portion of the lateral mass is not visible in this view because it is superimposed on the posterior border of the vertebral body. Screw trajectory in the sagittal plane and its relation to the facet joint can be assessed clearly in the lateral fluoroscopy. Recently, the value of the lateral fluoroscopy in determining the Roy-Camille screw length has been evaluated. Ebraheim et al [19] found that most of the screw tips placed in the ventral cortex of the lateral mass were located in the posterior one fourth of the vertebral body just anterior to the posterior border of the vertebral body. The exit point for the Roy-Camille screw is located just lateral to the origin of the transverse process, which projects anterior to the posterior border of the vertebral body on the sagittal plane. Ebraheim et al [21, 24] suggested that the screw length might be proper and safer if the tip of a Roy Camille screw is located just anterior to the posterior border of the vertebral body as seen on the lateral radiograph.

The oblique projection of fluoroscopy is also valuable in evaluating the relationship of lateral mass screw to the intervertebral foramen after screw placement. The oblique view of the cervical spine best demonstrates the shape and size of the intervertebral foramen, the surrounding pedicles, the posterolateral comer of the vertebral body, and the anterolateral aspect of the lateral mass. The oblique radiograph could detect an excessively long screw that invades the intervertebral foramen. The line connecting the posterior borders of the intervertebral foramina may be considered a useful landmark for surgeons to determine whether or not a screw is too 1ong [22]. If the tip of a screw crosses this line, the screw has most likely over-penetrated. Because the exiting cervical spinal nerve occupies the lower portion of the intervertebral foramen and courses laterally and inferiorly, the spinal nerve may be at high risk of injury if the tip of a screw is seen in the lower portion of the intervertebral foramen or is superimposed on the upper portion of the pedicle on the oblique radiograph [20, 23].

In contrast, the spinal nerve may be not compromised if the tip of a screw is seen in the top of the intervertebral foramen. In this case, replacement of the screw in an asymptomatic patient is unnecessary.

Computed tomographic scans (CT) has been recommended as a useful radiologic means for preoperative evaluation of the dimensions of the lateral masses of the cervical spine and postoperative evaluation of lateral mass screw position. The screw orientation in the transverse plane and the screw length can be clearly appreciated in axial CT scans.

However, it is difficult to determine if an over-penetrated screw compromises the spinal nerve or not [24]. A reconstructed image in the sagittal or oblique sagittal plane may delineate the relationship of the over-penetrated screw to the spinal nerve.

In summary, the current study indicates that posterior lateral mass plate-screw fixation using the Roy-Camille technique is a safe procedure for traumatic instability of the lower cervical spine with a higher fusion rate and no neurological complications. To achieve a satisfactory outcome, a solid anatomic and radiologic knowledge of the lateral mass and adjacent vital structures and meticulous surgical technique are required.

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References

1. Anderson P A, Henley MB, Grady MS, et al. Posterior cervical arthrodesis with AO reconstruction plates and bone graft. Spine. 1991; 16:S72- 79.
2. Cooper PR, Cohen AF, Rosiello A, et al. Posterior stabilization of cervical spine fractures and subluxation using plates and screws. J Neurosurg. 1988; 23:300-306.
3. Ebraheim NA, An HS, Jackson WT, et al. Internal fixation of the unstable cervical spine using posterior Roy-Camille plates: a preliminary report. J Orthop Trauma. 1989; 3 :23-28.
4. Fehlings MG, Cooper PR, Errico TJ. Posterior plates in the management of cervical instability: long-term results in 44 patients. J Neurosurg. 1994; 81 :341-349.
5. Jeanneret B, Magerl F, Ward EH, et al. Posterior stabilization of the cervical spine with hook plates. Spine. 1991; 16:S56-S63.
6. Levine AM, Maze1 C, Roy-Camille R. Management of fracture separations of the articular mass using posterior cervical plating. Spine. 1992; 17:S447-S454.

7. Nazarian SM, Louis RP. Posterior internal fixation with screw plates in traumatic lesions of the cervical spine. Spine. 1991; 16:S64-S71.
8. Roy-Camille R, Saillant G, Lavile C, et al. Treatment of lower cervical spinal injuries C3 to C7. Spine. 1992; 17:S442-S446.
9. Roy-Camille R, Saillant G, Mazel C. Internal fixation of the unstable cervical spine by a posterior osteosynthesis with plate and screw. In: Sherk HM, ed. The Cervical Spine. Philadelphia, PA: Lippincott; 1989: 390-403.
10. Sutterlin CE, McAfee PC, Warden KE, et al. A biomechanical evaluation of cervical spinal stabilization methods in a bovine model. Spine. 1988; 13:795-802.
11. Coe JD, Warden KE, Sutterlin CE, et al. Biomechanical evaluation of cervical spine stabilization methods in a human cadaveric model. Spine. 1989; 14: 1122-1131.
12. Gill K, Paschal S, Corin J, et al. Posterior plating of the cervical spine: a biomechanical comparison of different posterior fusion techniques. Spine. 1988;13:813816.
13. Kotani Y, Cunningham RW, Abumi K, et al. Biomechanical analysis of cervical stabilization systems. Spine. 1994; 19:2529-2539.
14. Smith ME, Cibischino M, Langrana NA, et al. A biomechanical study of a cervical spine stabilization device: Roy-Camille plates. Spine. 1997; 22:38-43.
15. Heller JG, Silcox H, Sutterlin CE. Complications of posterior cervical plating. Spine. 1995; 20:2442-2448.
16. Graham AW, Swank ML, Kinard RE, et al. Posterior cervical arthrodesis and stabilization with a la_eral mass plate: Clinical and computed tomographic evaluation of lateral mass screw placement and associated complications. Spine. 1996; 21:323-329.
17. An H, Gordin R, Renner K. Anatomic considerations for plate-screw fixation of the cervical spine. Spine. 1991; 16:8548-551.
18. Ebraheim NA, Xu R, Challgren E, et al. Quantitative anatomy of the cervical facet and the posterior projection of its inferior facet. J Spinal Disorders. 1997; 10:308-316.
19. Ebraheim NA, Tremains MR, Xu R, et al. Lateral radiologic evaluation of lateral mass screw placement in the cervical spine. Spine. 1998; 23(4): 458-62.
20. Ebraheim NA, Haman SH, Xu R, et al. The anatomic location of the dorsal ramus of the cervical nerve and its relation to the superior articular process of the lateral mass. Spine. 1998; 23(18): 1968-71.
21. Ebraheim NA, Xu R, Yeasting RA. The location of the vertebral artery foramen and its relationship to posterior lateral mass screw fixation. Spine. 1996; 21: 1291-1295.
22. Wellman BJ, Follett KA, Traynelis VC. Complications of posterior articular mass plate fixation of the subaxial cervical spine in 43 consecutive patients. Spine. 1998; 23:193-200.
23. Xu R, Robke J, Ebraheim NA, et al. Evaluation of cervical posterior lateral mass screw placement by oblique radiographs. Spine. 1996; 21 :696-701.
24. Ebraheim NA, Xu R, Challgren E. Radiologic evaluation of the relation of the screw tip to the nerve root in the intervertebral foramen. J Spinal Disorders. 1997; 10:234-239.
25. Ebraheim NA, Xu R, Stanescu S, Yeasting RA. Anatomic relationship of the cervical nerves to the lateral masses. Am J Orthop. 1999 Jan;28(1):39-42.
26. Ebraheim NA, Klausner T, Xu R, Yeasting RA. Safe lateral-mass screw lengths in the Roy-Camille and Magerl techniques. An anatomic study. Spine. 1998 Aug 15;23(16):1739-42.
27. Ebraheim NA, Rupp RE, Savolaine ER, Brown JA. Posterior plating of the cervical spine. J Spinal Disord. 1995 Apr;8(2):111-5.
28. Muffoletto AJ, Yang J, Vadhva M, Hadjipavlou AG. Cervical stability with lateral mass plating: unicortical versus bicortical screw purchase. Spine. 2003 Apr 15;28(8):778-81.
29. Papagelopoulos PJ, Currier BL, Neale PG, Hokari Y, Berglund LJ, Larson DR, Fisher DR, An KN. Biomechanical evaluation of posterior screw fixation in cadaveric cervical spines. Clin Orthop Relat Res. 2003 Jun;(411):13-24.
30. Seybold EA, Baker JA, Criscitiello AA, Ordway NR, Park CK, Connolly PJ. Characteristics of unicortical and bicortical lateral mass screws in the cervical spine. Spine. 1999 Nov 15;24(22):2397-403.

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