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TECHNICAL NOTE

C1-C2 Posterior Cervical Fixation by a Harms Technique Modification

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ABSTRACT

Introduction: The unique anatomy of the upper cervical spine in conjunction with its supportive role in the axial stabilization and rotatory function of the head increases the surgical risk and associated complications for corrective surgeries performed in this spinal region. C1-C2 posterior fixation is indicated in the occurrence of instability at the craniocervical junction; and it can be performed by specific surgical techniques, such as the Harms and Magerl techniques. In this technical note, the authors present a simplified modification of the Harms technique that increases the accuracy of screw placement in the lateral mass of the C1 vertebra and in the pedicle of the C2 vertebra. This modification provides a secure path for screw placement by obtaining fluoroscopic images of K-wires inserted in the lateral masses of C1 and the pedicles of C2 as in the original technique. According to this technique, a pin driver is used to guide a K-wire through the initially marked entry point to the lateral mass of C1. After fluoroscopic confirmation of the optimal position of the guide wire, a cannulated hand drill is placed over the guidewire. A pilot hole is drilled in the same trajectory for the screw placement under fluoroscopic control. Then the guidewire and the hand drill are removed and an appropriately sized 3.5 mm polyaxial screw is placed with a hand drill under confirmation of the correct position with anteroposterior and lateral fluoroscopy. The same procedure is followed for the placement of the C2 pedicle screws. Then, a small rod is placed and secured within the polyaxial screw heads of the C1 and C2 screws bilaterally. Decortication of the spinous processes of the involved vertebrae and the occiput is the final step before closure of the fascia, cervical muscle layer, subcutaneous tissue, and skin.

Keywords: Atlantoaxial posterior fixation, C1 lateral mass, C2 pedicle screws, Harms technique.

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INTRODUCTION

Atlantoaxial posterior fixation has always been a great challenge for spine surgeons because of the unique and important anatomical structures of the upper cervical spine. The vertebral artery's third segment, as well as the presence of other elements, such as the venous cervical plexus, cervical nerve roots, the atlantooccipital membrane, and the dura in addition to the risk of failure related to the fixation makes every surgical manipulation critical for an optimal radiographic and clinical outcome.[1-6] Indications for C1-C2 posterior fixation include instability caused by degenerative diseases and infections, as well as trauma, tumors, congenital malformations, and os odontoideum.[6,7] Several C1-C2 posterior fixation surgical techniques and their modifications are frequently applied.[8-21] One of the most popularized surgical fixation techniques of the C1 lateral mass and the C2 pedicle with screws and rods is referred to in the literature as the Harms technique.[11] Although this technique is associated with increased surgical time, length of hospitalization, blood loss, and costs of instrumentation, it incurs a lower rate of complications, such as vertebral artery trauma and broken screws.[7] The anatomical exposure and the biomechanical setting of this technique provide the availability for additional intraoperative fixation maneuvers compared with other fixation methods, such as Magerl's technique, which is positively reflected in the final radiological and clinical outcome.[6,7] Our goal is to present a technical modification of the Harms technique that contributes significantly to accurate screw placement especially in the lateral mass of the C1 vertebra and less in the pedicles of the C2 vertebra.

CASE REPORT

A 93-year-old man presented with 2 weeks of neck pain. He had a history of type II odontoid fracture after a fall 3 months before his admission to the emergency department at our hospital. Computed tomography scan of his cervical spine demonstrated a type II odontoid fracture that had some well-corticated edges as well as bilateral laminar fractures of the posterior arch of C1 (Figs 1 and 2). A modification of the Harms technique was used to stabilize the atlantoaxial region of his cervical spine.

Fig. 1: Sagittal computed tomography scan demonstrating a type II odontoid fracture with posterior displacement

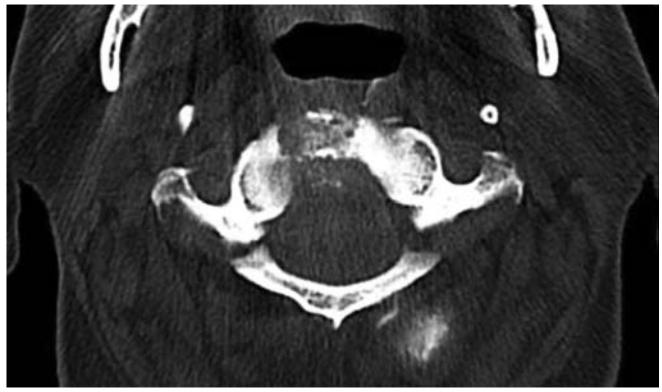


Fig. 2: Axial computed tomography scan of C1 vertebrae demonstrating fractures through bilateral posterior arches of C1 without significant displacement

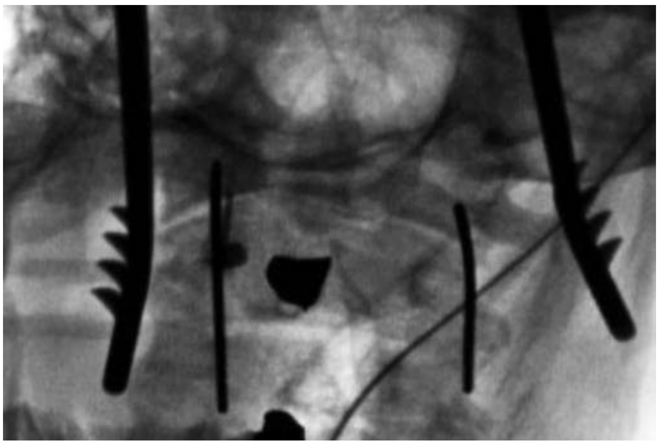


Fig. 3: Anteroposterior intraoperative X-ray showing 2.9 mm spade tip K-wire (Stryker) placed in bilateral lateral masses of C1 after being advanced by hand

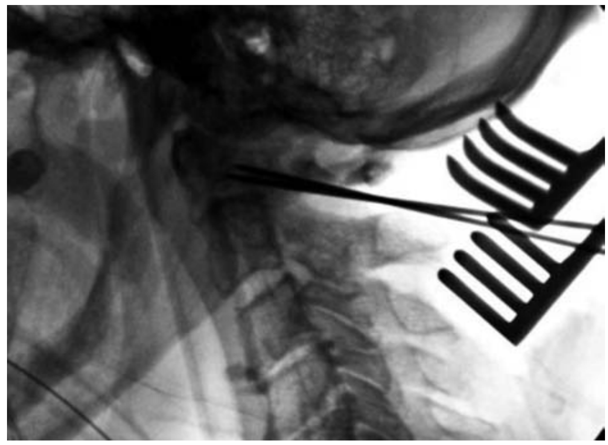


Fig. 4: Lateral intraoperative X-ray showing spade tip K-wire (Stryker) in lateral masses of C1, placed just under the fracture posterior arch of C1

SURGICAL TECHNIQUE

After prone positioning of the patient and fixation of the patient's head in slight flexion, a midline incision is made dorsally to the neck from the occipital area to the spinous process of C2. Cervical muscles are bilaterally detached from the spinous processes with the use of monopolar cautery proceeding downward on the surface of the laminas. Skin and subcutaneous retractors are then replaced by cerebellar retractors after the facets are exposed. The C2 nerve root in the facet area between the C1 and C2 vertebrae is exposed and carefully retracted in a caudal direction.

The medial borders of the C1 lateral mass and the C1-C2 facet are then palpated with the use of a Penfield dissector number 4. The entry point to the lateral mass of C1 is determined and marked. Under anteroposterior and lateral fluoroscopy, a pin driver is used to guide a K-wire through the marked entry point with a direction of 10° medially and 10° cephalad (Fig. 3). After fluoroscopic confirmation of the optimal position of the guide wire, a cannulated hand drill is placed over the guide wire.

Fig. 5: Lateral intraoperative X-ray after cannulated drill is hand-drilled down the length of the K-wire

A pilot hole is drilled in the same trajectory for the screw placement under fluoroscopic control (Figs 4 and 5). Then the guide wire and hand drill are removed. The created hole is palpated with a Murphy probe. After confirmation of consistency in the inner bone wall toward all aspects

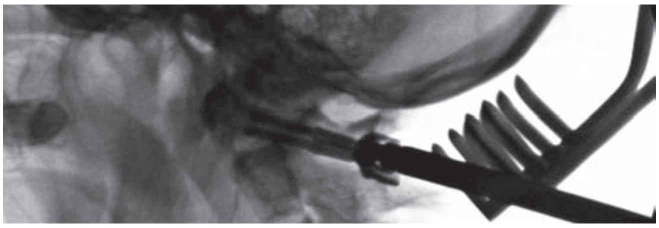


Fig. 6: Lateral intraoperative X-ray for verification of placement of C1 lateral masses screws following cannulated drill trajectory

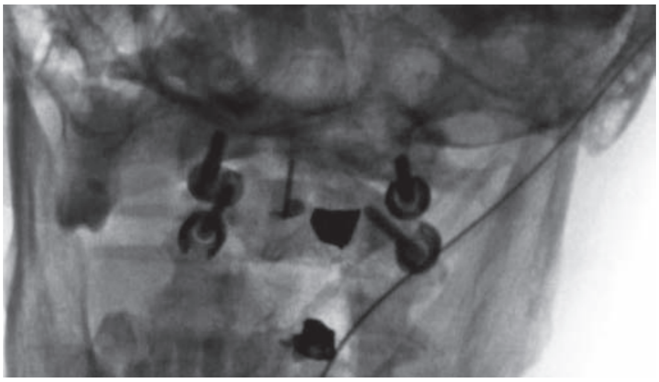


Fig. 8: Final anteroposterior X-ray showing C1 lateral mass and C2 pedicle screws in place prior to placement of rod

of the created hole, an appropriate sized 3.5 mm polyaxial screw is placed with a hand drill under confirmation of the correct position with anteroposterior and lateral fluoroscopy (Fig. 6).

The next step involves placement of the C2 pedicle screw insertion (Figs 7 and 8). The entry point is marked approximately 3 mm superior to the C2-C3 facet joint and approximately 1 mm lateral to the midline. A Penfield dissector number 4 is used to palpate the lateral aspect of the C2 pars interarticularis as well as the medial portion of the C2 pedicle on the same side to estimate the trajectory of the screw placement. After defining the entry point, a pin driver is used to drive a guidewire in the optimal trajectory under anteroposterior and lateral fluoroscopic control. The same procedure as in lateral mass screw placement is then followed. A small rod is placed and secured within the polyaxial screw heads of the C1 and C2 screws bilaterally. Decortication of the spinous processes of the involved vertebrae and the occiput with a high speed drill is the final step before closure of the fascia, cervical muscle layer, subcutaneous tissue, and skin. The procedure was performed under intraoperative neuromonitoring.

DISCUSSION

C1-C2 fixation can be achieved through anterior, posterior, and bilateral techniques.[17,22,23] According to Jacobson et al,[6] posterior fixation techniques can be divided further to include the dorsal wiring technique, the transarticular

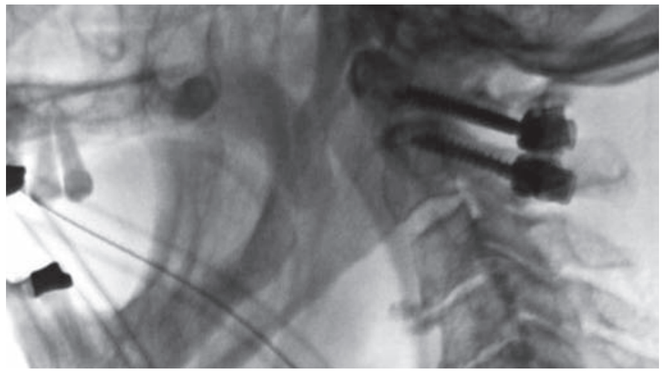
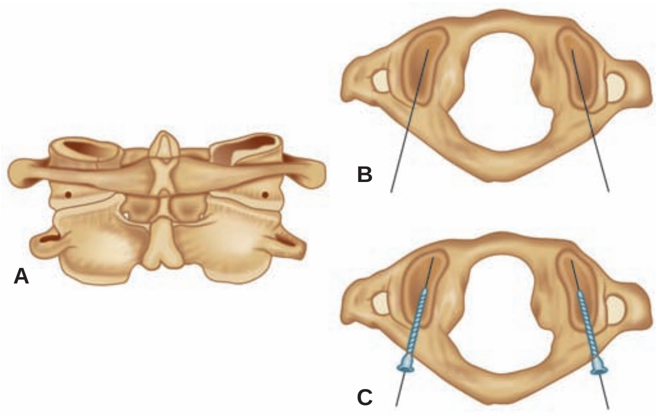


Fig. 7: Final lateral X-ray showing C1 lateral mass and C2 pedicle screws in place prior to rod placement

atlantoaxial arthrodesis initiated by Magerl, the polyaxial screw and rod fixation invented by Harms, and finally the C2 translaminar constructs. Harms technique has been biomechanically tested in comparison to wiring arthrodesis methods and proved to be superior for flexion, extension, and rotation at the cervical level.[24] Also, comparison with Magerl's technique has shown similar biomechanical characteristics for both stabilization methods.[25] Posterior element integrity is not a necessity for this technique as it can be applied in fractures of the laminae.[26] In addition, the provided biomechanical construction sustained by polyaxial screws and rods allows for corrective intraoperative surgical manipulations to the occipitocervical junction.[26] Rotatory subluxation is another pathological entity in which Harms technique contributes significantly because it does not affect the facets.[26]

Complications regarding this technique are relatively low in comparison to other stabilization techniques. The mean incidence of vertebral artery injury is lower with this method than that with Magerl's technique.[3,27,28] Screw malpositioning, compression of the vertebral artery, and sensory deficit due to C2 nerve root injury or dissection are the most commonly reported complications associated with Harms technique.[6,11,29] The C2 nerve root is not routinely dissected and ligated because this could lead to sensory deficit and risk for postoperative neuralgias, as confirmed by other studies in the literature.[3,30] The only indication for ligation is to control blood loss from the venous plexus, which is closely located to the C2 nerve root. Our modification seems to work efficiently, especially for the placement of screws in C1 vertebra, minimizing the risk for vertebral artery injury. The use of the K-wires prior to the insertion of the screws under anteroposterior and lateral fluoroscopy ensures the placement of the screws in their optimal position (Figs 9A to C). One potential issue for the surgeon is the migration of the K-wires through the anterior cortex of the vertebral body. This can be avoided by step-by-step fluoroscopic confirmation of the K-wires' position.



Figs 9A to C: Schematic presentation showing: (A) Marked entry points for K-wires at the posterior arch of C1, (B) optimal position of K-wires; and (C) placement of screws in their final position over the K-wires, following the cannulated path

Current literature demonstrates that there are several evolving intraoperative modalities for guidance during spine procedures that could significantly improve accuracy in screw placement and reduce operative time and patient exposure to radiation.[31-36] Although their overall contribution is substantial, there is skepticism about their use in the upper cervical spine because of the limited operative field and the importance of the anatomical structures in this area.[30]

CONCLUSION

The described modification of the Harms technique with the use of K-wires for guidance contributes significantly to the accuracy of screw placement especially in C1 vertebra and diminishes the risk for a vascular injury. Additionally, it can be utilized in every operation room as only fluoroscopic control is required and there is no increase in operative time or radiation exposure.

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REFERENCES

1. O'Donnell CM, Child ZA, Nguyen Q, Anderson PA, Lee MJ. Vertebral artery anomalies at the craniovertebral junction in the US population. Spine (Phila Pa 1976) 2014 Aug;39(18):E1053-E1057.
2. Abtahi AM, Brodke DS, Lawrence BD. Vertebral artery anomalies at the craniovertebral junction: a case report and review of the literature. Evid Based Spine Care J 2014 Oct;5(2):121-125.
3. Gautschi OP, Payer M, Corniola MV, Smoll NR, Schaller K, Tessitore E. Clinically relevant complications related to posterior atlanto-axial fixation in atlanto-axial instability and their management. Clin Neurol Neurosurg 2014 Aug;123: 131-135.
4. Nakao Y, Shimokawa N, Morisako H, Tsukazaki Y, Terada A, Nakajo K, Fu Y. Late complication of surgically treated atlantoaxial instability: occipital bone erosion induced by protruded fixed titanium rod: a case report. J Chiropr Med 2014 Dec;13(4):278-281.
5. Lee SH, Kim ES, Eoh W. Modified C1 lateral mass screw insertion using a high entry point to avoid postoperative occipital neuralgia. J Clin Neurosci 2013 Jan;20(1):162-167.
6. Jacobson ME, Khan SN, An HS. C1-C2 posterior fixation: indications, technique, and results. Orthop Clin North Am 2012 Jan;43(1):11-18, vii.
7. Vergara P, Bal JS, Hickman Casey AT, Crockard HA, Choi D. C1-C2 posterior fixation: are 4 screws better than 2? Neurosurgery 2012 Sep;71(Suppl 1 Operative):86-95.
8. Mixter SJ, Osgood RB. IV. Traumatic lesions of the atlas and axis. Ann Surg 1910 Feb;51(2):193-207.
9. Gallie WE. Skeletal traction in the treatment of fractures and dislocations of the cervical spine. Ann Surg 1937 Oct;106(4):770-776.
10. Brooks AL, Jenkins EB. Atlanto-axial arthrodesis by the wedge compression method. J Bone Joint Surg Am 1978 Apr;60(3):279-284.
11. Harms J, Melcher RP. Posterior C1-C2 fusion with poly-axial screw and rod fixation. Spine (Phila Pa 1976) 2001 Nov;26(22):2467-2471.
12. Magerl, F.; Seemann, P. Stable posterior fusion of the atlas and axis by transarticular screw fixation. In: Kehr P, Weidner A, editors. Cervical spine. New York: Springer-Verlag; 1985. p. 322-327.
13. Richter M, Schmidt R, Claes L, Puhl W, Wilke HJ. Posterior atlantoaxial fixation: biomechanical in vitro comparison of six different techniques. Spine (Phila Pa 1976) 2002 Aug;27(16):1724-1732.
14. Dickman CA, Sonntag VK, Papadopoulos SM, Hadley MN. The interspinous method of posterior atlantoaxial arthrodesis. J Neurosurg 1991 Feb;74(2):190-198.
15. Fidler MW, Valentine NW, Rahmatalla AT. Posterior atlantoaxial fusion. A new internal fixation device. Spine (Phila Pa 1976) 1994 Jun;19(12):1397-1401.
16. Fielding JW, Hawkins RJ, Ratzan SA. Spine fusion for atlanto-axial instability. J Bone Joint Surg Am 1976 Apr;58(3): 400-407.
17. McGraw RW, Rusch RM. Atlanto-axial arthrodesis. J Bone Joint Surg Br 1973 Aug;55(3):482-489.
18. Mimatsu K, Katoh F, Kawakami N, Nakagami W. Atlantoaxial fusion with posterior double wire fixation. Spine (Phila Pa 1976) 1992 Nov;17(11):1409-1413.
19. Rodrigues FA, Hodgson BF, Craig JB. Posterior atlantoaxial arthrodesis. A simplified method. Spine (Phila Pa 1976) 1991 Aug;16(8):878-880.
20. Goel A, Laheri V. Plate and screw fixation for atlanto-axial subluxation. Acta Neurochir (Wien) 1994;129(1-2):47-53.
21. Wright NM. Posterior C2 fixation using bilateral, crossing C2 laminar screws: case series and technical note. J Spinal Disord Tech 2004 Apr;17(2):158-162.
22. Ashraf J, Crockard HA. Transoral fusion for high cervical fractures. J Bone Joint Surg Br 1990 Jan;72(1):76-79.
23. Simmons EH, du Toit G Jr. Lateral atlantoaxial arthrodesis. Orthop Clin North Am 1978 Oct;9(4):1101-1114.
24. Grob D, Crisco JJ 3rd, Panjabi MM, Wang P, Dvorak J. Biomechanical evaluation of four different posterior atlantoaxial fixation techniques. Spine (Phila Pa 1976) 1992 May;17(5): 480-490.

25. Elliott RE, Tanweer O, Boah A, Morsi A, Ma T, Frempong-Boadu A, Smith ML. Outcome comparison of atlantoaxial fusion with transarticular screws and screw-rod constructs: meta-analysis and review of literature. J Spinal Disord Tech 2014 Feb;27(1):11-28.
26. Lee SH, Kim ES, Sung JK, Park YM, Eoh W. Clinical and radiological comparison of treatment of atlantoaxial instability by posterior C1-C2 transarticular screw fixation or C1 lateral mass-C2 pedicle screw fixation. J Clin Neurosci 2010 Jul;17(7):886-892.
27. Elliott RE, Tanweer O, Boah A, Morsi A, Ma T, Frempong-Boadu A, Smith ML. Atlantoaxial fusion with transarticular screws: meta-analysis and review of the literature. World Neurosurg 2013 Nov;80(5):627-641.
28. Elliott RE, Tanweer O, Boah A, Morsi A, Ma T, Frempong-Boadu A, Smith ML. Comparison of screw malposition and vertebral artery injury of C2 pedicle and transarticular screws: meta-analysis and review of the literature. J Spinal Disord Tech 2014 Aug;27(6):305-315.
29. Stulik J, Vyskocil T, Sebesta P, Kryl J. Atlantoaxial fixation using the polyaxial screw-rod system. Eur Spine J 2007 Apr;16(4):479-484.
30. Bourdillon P, Perrin G, Lucas F, Debarge R, Barrey C. C1-C2 stabilization by Harms arthrodesis: indications, technique, complications and outcomes in a prospective 26-case series. Orthop Traumatol Surg Res 2014 Apr;100(2): 221-227.
31. Holly LT, Foley KT. Percutaneous placement of posterior cervical screws using three-dimensional fluoroscopy. Spine (Phila Pa 1976) 2006 Mar;31(5):536-540; discussion 41.
32. Kumar Singh P, Garg K, Sawarkar D, Agarwal D, Satyarthi G, Gupta D, Sinha S, Kale S, Sharma B. CT-guided C2 pedicle screw placement for treatment of unstable Hangman's fractures. Spine (Phila Pa 1976) 2014 May.
33. Singh PK, Garg K, Sawarkar D, Agarwal D, Satyarthee GD, Gupta D, Sinha S, Kale SS, Sharma BS. Computed tomography-guided C2 pedicle screw placement for treatment of unstable hangman fractures. Spine (Phila Pa 1976) 2014 Aug;39(18): E1058-E1065.
34. Uehara M, Takahashi J, Hirabayashi H, Hashidate H, Ogihara N, Mukaiyama K, Kato H. Computer-assisted C1-C2 transarticular screw fixation "Magerl Technique" for atlanto-axial instability. Asian Spine J 2012 Sep;6(3):168-177.
35. Weng C, Tian W, Li ZY, Liu B, Li Q, Wang YQ, Sun YZ. Surgical management of symptomatic os odontoideum with posterior screw fixation performed using the Magerl and harms techniques with intraoperative 3-dimensional fluoroscopy-based navigation. Spine (Phila Pa 1976) 2012 Oct;37(21):1839-1846.
36. Yang Y, Wang F, Han S, Wang Y, Dong J, Li L, Zhou D. Isocentric C-arm three-dimensional navigation versus conventional C-arm assisted C1-C2 transarticular screw fixation for atlantoaxial instability. Arch Orthop Trauma Surg 2015 Aug; 135(8):1083-1092.