Clinical Outcome Analysis of Posterior C1 and C2 Screw Rod Fixation (Harms–Goel Technique) in Traumatic Atlantoaxial Dislocation

Deepak Kumar Singh[1] Vrihaspati Kumar Agrahari[1] Md. Kaif[1] Kuldeep Yadav[1] Rakesh Kumar Singh[1] Farhan Ahmad[1] Khursheed Khan[1] Vipul Pathak[1]

[1]Department of Neurosurgery, Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow, Uttar Pradesh, India

Address for correspondence Deepak Kumar Singh, MS, MCh, Department of Neurosurgery, Dr. Ram Manohar Lohia Institute of Medical Science, Gomti Nagar, Lucknow 226010, Uttar Pradesh, India (e-mail: gkp.deepak@gmail.com).

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Abstract

Aims Evaluation of clinical profile, mode of injury, and clinical outcome in patients of traumatic atlantoaxial dislocation (AAD) who underwent posterior C1 and C2 screw and rod fixation by using Harms and Goel technique.

Materials and Methods It is a retrospective study involving all traumatic AAD patients of all age groups admitted at Department of Neurosurgery, RMLIMS, Lucknow, during the last two years. Inclusion criteria was all cases having traumatic AAD with or without C2 fracture and underwent posterior C1 and C2 screw and rod fixation by Harms and Goel technique. Clinical profile, age, sex, mode of injury, types of injury (detected in MRI and CT of cranio-vertebral junction), preoperative and postoperative (after one month of surgery) neurological status were evaluated and outcome analyzed.

Results Over all, out of 14 patients, 12 (85.7%) patients improved in the form of either reduced spasticity, improved sensation, increased power of one or more limbs, or bladder and bowel control. One (7.1%) patient retained preoperative status, neither improved nor deteriorated. However, one (7.1%) patient deteriorated, lost all sensations, motor functions below the lesion, bladder and bowel control, and died due to respiratory failure after one and half month of the surgery.

Conclusion We concluded that Harms and Goel technique is a safe and effective system for achieving C1–C2 fusion in traumatic AAD. Although this study is very small, does not provide Class 1 data, and is subject to the bias of any retrospective series, we believe our findings to be a useful addition to the body of literature on the surgical treatment of C1–C2 instability.

Keywords
- atlantoaxial dislocation
- Harms and Goel technique
- C2 fracture
- C1–C2 fusion

Introduction

The atlantoaxial junction is highly mobile, accounting for 50% (47 degrees) of the rotational and 12% (10 degrees) of the flexion and extension movements of the cervical spine.[1,2] Treatment of traumatic atlantoaxial dislocation (AAD) associated with odontoid fracture has remained controversial and has evolved over the past decade. This high degree of mobility makes adequate stabilization inherently problematic, and the rates of fusion at the C1–C2 motion segment have been lower than in the subaxial spine.[3,4] The set of potential operative interventions is further limited by the anatomy of

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this region, which is characterized by horizontal articular surfaces and an inconstant vertebral artery (VA) location not seen elsewhere in the spine.[5,6] Treatment initially began with external arthrosis or cable internal fixation, but now management has become more precise as surgical techniques have advanced. These include odontoid screws, transarticular screws, and screw and rod system, including the Harms and Goel technique and translaminar screws.[7] In the last decade, however, there have been significant advancements in atlantoaxial fixation that incorporate novel polyaxial screw/rod techniques, as described by Harms and Mechler,[8] as well as screw and plate/spacer techniques, as first described by Goel et al.[9-12] The Harms technique uses polyaxial C1 lateral mass screws and polyaxial C2 pedicle screws connected by longitudinal bilateral rods.[8] In the Goel technique, C1 lateral mass screws and C2 pars screws are connected by longitudinal bilateral titanium plates.[10] Fixation according to this method avoids the need for passing sublaminar wires and does not rely on the integrity of the posterior elements of C1 or C2, making the Harms technique attractive in the setting of C1 ring disruption or when removal of the posterior elements of C1 or C2 is required for surgical decompression. The technique does not require the acute angle of approach associated with transarticular screw placement and minimizes the risk of injury to the VA.[9,13,14] Additionally, the path for the C2 pedicle screw can be selected independently of the location of the atlas. Anatomical studies support the argument that cervical pedicle screws are safe with respect to VA injury.[15] This technique also allows reduction in any displacement of the elements of the atlantoaxial complex by repositioning the patient's head or directly manipulating the C1 or C2 screws.

Fig. 1 Preoperative sagittal and coronal view of type 2 odontoid fracture with atlantoaxial dislocation (AAD) on computed tomography (CT) scan.

Aims

This article evaluates the clinical profile, mode of injury, and clinical outcome in patients of traumatic AAD who underwent posterior C1 and C2 screw and rod fixation by using the Harms and Goel technique.

Materials and Methods

It is a retrospective study involving all traumatic AAD patients of all age groups admitted at the Department of Neurosurgery, RMLIMS, Lucknow, Uttar Pradesh, India, during last 2 years. Inclusion criteria were all cases having traumatic AAD with or without C2 fracture that underwent posterior C1 and C2 screw and rod fixation by Harms and Goel technique. Exclusion criteria were AAD with causes other than trauma like congenital, inflammatory, etc. Initial hospital records were reviewed. Clinical profile, age, sex, mode of injury, types of injury (detected in magnetic resonance imaging and computed tomography [CT] of craniovertebral junction), and preoperative and postoperative (after 1 month of surgery) neurologic status were evaluated and outcomes analyzed. Strength of muscle was assessed according to the Medical Research Council grading system and spasticity was measured according to the Modified Ashworth score system (►**Figs. 1**–**3**).

Results

The study population comprised of 14 patients out of whom 11 (78.5%) patients were male and 3 (21.5%) were female (►**Table 1**).

History of road traffic accident was found in seven (50%) patients and fall from height in seven (50%) (►**Table 2**).

On CT of craniovertebral junction, the most common structural injury in traumatic AAD patients was type 2 odontoid fracture (57.2%) followed by AAD without bony fracture (28.6%). However, C1 fracture with AAD and Hangman's fracture contributed as least common type of injury, that is, 7.1% each (►**Table 3**).

Out of 14 patients, only 1 patient (7.1%) was found to have decreased sensation which improved postoperatively. In

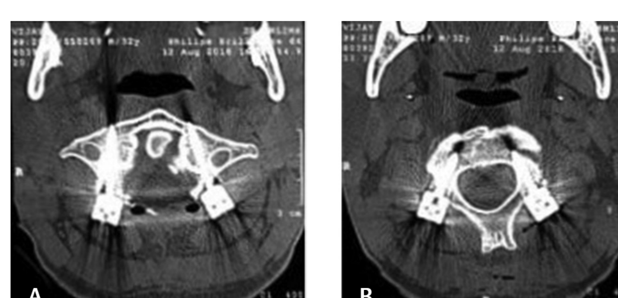

Fig. 2 Postoperative axial view of C1 lateral mass screw (**A**) and C2 pedicle screw (**B**) fixation on computed tomography (CT) scan.

one patient, sensation was found to be absent after surgery (►**Table 4**).

In 11 (78.6%) patients, muscle tone was increased in either one or all limbs while it was within normal limits in 3 (21.4%) patients. In 10 (91%) patients, spasticity got reduced postoperatively. However, one patient (7.14%) developed flaccid quadriplegia postoperatively. Remaining three patients having normal tone maintained the same status postoperatively (►**Table 5**).

All patients of traumatic AAD had decreased power in preoperative examination in either one or more limbs. Postoperatively, 10 (71.4%) patients showed improved power in one or more limbs. However, in three (21.4%) patients there was no improvement in power in either limb. In one patient, power

Fig. 3 X-ray lateral view of craniovertebral junction showing C1 lateral mass and C2 pedicle screw fixation.

Table 1 Gender distribution

Sex	No. of patients	Percentage
Male	11	78.5
Female	3	21.5
Total	14	100

Table 2 Mode of injury

Mode of injury	No. of patients	Percentage
RTA	7	50
Fall from height	7	50
Total	14	100

Abbreviation: RTA, road traffic accident.

Table 3 Type of injury

Type of injury	No. of patients	Percentage
Type 2 odontoid fracture with AAD	8	57.2
AAD without bony fracture	4	28.6
C1 fracture with AAD	1	7.1
Hangman's fracture with AAD	1	7.1
Total	14	100

Abbreviation: AAD, atlantoaxial dislocation.

Table 4 Sensory status

Sensory status (preoperative)	No. of patients	Sensory status (postoperative)	No. of patients
Normal	13	Same status	12
		Decreased	01
Decreased	01	Same status	0
		Improved	01
Total	14	Total	14

Table 5 Muscle tone

Muscle tone (preoperative)	No. of patients	Muscle tone (postoperative)	No. of patients
Normal	03	Same status	03
Increased	11	Same status	0
		Improved	10
		Flaccid	01
Total	14	Total	14

Table 6 Muscle strength

Muscle power (preoperative)	No. of patients	Muscle power (postoperative)	No. of patients
Decreased	14	Improvement	10
		Same status	03
		Deteriorated	01
Total	14	Total	14

Table 7 Autonomic system (bladder and bowel involvement)

Bladder and bowel (preoperative)	No. of patients	Bladder and bowel (postoperative)	No. of patients
Normal	07	Same status	07
Involved	07	Same status	05
		Improved	01
		Deteriorated	01
Total	14	Total	14

deteriorated and found to be flaccid quadriplegic postoperatively (►**Table 6**).

Autonomic system found to be involved in the form of either bladder or bowel in seven (50%), out of which only one (14.28) patient improved; however, one patient lost bladder and bowel control postoperatively. All the remaining patients retained their preoperative bladder and bowel function status (►**Table 7**).

Overall, out of 14 patients, 12 (85.7%) patients improved in the form of either reduced spasticity, improved sensation, increased power of one or more limbs, or bladder and bowel control. One (7.1%) patient retained preoperative status, neither improved nor deteriorated. However, one (7.1%) patient deteriorated, lost all sensation and motor functions below the lesion, bladder and bowel control, and died due to respiratory failure after one and half month of the surgery.

Discussion

Although C1–C2 fusion procedures have been developed for around 100 years, safe and highly effective techniques have not been available until recently.[16] Early methods that relied on posterior wiring had a high incidence of nonunion.[17] Although the fusion rate can be augmented by the use of postoperative orthotic immobilization, significant comorbidities associated with halo-vest immobilization are well documented among elderly and fragile patients.[18] In the past 10 years, transarticular screws have gained significant popularity among spine surgeons[14,19,20]; however, as many as 20% of patients have VA anatomical anomalies that can preclude bilateral placement of these screws.[5,21] The development of lateral mass screws in C1 and pedicle screws in C2 together with a polyaxial screw system, as described by Harms and Melcher[8] in 2001, represented a safe and effective technique for C1–C2 fusion. The biomechanical properties suggest that this technique provides stability similar to transarticular screws.[22,23] Early clinical experience with this fusion technique has also been successfully demonstrated in several small clinical series.[8,24,25] Our experience in 14 patients with traumatic AAD in the present study demonstrates the efficacy of this technique. We were able to place bilateral screw/rod fixation in all patients in our study. We sacrificed the C2 nerve roots bilaterally in all patients but no patient developed neuropathic pain.

Using C1 lateral mass screws and C2 pedicle screws with a polyaxial screw/rod system is favored by us and has a low complication rate. Compared with a posterior wiring procedure, the screw/rod system does not require intact posterior elements, which can be disrupted in conditions such as trauma.[26] In addition, the passage of sublaminar wires, especially with the Brook technique, can further compress the spinal cord.[26,27] Similarly, although the laminar screw system does not protrude into the spinal canal, it does require intact posterior elements.[28,29] The transarticular screw system does not require intact posterior elements; however, it has several specific anatomical constraints, specifically the VA anatomy. Injury to the VA is a known complication in the placement of a transarticular screw system. In fact, the overall complication rate is estimated to be approximately 4.1% (known and suspected injury), and 3.7% of the patients have known neurologic consequences. The screw/rod system has fewer of these constraints—there is no need for a complete reduction before instrumentation, and the risk of VA injury is also lower. Biomechanically, the screw/rod system is superior to the wiring system and at least comparable to the transarticular screw system.[22,30,31]

Although authors have suggested that approximately 9 to 12% of patients will have VA anatomy deemed at risk in the placement of C2 pedicle screws, our experience has indicated that the risk with C2 pedicle screws is probably lower. In the present study, we had no injury to the VA because of screw placement. Bilateral screw placement was possible in all of the cases, although we recognized that C2 pedicle screw placement was not possible in some of the patients. Hypoglossal nerve injury, another known complication in transarticular screw placement, was not observed among our series.

Limitations of the Study

The major limitation of this study is the small sample size and it is a retrospective study.

Conclusion

We concluded that the use of Harms and Goel technique is a very effective system for achieving C1–C2 fusion in traumatic AAD. It is a very safe procedure, associated with a low morbidity and mortality, and we believe it is applicable to most patients.

Although C2 nerve root sacrifice is often necessary in placing C1 lateral mass screws, the incidence of neuropathic pain is not found in any case in this study.

Although this study is very small, does not provide level 1 data, and is subject to the bias of any retrospective study, we believe our findings to be a useful addition to the body of literature on the surgical treatment of C1–C2 instability.

Conflict of Interest

There is no conflict of interest. All authors agree to the content written and have given their approval for its publication in this journal.

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