Original Article

Posterior C1 Lateral Mass and C2 Pedicle Screw Fixation with Iliac Crest Graft in Post Traumatic Atlantoaxial Instability; Clinical and Radiological Outcome

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ABSTRACT

Background: Atlanto axial instability is a serious life-threatening condition which occurred due to disruption of the bony and/or the ligamentous structures of the atlas and the axis vertebrae. The common causes of instability are trauma, rheumatoid arthritis and congenital anomalies. Objective: In this retrospective study, we analyzed the postoperative clinical and radiological outcomes of twenty one patients operated upon for atlantoaxial instability by C1 lateral mass and C2 pedicle screw fixation. Patients and Methods: Patient selection: patients with post traumatic atlantoaxial instability with or without bony fracture. Operation: C1 lateral mass and C2 pedicle screw fixation with iliac crest bone graft fusion. Results: Clinical and radiological outcome at six months follow up interval revealed full motor recovery in twelve patients (80%) out of fifteen myelopathic patients and bony fusion was achieved in twenty one patients (100%). No vertebral artery injury or implant failure were encountered. Conclusion: Posterior C1 lateral mass and C2 pedicle screw fixation with iliac crest bone graft fusion is an effective and safe option for stabilizing the atlantoaxial complex. It is stronger, practical, and less dependent on anatomical variations of the vertebral artery and with no incidence of it’s injury.

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INTRODUCTION

The atlantoaxial complex is a complicated structure composed of the upper two vertebrae of the cervical spine, their articular surfaces, and several crucial ligaments. Because of this relationship, its architecture allows flexion, extension, lateral bending and rotation. Atlantoaxial instability can occur when any part of the components are damaged by trauma, inflammation, neoplasm, or congenital defects.

The clinical presentation of atlantoaxial instability varies from mild symptoms as high posterior cervical pain to severe presentation as different grades of myelopathy. The diagnosis should be based on proper radiological evaluation such as X-ray, computerized tomography (CT) with 3D views and magnetic resonance imaging (MRI).

Multiple techniques have been described for C1–C2 fixation. Historically these techniques include either a posterior cable and bone graft, posterior transarticular screws or a combination of both. Rigid fixation with transarticular screws has been demonstrated to be a safe and effective method for C1 to C2 stabilization in most patients; however, this technique is not applicable in all patients and exposes the vertebral artery to risk. Recently, C1 lateral mass–C2 pedicle screw fixation and C1 lateral mass and C2 intralaminar screws have been described. These techniques provide more rigid fixation than cable alone techniques and may be applicable to patients whose anatomy prohibits transarticular screw fixation.

PATIENTS AND METHODS

Between Jan 2011 and December 2013, twenty one patients with post traumatic atlantoaxial instability due to unstable odontoid fracture and/or atlantoaxial ligamentous instability were admitted and managed in the Neurosurgery Department in Cairo University Hospitals.

Diagnosis was established on basis of clinical presentation as well as radiological investigations.

All patients underwent proper history taking including age, sex, time of presentation, mode of trauma, and complete neurological assessment (motor assessment, sensory examination, reflexes evaluation and autonomic dysfunction examination).

Proper radiological assessment was done for all patients including X-ray cervical spine, C.T. cervical spine (thin cuts) with 3D reconstruction and sagittal views to evaluate the integrity of the bone at the intended site of screws fixation or unsuitable small C2 pars and M.R.I. of cervical spine to evaluate the degree
of spinal cord compression as well as to delineate the course of vertebral arteries. In five cases with suspected aberrant vertebral arteries, magnetic resonance angiography and/or CT angiography were requested and revealed negative in all.

In the acute cases with cord compression (eighteen patients), methylprednisolone started immediately within 8 hours followed by head traction with proper weight to reduce the compressing odontoid. In non reducible cases (two patients) transoral odontoid resection was attempted before posterior fixation.

Preoperatively, all patients were immobilized using a rigid collar.

**Surgical technique:**

In operating room, intubation was performed in neutral supine position using a fiber optic scope.

The patient is turned into prone position on chest rolls using mild manual cervical traction to maintain a neutral and reduced C1-C2 relationship. The head is secured to a rigid traction with proper weight. The abdomen is allowed to hang freely between chest rolls.

A midline incision is made extending from the suboccipital area to the spinous process of C4. C2-3 facet joints are exposed and arch of C1 is exposed laterally. The vertebral artery is exposed in the vertebral groove on the superior aspect of C1 arch. The C2 nerve root is identified and mobilized inferiorly. Bipolar cautery and hemostatic agents are used to control bleeding from the venous plexus surrounding C2 nerve root.

The inferior third of C1 posterior arch which overlies the C1 lateral mass is removed with high speed drill and lateral mass is exposed. The entry point of the C1 lateral mass is the junction point of the midpoint of the C1 lateral mass and the inferior aspect of the C1 arch. Using a low speed drill with 3 mm diameter drill bit and guide into the decorticated C1 lateral mass entry point and under fluoroscopy a pilot hole is drilled. The trajectory of the pilot hole is 10 degree medial angulation in the axial plane and parallel to the ring of C1 in the sagittal plane. The lateral mass polyaxial screw is placed with dimension of 3.5-4mm wide and 36 mm long. The screw length (36 mm) allows the head to be superficial to the C2 nerve root without causing any compression.

Using a Penfield number 4, the medial border of the pars interarticularis of C2 was identified and in the cranial and medial quadrant of the isthmus surface of C2, the entry point of the C2 pedicle screw was marked with high speed drill the direction is 20-30 degree in lateral to medial and cephalad trajectory. The appropriate length 3.5 mm polyaxial screw was inserted. Contoured longitudinal rods were placed in the screw heads. C1 and C2 were decorticated posteriorly and iliac crest cancellous bone was placed over the decorticated surfaces.

The patient was admitted to ICU for 24 hours postoperative.

Clinical outcome was evaluated immediately postoperative, during the hospital stay and at 3, 6 months intervals.

Postoperative flexion and extension X-ray and CT scanning of cervical spine were done on the 2nd day after surgery to ensure the proper placement of the screws, and after 3 and 6 months to document the bony fusion of the bone graft with C1 and C2 posterior arches.

The collected preoperative and postoperative data included age, sex, date of operation in relation to trauma, comorbidites, reason for fixation either ligamentous instability or unstable odontoid fracture or both, presence of any craniocervical anomalies,operative details , duration of surgery, complications , blood loss, evaluation of the position and direction of screws, detection of any C1-C2 movement in dynamic cervical x-ray postoperatively and evaluation of the fusion, hospital stay, revision surgery, preoperative and postoperative neck pain, C2 radiculopathy.

The severity of pain in our study was assessed according to the following postulated scale (0=no pain, 1=mild pain, 2=moderate pain, 3=sever pain and 4=worst possible pain).

**RESULTS**

During the years 2011-2013, twenty one patients (sixteen men and five women) with age ranged from 20-55 years were admitted to our service with atlantoaxial instability. All patients underwent surgical posterior lateral mass and C2 pedicle screw fixation with iliac crest bone graft fusion.

The mode of trauma was motor car accident in sixteen cases (76.2%), fall from height in three cases (14.3%) and hitting with heavy object in two cases (9.5%). The time of presentation was in the same day of trauma in eighteen cases (85.7%) while three cases (14.3%) presented in 20 days, one month, two months intervals (Fig. 1).
The atlantoaxial instability was due to odontoid fracture in eight cases (38.1%), ligamentous injury (disruption of transverse ligament) in nine cases (42.9%) and both of them in four cases (19%) (Fig. 2).

Eight patients (38.1%) presented with neck pain G1, ten patients (47.6%) G2, one patient (4.8%) was G3 and two patients (9.5%) with pain G4. Myelopathic affection was presented in fifteen patients (71.4%), sensory affection in the form of dysthesia, hypothesia and sensory level in twelve cases (57%) and sphincteric affection in two cases (9.5%).

Radiological assessment of the patients revealed cord compression in twelve cases (57%), cord signal without compression in three cases (14.3%), anomalies in C1 posterior arch in one case (4.8%) and no vertebral artery anomalies were found.

Reduction was successfully achieved by head traction in nineteen cases (90.5%) while two cases (9.5%) -being non reducible- needed transoral odontoidectomy before posterior fixation (Fig. 3 a&b).

Fifteen patients (71.4%) were operated upon in the same day of presentation while six patients (28.6%) underwent surgery within 48 hours due to logistic difficulties.
Blood transfusion was needed in two cases (9.5%) due to excessive blood loss from venous plexus around C2 root in addition to bony bleeding throughout surgery.

One patient (4.8%) had unintended dural tear and was primarily sutured with no postoperative leak. Injury of C2 root occurred in one case (4.8%) and the patient developed postoperative radiculopathy and managed by medical treatment and local injection of steroids and analgesics.

Seven (46.7%) out of fifteen patients presented with myelopathy had partial recovery during the hospital stay while at six months follow up interval twelve patients (80%) out of fifteen had full motor recovery.

All patients developed mild postoperative neck pain G1 for 2-3 days. Three patients (14.3%) suffered postoperative C2 radiculopathy which was mild G1 in two cases and severe G3 in one case.

Immediate postoperative radiological assessment showed no movement between C1 and C2 in all cases (100%) and no maldirection of the screws except in one case (4.8%), in which C2 screw necessitated revision (Fig. 4 a&b).

Postoperative complications were encountered in three cases (14.3%), two patients suffered deep venous thrombosis and one patient had wound infection which needed debridement and antibiotic therapy (Table 1).

Hospital stay ranged from 2-14 days (average 8 days).
Table 1: Surgical and medical complications.

<table>
<thead>
<tr>
<th>Complications</th>
<th>Number of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surgical</strong></td>
<td></td>
</tr>
<tr>
<td>Vertebral artery injury</td>
<td>No patient (0%)</td>
</tr>
<tr>
<td>Screw fracture</td>
<td>No patient (0%)</td>
</tr>
<tr>
<td>C2 root injury</td>
<td>One patient (4.8%)</td>
</tr>
<tr>
<td>Dural tear</td>
<td>One patient (4.8%)</td>
</tr>
<tr>
<td>Surgery revision</td>
<td>One patient (4.8%)</td>
</tr>
<tr>
<td>Wound infection</td>
<td>One patient (4.8%)</td>
</tr>
<tr>
<td><strong>Medical</strong></td>
<td></td>
</tr>
<tr>
<td>Deep venous thrombosis</td>
<td>Two patients (9.5%)</td>
</tr>
</tbody>
</table>

Bony fusion was achieved in eighteen patients (85.7%) at 3 months follow up interval and in 21 patients (100%) at 6 months postoperatively (Fig. 5). No malfusion was detected on radiological follow up.

![Fig. 5: 3 months postoperative 3D cervical C.T. showing atlantoaxial fusion.](image)

**DISCUSSION**

Atlanto axial instability is a serious life-threatening condition which occurred due to disruption of the bony and/ or the ligamentous structures of the atlas and axis vertebrae. The common causes of instability are trauma, rheumatoid arthritis and congenital anomalies. The atlantoaxial complex accounts for more than half of the rotatory movement of the head with respect to the thoracic spine, because of this, a higher failure of immobilization (external and surgical fusion) in this region compared with the remainder of the cervical spine.

Several types of atlantoaxial fusion techniques have been described over the years from the earliest no-screw fusion (Gallie, Brooks, and Sonntag) to the two screws fusion (transarticular technique of Magerl) and four screws technique (Goel and Harms) with its variations. The no screw techniques have been used for decades and are technically simple to perform but with high non fusion rates, neurological complications and biomechanical weakness. The two screws technique is currently one of the most commonly performed atlantoaxial fusion with fusion rate from 87% to 100% but it is technically difficult with risk of vertebral artery injury higher than other techniques. The four screw technique (C1 lateral mass and C2 pedicle screw) which was introduced by Goel and Laheri and then modified by Harms and Melcher with the use of polyaxial screws and rods instead of plates, is relatively newer procedure than the two screws fusion but has reached a similar popularity being simpler, with much lower risk of vertebral artery injury and higher fusion rate 100%.

In this study, twenty one patients with posttraumatic atlantoaxial instability were operated upon with C1 lateral mass and C2 pedicle screw fixation and followed up clinically and radiologically for 6 months. In the clinical follow up, full motor recovery was achieved in twelve (80%) patients out of fifteen myelopathic patients at 6 months interval, three patients (14.3%) suffered postoperative C2 radiculopathy and there was no vertebral artery injury. Bony fusion was achieved in eighteen patients (85.7%) at 3 months follow up interval and in twenty one (100%) patients at 6 months. No mal fusion or screw fracture were detected on radiological follow up.

Vergara et al. performed 123 operations for atlantoaxial instability, 47 patients operated upon by C1 lateral mass and pedicle screw fixation (Harms technique) and 76 patients operated upon by transarticular screws fixation (Magerl technique), in comparison with the group of Harms technique there was vertebral artery injury in one case (2.1%), dural tear in two patients (4.2%), implant failure in one case (2.1%), C2 nerve root injury in one patient (2.1%), wound infection in three patients (6.4%) and solid fusion in all patients (100%)17. There is no differences between Vergara et al study and our study except they have one case of vertebral artery injury and one case of implant failure and this is attributed to the larger number of patients in their study.

In comparison with the group of 76 patients with atlantoaxial instability operated upon with transarticular screw fixation in Vergara et al. study, the vertebral artery injury happened in ten cases (13%), implant failure in seven patients (9.2%) and solid fusion in all patients (100%), as the risk of the vertebral artery injury is much higher in Magerl technique than that of the Harms technique.

On the contrary, the results of our study matched with that of Leonard and Wright who performed C1 lateral mass and C2 laminar screw fixation in 20 patients.
patients with fusion achieved in all patients (100%) without vertebral artery injury.\textsuperscript{18}

Harms and Melcher studied 37 patients with atlantoaxial instability operated upon by Harms technique, their study had nearly the same results as they have no vertebral artery injury, no implant failure and fusion rate was 100%.\textsuperscript{19}

The limitation in our study is the small sample size, absence of long term follow up and absence of other groups with different fusion techniques for comparison.

\textbf{CONCLUSION}

Posterior C1 lateral mass and C2 pedicle screw fixation with iliac crest bone graft fusion is an effective and safe option for stabilizing the atlantoaxial complex. It is stronger, practical and less dependent on anatomical variations of the vertebral artery and with no incidence of vertebral artery injury.

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