Anterior Extra Pharyngeal Approach and Fixation of the Atlanto-axial Joint with Screw Plate Construct or Anterior Transarticular Screws : and Review of Literature

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Abstract : Both the atlanto-axial joints can be exposed adequately by an unilateral extra-pharyngeal approach from the right side. The atlanto-axial dislocation can be reduced, joints can be decorticated and bone graft can be introduced into the joint. The odontoid process can be drilled and removed. The C1-C2 joint can be fixed either by 1. C1 lateral mass and C2 body screw plate bilaterally, or 2. Bilateral anterior C2-C1 transarticular screws.

Material and method

Since 2008, 62 patients, 39 patients anterior transarticular screws, 23 patients anterior screw plate fixation, 40 males 22 females, AAD 42, tuberculosis 12, fixed AAD with basilar invagination 8. All patients underwent preoperative dynamic X-rays of cranio-vertebral junction, computerized tomography (CT scan) of C1-C2 static and dynamic study with bone window settings and 3D reconstruction, magnetic resonance imaging (MRI) and MR angiography to study course of vertebral artery.

1 Operative technique

Anaesthesia : Awake endoscopic nasal intubation and general anaesthesia.

Position : Supine with extension of the head and mild rotation to left side, lateral X-ray image to confirm that mandible is at or above C2 body on extending the head.

Skull tongs applied for intra operative manipulation.

Stevenson's¹⁾ technique for exposure to reach the pre-vertebral space at C1-C2.

Curved from midline to angle of mandible at a distance of 2 cms below the mandibular margin to protect the marginal mandibular nerve. Skin and platysma flaps reflected bilaterally. Mylohyoid muscle divided from the midline to the angle of the mandible. Upper flap of mylohyoid muscle reflected upwards to expose the mandibular gland and the

digastric muscle and stylohyoid muscle (**Fig. 1-5**). Both muscles disconnected from the hyoid bone and reflected upwards to identify the hypoglossal nerve. Hypoglossal nerve separated from surrounding connective tissue to mobilize it upwards for 1-2 cms.

Facial artery and vein identified and protected. Internal carotid artery pulsations felt and plane of dissection just medial to the artery to reach the retropharyngeal space on the anterior aspect of the C2 body. X-ray imaging is performed to confirm position. Long bladed Langenbeck's retractors (6-8 cms) used and anterior surface of C1 exposed with electrocautery and periosteal elevators. The C2 body was cleared of all soft tissue, anterior longitudinal ligament and longus colli divided to expose the atlanto-axial joints bilaterally. The anterior joint capsule was cut with a no. 15 blade and the synovium exposed. The joint cartilage on either side was curetted with a 2-3 mm angled Karlin's curette till the posterior margin of the joint. Skull traction could be used manipulate and distract the joint for satisfactory decortications of both the C1 and C2 lateral mass surfaces of the joint till there was some bleeding from the cortical endplates. In cases with fixed C1-C2 dislocation all soft tissue between anterior arch of C1 and odontoid process was removed, a microdrill was used to drill a hole of 3 mm into the base of the odontoid

Fig. 1 Anatomy of neck muscles

Fig. 2 Position of hypoglossal nerve under digastrics muscle

Fig. 3 Position of head and long Langenbeck's retractors

Fig. 4 Steps of exposure

process and a 3.5 mm tap was passed for securing a hold on the odontoid process which could be reduced by a gentle upward pull to reduce the distance between the anterior arch of atlas and odontoid process. The joints were grafted with tricorticate wedge graft harvested from the iliac crest or artificial bone from Surgiwear Company India.

When the atlanto-axial dislocation could not be reduced or there is significant basilar invagination the odontoid process was drilled out similar to the transoral technique to decompress the cervicomedullary junction. In 4 cases of congenital fixed dislocations, the odontoid had to be excised.

2 Fixation techniques

1. Screw plate technique

The anterior surface of the lateral mass of C1 was cleared of soft tissue. 5 mm above the midpoint of the C1-C2 joint a hole was drilled with a 3 mm drill bit directed 20 degrees upward and outwards (direction and length based on preoperative CT scan analysis) for 15 mm to 20 mm depth. 4 mm thick cortical titanium screws of 18 mm to 20 mm length were passed through a 3.5 mm thickness titanium bone compression plate (used for treatment of radius or clavicle fracture treatment). The lower hole was adjusted over the anterior surface of the C2 body just above the C2-C3 disc space and the drill hole was made

Fig. 5 Anterior surface of axis vertebra marked with needle for check X-ray

with plate in position directed 20 degrees medially and depth according to calculations on the preoperative CT scan, usually 18 mm to 20 mm, and, another 4 mm cortical screw was passed to secure the plate. Before fixing the lower screw the head was extended rotation corrected and positioned to reduce the atlanto-axial dislocation which was confirmed with intraoperative "C" arm imaging. Procedure was repeated on opposite side (Fig. 6, 7).

2. Transarticular C2-C1 screw technique

The sub-facetal surface of the C2 was cleared of soft tissue bilaterally. The anterior surface of the C2 body was made flat with a diamond 4 mm drill. The C1 lateral mass was cleared of soft tissue till its upper lateral limit could be visualized bilaterally. The skull tongs were used to correct rotation, and achieve satisfactory reduction of the atlanto-axial dislocation by extension which was confirmed by intra operative X-ray imaging. The midpoint of the C2 lateral mass was identified and the entry point chosen was 5 mm inferomedial to the midpoint, and with a 3.5 mm drill bit a hole was drilled directed to the upper-outer limit of C1 lateral mass with a 25 degree to 30 degree downward tilt (intraoperative "C" arm imaging used to confirm trajectory). The drill could be seen and felt traversing the joint space bone graft, and passing into the lateral mass of C1. A 3.5 mm titanium cortical screw 20-22 mm was passed to secure the C1-C2 lateral masses. Procedure was repeated on opposite side (Fig. 8, 9).

From a right sided approach it was always easier to pass the contralateral (left) screw so it was performed first, the ipsilateral screw requires retraction of the soft tissues of the pharynx which can add to technical difficulty.

The wound was closed by approximating the mylohyoid muscle, platysma and skin with a drain in the retropharyngeal space which was removed after 48 hrs.

Most patients were ambulated next day with a hard cervical collar with full diet next day and discharged from hos-

Fig. 6 Implants used for screw plate fixation of C1 lateral mass and C2 body

Fig. 7 Position of plate and direction of screws

pital on 3rd day. Postoperative X-rays and CT-scan confirm reduction and fixation (Fig. 10-14).

3 Results and complications

Average procedure time 3 hrs, no case required blood transfusion, reoperation in 5 cases.

2 screw malposition both ipsilateral (right sided), Reoperated within 48 hrs and screw repositioned correctly (Fig. 15).

One overdistracted of C1-C2 joint due to screw not piercing the C1 lateral mass and pushing the lateral mass of C1 away from C2 (because of inadequate drilling of C1 lateral mass) (Fig. 16). Reoperated on 3rd day and lateral mass of C1 drilled correctly and screw passed successfully.

One inadequate excision of odontoid process due to excessive preoperative backward angulation of odontoid process which had to be removed transorally after 3 weeks.

One case of screw loosening which was due to incorrect plate contouring, Reoperation after 3 weeks when patient had come for first post-operative follow-up (Fig. 17).

Follow-up in 75% for 24 mths. Rigid fixation in 100%, Mortality 0%.

Transient neuropraxia of marginal mandibular nerve and hypoglossal nerve in 17 cases (Fig. 18). Vertebral artery injury 0% Image guidance redundant and implant cost US \$ 20.

Discussion

The success of C1-C2 surgery depends upon adequate reduction and decompression of the cervicomedullary junction followed by immediate rigid fixation of the atlanto-axial joint, and ultimately, successful bony fusion of the C1-C2 joint. During atlanto-axial joint fixation surgery

Fig. 8 Trajectory for transarticular screws

Fig. 9 Anterior transarticular screw position

the main goal of the operation is adequate exposure of the atlanto-axial joints, reduction of joint malposition, decortications of the joint cartilage, bleeding from the endplates on either side for osteoinduction, and, adequate quantity bone grafting which will remain under compression. Thus the entire focus of C1-C2 surgery revolves around manipulation bone grafting and fixing the C1-C2 joint along the line of weight transmission.

As rotation is the main movement at C1-C2, the technique which stops rotation between the joint surfaces is destined for success²⁾. All metallic implants are destined

Fig. 10 Postoperative CT scan showing screw plate position with bone graft in C1-C2 joint

Fig. 11 Postoperative dynamic X-rays of a case of atlanto-axial dislocation showing rigid fixation with C1 lateral mass and C2 body screw-plate rigid fixation

Fig. 12 CT scan images showing screw position of C1 lateral mass and C2 body screw with bone graft in C1-C2 joint

for failure and their role is only till bony fusion of the joint is complete. So achieving solid bony fusion across the joint should be the ultimate goal of the operation.

Over the past century, steady advances have been made in fixating an unstable atlanto-axial complex. Current options for fixation of the atlanto-axial complex include posterior clamps, posterior wiring techniques, C1-C2 transarticular screw fixation, posterior C1 lateral mass screw

with C2 pars or pedicle screw fixation³⁾.

The posterior wiring techniques, C1-C2 clamps Hartshill sublaminar wire relied on onlay grafting or grafting between the posterior arch of C1 and lamina of C2. These techniques fail in rotation and thus came to disrepute.

In 1986 Magerl⁴⁾ described the posterior transarticular C2-C1 fixation technique (PTS) which had 100 percent fixation and fusion rate. However, there was a significant

Fig. 13 Preoperative and postoperative X-rays showing rigid fixation of atlanto-axial dislocation with anterior transarticular screws bilaterally and type of screws used

Fig. 14 CT scan and tomogram showing correct position of anterior transarticular screws

chance of vertebral artery injury with devastating complications. Anatomical variation in the C2 pedicle anatomy on pre-operative imaging has prevented passage of posterior transarticular screw in a significant number of patients⁵⁾.

Goel⁶⁾ in 1994 published posterior C1 mass screw and C2 pedicle screw with plate to fix the C1 C2, later Harm's⁷⁾ et al in 2001 popularized the technique of poly axial screw rod technique for the same. With both these technique's the incidence of vertebral artery injury reduced but still persists.

Recent literature has focused on the use of intraoperative image guidance to avoid vertebral artery injury.

Intraoperative bleeding from the paravertebral venous plexus and manipulation of the C2 ganglion to avoid injury remain surgical problems for surgeons^{8~10)}.

In a recent comparison of Harm's technique (Group H) with Magerl's technique (Group M), the major complications were vertebral artery injury (2.1% in Harms, 13.1% in Magerl's, $p=0.05$) and screw fracture (2.1% in Group H, 9.2% in Group M, $p>0.05$). Fusion rate at the end of follow-up was not-significantly higher in Group H. C1-C2 range of movements in flexion/extension at the end of follow-up was lower in Group H¹¹⁾.

Also all posterior surgical techniques involve massive disruption of the musculo-ligamentous complex which are

Fig. 15 X-ray and CT scan showing malposition of right sided anterior transarticular screw

Fig. 17 Dynamic X-ray showing rigid fixation, but, screw pull-out due to bent plate on one side

essential for spinal stability and thus these techniques are contradictory to success by adding insult to injury and against the principle of minimal invasion^{12,13}.

During the anterior extrapharyngeal approach the atlanto-axial joint reduces in extension which is used in supine position for surgery. The vertebral artery, venous plexus and C2 nerve root or ganglion are at no risk of injury in the anterior extrapharyngeal approach. The dissection is through muscle planes which do not have any postoperative adverse consequence on spinal balance and stability. From the anterior approach the C1-C2 joint exposure, decortication and bone grafting is without any anatomical constraints.

Fig. 16 Overdistracted of C1-C2 joint due to incomplete drilling of C1 lateral mass on right side

Fig. 18 Immediate postoperative tongue and lower lip weakness due to retraction induced neurapraxia of hypoglossal and marginal mandibular nerve

Anterior C1-C2 arthrodesis with separate unilateral approach for each joint has been described earlier by Barbour¹⁴) and Whitesides¹⁵).

Unilateral approach and bilateral anterior screw plate fixation with wedge bone grafting of the C1-C2 joint has not been described in literature.

Since Barbour's description in 1971 of anterior transarticular screws (ATS), many authors have published their experiences, Lesoin (1976)¹⁶), Apostolides (1987)¹⁷), Lu and Ebraheim (1998)¹⁸) Vaccaro (1999)¹⁹), Knöller's 11 cases (1999)²²), Reindl (2003)¹³) and Reimann (2004)¹²) with the largest series of 16 cases. All the authors have written about the simplicity of the technique and impor-

tance of preserving the posterior paraspinous musculature.

Kim et al (2004)²⁰⁾ showed in a cadaveric analysis that ATS was comparable to PTS and the commonly prevalent C1 lateral mass and C2 pedicle screw rod/plate techniques. Sen et al (2005)²⁾ also showed that ATS and PTS were comparable and bone grafting in the joint was redundant. Koller et al (2006)²¹⁾ in a technical analysis have suggested modification in the ATS technique with a transcorporeal pathway to enhance fixation of the C2 body.

Posterior fixation of the atlanto-axial joint is a challenging procedure with inherent risk of vascular injury (vertebral artery) and neural injury. Magerl's posterior transarticular screw fixation provides the most rigid fixation because it restricts rotational movement but is difficult in significant percentage due to variable anatomy of the axis pedicle and the course of the vertebral artery and thus was replaced by the technique of C1 lateral mass and C2 pedicle screw rod fixation, which has become the procedure of choice. However the risk of injury to the vertebral artery and haemorrhage from the perivertebral venous plexus remain deterrents to most surgeons.

Anterior extrapharyngeal approach allows reduction of the atlanto-axial dislocation, opportunity for bone grafting of the joint and with anterior C1 lateral mass and C2 body screw plate fixation or anterior transarticular screws provides rigid fixation without any risk to the vertebral artery venous plexus or spinal cord.

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