

Alternative technique of C1-2-3 stabilization-sectioning of muscles attached to C2 spinous process and C2-3 fixation

ABSTRACT

Aim: An alternative technique of C1-2-3 fixation is described that blocks the critical anteroposterior odontoid process movements and retains rotatory movement at the atlantoaxial joint. The technique involves sharp section of the muscles attached to the C2 spinous process and C2-3 transarticular interfacetal screw fixation.

Materials and Methods: We successfully used this technique of fixation in 14 cases wherein in similar case situation; we earlier advocated inclusion of C1 in the fixation construct. Eleven patients had multisegmental spinal degeneration, 1 patient had Hirayama disease, and 2 patients had ossified posterior longitudinal ligament.

Results and Technical Advantages: The procedure avoids manipulating C1 vertebra and excludes it from the fixation process, disables movement of C2 vertebra but retains rotation movements of the atlantoaxial joint that are executed by the muscles attached to the transverse process of atlas. The net effect is that the anteroposterior odontoid process movements that threaten the cervicomedullary neural structures are blocked and the critical rotatory atlantoaxial movements are retained.

Conclusions: The discussed technique can be useful for cases undergoing multisegmental fixation that includes atlantoaxial joint.

Keywords: Atlantoaxial fixation, cervical spondylosis, odontoid process

INTRODUCTION

The indications of multisegmental spinal fixation that include atlantoaxial joint and subaxial cervical vertebrae are relatively few. We recently discussed the rationale of inclusion of atlantoaxial joint in the multisegmental cervical spinal fixation for cervical spondylosis, ossification of posterior longitudinal ligament, cervical kyphosis in the pediatric age group, and that related to degenerative disease, Hirayama's disease and a host of other clinical conditions.^[1-7] It was identified that atlantoaxial instability plays a crucial or nodal role in the pathogenesis of these clinical conditions. However, it was observed that such multisegmental spinal stabilization severely restricts neck movements and can be disabling. We report an alternative technique of multisegmental spinal fixation wherein the critically dangerous atlantoaxial movements are blocked and rotatory movements are retained. The technique avoids direct inclusion of the atlas in the fixation construct.

MATERIALS AND METHODS

During January 2017 to September 2017, 14 patients were treated by multisegmental spinal fixation with the technique discussed. The indications for such multisegmental fixation are elaborated in Table 1. The number of spinal segments that were fixated is shown in Table 2. The ages of the patient ranged from 18 to 70 years (average being 48.6 years). There were 12 males and 2 females. The examination of the clinical

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status was based on Goel clinical scale,^[8] JOA,^[9] and VAS^[10] and is detailed in Table 3. All patients were investigated with dynamic computed tomography scan with the head in flexed and extended positions and magnetic resonance imaging.

The patients were operated in the prone position. Gardner Wells cervical traction was applied before the patient was turned prone. The head end of the operation table was elevated by 30° and was aimed to provide counter-traction. C2-3 and rest of the subaxial spinal fixation was done by transarticular screw fixation with the technique described by Roy-Camille and Saillant in 1972.^[11] Appropriate size osteotome was introduced into the articular cavity and rotated in a screwing fashion to denude the articular cartilage widely. 12–16 mm screws were inserted at each level [Figures 1 and 2]. In most cases, a single screw was inserted at each level, but wherever it was feasible, safe or necessary, two screws were inserted in a transarticular fashion to provide a double-insurance fixation.^[12,13] Bone graft pieces were inserted into the articular cavity by the sides of the screws. All soft tissues attached to the spinous process that included muscles and ligaments were cut sharply. The muscles attached to the C2 spinous process were specially removed by sharp dissection and with the help of drill.^[14] Bone graft was harvested from the iliac crest. The outer cortex of lamina, spinous process, and exposed part of facets was drilled to make it a suitable host for bone graft acceptance.

The follow-up period ranged from 10 to 18 months (average 14 months). There were no postoperative neurological or

infective complications. All patients improved in their clinical status after the surgery, and improvement was sustained at the time of follow-up [Table 3]. Neck movements were restricted related to multisegmental spinal fixation. Although some degree of rotation of the neck was present, it was not appropriately evaluated or compared with patients undergoing multisegmental fixation that included the atlas bone [Figure 1g].

DISCUSSION

The flat and round articular surfaces of the facets of atlantoaxial joint permit circumferential and unrestricted movements. While the special architecture of the joints permits wide range movements, it also subjects it to an enhanced possibility of instability. Our analysis suggests that whilst atlantoaxial joint is the most mobile joint of the body, it is also potentially the most unstable joint of the body.

Atlantoaxial instability can be of anteroposterior,^[15,16] lateral,^[17] vertical,^[18] rotatory,^[19] and of translatory^[17,20] types. On the basis of facet alignment and direct intraoperative observation of bones of the atlantoaxial region and status of facet articulation, we introduced an alternative classification of atlantoaxial dislocation.^[21] Imaging is done with the head in neutral position and the sagittal cuts passing through the atlantoaxial facets. In type 1 atlantoaxial facet instability, the facet of the atlas is positioned anterior to the facet of axis. In such a situation, atlantodental interval is generally increased and the odontoid process compresses the dura and neural structures of the craniocervical region. In type 2 atlantoaxial facet instability, the facet of atlas is positioned posterior to the facet of axis. In type 3 atlantoaxial facet instability, the facets are in alignment, and instability is diagnosed on the basis of direct intraoperative observations of instability by direct manual manipulation of bones of the region. In both

Table 1: The indications of the technique

Condition	Number of patients
Cervical spondylotic myelopathy	11
OPLL	2
Hirayama disease	1

OPLL - Ossified posterior longitudinal ligament

Table 2: The radiological features and the number of levels fixed

Case number	Age/sex	Radiological features	Number of levels fixed
1	69/male	C4-5, C5-6 degenerative changes with type 2 atlantoaxial facet instability	C2-C6
2	54/male	C3-C6 OPLL with type 3 atlantoaxial facet instability	C2-C6
3	32/male	C2-3, C3-4 spondylotic changes with type 2 atlantoaxial facet instability	C2-C5
4	50/male	C3-4 spondylotic changes with type 3 atlantoaxial facet instability	C2-C7
5	45/male	C3-4 OPLL with type 2 atlantoaxial facet instability	C2-C7
6	41/male	C5-6 spondylotic changes with type 2 atlantoaxial facet instability	C2-C6
7	28/male	C3-4, C4-5, C5-6 spondylotic changes with type 2 atlantoaxial facet instability	C2-C7
8	18/male	Hirayama disease, C4-C7	C2-C7
9	48/male	C3-4, C4-5, C5-6 spondylotic changes with type 3 atlantoaxial facet instability	C2-C6
10	48/male	C3-4, C4-5, C5-6 spondylotic changes with type 3 atlantoaxial instability	C2-C7
11	36/female	C4-5, C5-6 spondylotic changes with type 3 atlantoaxial instability	C2-C7
12	70/female	C5-6, C6-7 spondylotic changes with type 2 atlantoaxial instability	C2-C7
13	69/male	C3-4, C4-5, C5-6 spondylotic changes with type 3 atlantoaxial instability	C2-C6
14	67/male	C3-4, C4-5, C5-6 spondylotic changes with type 3 atlantoaxial instability	C2-C6

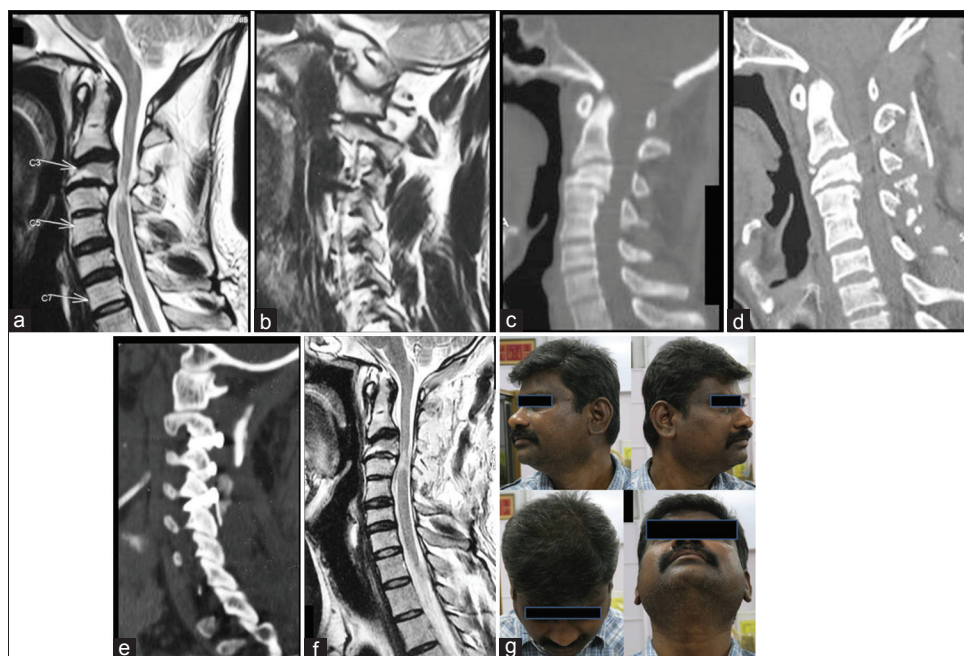


Figure 1: Images of a 32 year old male patient [Case 3]. (a) T2 weighted sagittal magnetic resonance imaging showing cervical spondylotic myelopathy with disc protrusions at C2-3 and C3-4 levels. (b) Sagittal magnetic resonance imaging with cut through the facets showing the Type 2 atlantoaxial facet instability. (c) Computed tomography scan of the cervical spine with the head in flexion. (d) Postoperative computed tomography scan of the patient showing posterior midline bone graft. (e) Postoperative computed tomography scan with the cuts through the facets showing the C2-3, C3-4 and C4-5 transarticular screw fixation. (f) Postoperative magnetic resonance imaging showing the reduction of cord compression. (g) Images showing the range of neck motion after fixation

Table 3: The pre- and post-operative clinical scores of the patients

Case number	Preoperative VAS	Preoperative JOA	Preoperative Goel grading	Postoperative VAS	Postoperative JOA	Postoperative Goel grading
1	6	12	3	0	16	1
2	9	15	2	1	17	1
3	9	8	3	0	14	2
4	7	15	2	1	16	1
5	7	11	2	0	16	1
6	9	12	3	1	15	1
7	6	5	4	1	15	2
8	3	15	1	0	16	1
9	7	5	5	1	12	2
10	8	11	3	1	15	1
11	5	7	5	0	16	1
12	9	12	3	0	17	1
13	6	10	3	1	16	1
14	7	7	4	1	14	2

VAS - Visual analog scale, JOA - Japanese Orthopedic Association Score

types 2 and 3, the atlantodental interval may not be abnormal, and there may be no compression of dural tube or neural structures. Such type 2 and 3 atlantoaxial facet instability is referred to as central or axial atlantoaxial instability.^[22] Central or axial instability may be associated with chronic or longstanding unstable atlantoaxial region in clinical conditions such as Chiari malformation, syringomyelia, basilar invagination, cervical degeneration, ossified posterior longitudinal ligament, Hirayama's disease, and cervical spinal kyphosis.^[1-7,23-25] It was observed that atlantoaxial instability

might be the nodal or the primary point of genesis of these clinical conditions. Atlantoaxial and subaxial stabilization was advocated as a rational treatment. Despite the fact that remarkably gratifying clinical neurological outcome was obtained following such surgery, restriction of all neck movements was disabling.

In terms of relative size of the vertebra, the transverse process of atlas and spinous process of axis are largest in their dimension when compared to the rest of the spine. The

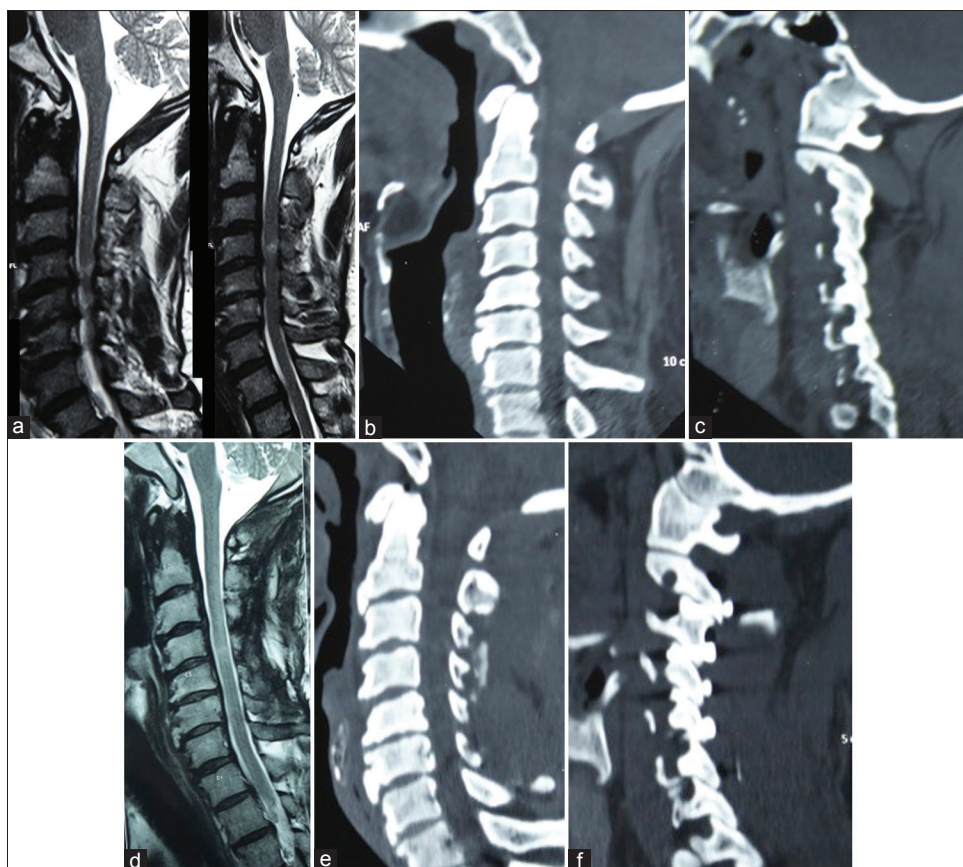


Figure 2: Images of a 48-year-old male patient [Case 9]. (a) T2 weighted sagittal magnetic resonance imaging showing cervical spondylotic myelopathy with disc protrusions at C3-4, C4-5 and C5-6 levels. (b) Computed tomography scan of the cervical spine. (c) Computed tomography scan of the cervical spine with cut through the facets showing the Type 3 atlantoaxial facet instability. (d) Postoperative magnetic resonance imaging showing the reduction of cord compression. (e) Postoperative computed tomography scan. (f) Postoperative computed tomography scan with the cuts through the facets showing C2-3, C3-4, C4-5 and C5-6 transarticular screw fixation

strongest muscles of the atlantoaxial segment are attached to the stubby spinous process of the axis. These muscles execute most anteroposterior and transverse movements that emanate from the axis. Majority of muscles attached to the atlas are focused on its transverse processes. These muscles help rotate the atlas over the odontoid process. Apart from these two sets of muscles, the muscles attached to the posterior arch of atlas, laminae and relatively short transverse processes of axis, and the thin veil like muscles located in the anterior aspect of body of the axis and anterior arch of atlas have critical but only a limited role in movements of the atlantoaxial joint. In our earlier article on the subject, we likened odontoid process and intervertebral disc to be the brain of all movements, while the brawn of all movements are the muscles that act as strings that have fulcrum over the facet joints.^[26]

The muscles attached to the spinous process of the axis conduct majority of atlantoaxial movements that occur from the posterior neck perspective. Sharp sectioning of these muscles block major anteroposterior movements of

the atlantoaxial joint and significantly affects the rotatory movements. Majority of muscles attached to the transverse process of atlas execute rotatory movements of atlas over the axis, the points of axis of rotation being at the odontoid process and atlantoaxial facets.

Combination of sectioning of muscles attached to the C2 spinous process and C2-3 facet fixation blocks all movements of axis and of odontoid process.^[14] The only major movements of the atlantoaxial joint that are retained are the rotatory movements executed by the muscles attached to the transverse process of atlas that now act on the atlantoaxial facet articulation and over the fixed odontoid process. As the movements of the axis are blocked, the potential danger of injury to the craniocervical spinal cord by the odontoid process is now avoided.

Avoidance of inclusion of the atlas in the fixation construct makes the surgical process relatively straightforward. The need to dissect in the lateral gutter is avoided. Moreover, the possibility of retaining some rotatory movements of the

neck significantly reduces the disability due to multisegmental fixation. Exact measurements of extent of rotation that was possible could not be monitored or compared as there was a wide variation in the treated groups and comparative studies were not conducted. However, it does appear that neck movements that are retained assisted in performing critically significant neck movements.

CONCLUSIONS

Sectioning of muscles attached to the large C2 spinous process and C2-3 transarticular facet screw fixation provides atlantoaxial stabilization, stops all movements of the odontoid process and retains rotatory movements executed by the muscles attached to the large transverse processes of atlas.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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