Case Report

Hybrid and double insurance atlantoaxial facetal fixation

ABSTRACT

The authors report a case of a 19-year-old female patient having basilar invagination with complex musculoskeletal abnormalities wherein atlantoaxial fixation was done with a combination of Goel and Magerl techniques on a single articulation on one side and two transarticular screws (Magerl technique) were deployed on the contralateral side articulation. The combination of Goel and Magerl techniques used in a novel fashion resulted in strong fixation and provided an environment for bone fusion. The special joint architecture and location of facet of atlas anterior and rostral to the facet of axis in the form of facetal-spondyloptosis were used to advantage as it provided a direct screw trajectory for transarticular screw insertion. The patient recovered after surgery in her neurological function. Craniovertebral junction realignment could be observed. Solid bone fusion was observed after 8 months of the surgical procedure.

Keywords: Atlantoaxial dislocation, Goel technique, Magerl technique

INTRODUCTION

Goel and Magerl techniques of atlantoaxial fixation are currently the more favored surgical treatment for atlantoaxial instability.[1-3] Direct fixation of the strongest part of the vertebral bone and stabilization at the site of the fulcrum of movements of the region is the principal advantage of both the techniques. While the individual use of both the techniques is now a commonplace surgery, their combined use as described has not been reported earlier. Furthermore, the use of two screws in a transarticular fashion in a single articulation has not been described.

CASE REPORT

A 19-year-old girl had short neck since early childhood. She presented with the complaints of pain in the nape of neck, tingling, and numbness of the left hand and weakness and spasticity of the left-sided limbs. On neurological examination, she had hyperreflexia, but motor power was essentially normal. Gait was spastic. She had decreased pain and temperature sensation in her left-sided limbs. Magnetic resonance imaging of the craniovertebral junction revealed Group A basilar invagination.[4] There was syringomyelia, external syringomyelia, and external syringobulbia.[5-7] [Figure 1a]. Computed tomography scan showed basilar invagination with occipitalization of the atlas [Figure 1b]. The facets of atlas and axis were abnormally aligned and had a complex alignment [Figure 1c and d]. The facets of atlas were located rostral and anterior to the facets of axis on both sides. On the left side, the vertebral artery was high riding and made a deep indentation into the pedicle and superior articular facet of the axis [Figure 1c]. Three-dimensional (3D) model of the patient's craniovertebral junction gave a panoramic view of the atlantoaxial region, delineated the anatomy of the region of lateral masses and atlantoaxial articulation, showed the sizes of the pedicles of C2 and relationship with the vertebral artery [Figure 1e].

Surgery

The basic surgical steps and the technique have been discussed earlier and are summarized.[1,2,4] The patient was

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placed in prone position under cervical traction. The rostral location of the joint, extensive venous bleeding in the region of the lateral gutter and complex relationship with vertebral artery made the exposure and conduct of surgery a formidable surgical task. Panoramic exposure of the region was obtained after tedious surgical dissection and section of the C2 ganglion. Bone graft was harvested from the iliac crest and stuffed in both the articular cavities after denuding the articular cartilage. On the left side, the exposure of the facet for direct screw implantation with Goel technique was not adequate. The location of the "high-riding" vertebral artery forced deployment of screws by the Magerl technique. The location of the vertebral artery was assessed on the basis of the 3D-model that was placed close to the surgeon during the operation. Two screws (2.6 mm diameter and 26 mm length) were inserted parallel to each other in a transarticular fashion. The entry point of the screw in C2 lateral mass was significantly rostral, was relatively close to the atlantoaxial articulation and traversed directly into the articular facet. The course of both the screws was above the dome of the vertebral artery as shown in Figure 2b. On the right side, the vertebral artery coursed away from the superior articular facet and pedicle of C2. The size of the C2 pedicle was significantly large [Figure 1d]. The facet of atlas was directly in the line of the pedicle of C2 [Figure 1d]. Transarticular screw insertion was first conducted. The screw head was tightened and buried in the substance of the pedicle. Plate (14 mm length) and screw (2.6 mm diameter and 26 mm length) fixation were then conducted by the side of the transarticular screw, as there was sufficient space to conduct the additional fixation procedure. In addition, bone graft was placed in the midline, after decorticating the host bone of rim of the suboccipital bone, C2 lamina, and spinous process. The patient was advised a hard cervical collar for 3 months, and neck movements were restricted during the period. Postoperative investigations revealed reduction of basilar invagination and fixation of the region using the implants [Figures 2a-c]. The patient recovered in the symptoms in the immediate postoperative phase. She was asymptomatic at the follow-up of 8 months.

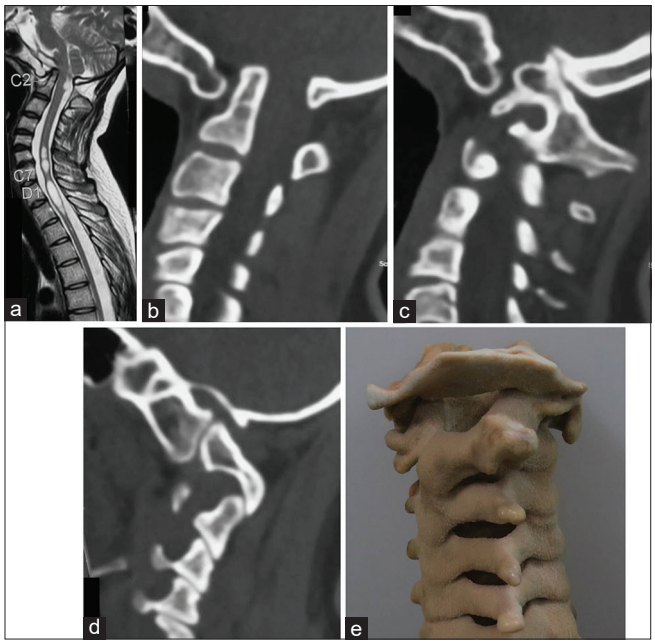

Figure 1: Preoperative images. (a) T2-weighted magnetic resonance imaging showing basilar invagination. Chiari formation and syringomyelia can be observed. (b) Computed tomography scan showing basilar invagination. Assimilation of the atlas can be seen. (c) Computed tomography scan with the cut passing through the left C1–2 articulation. The vertebral artery foramen is high riding. The facet of C1 is markedly anterior and rostrally located, making direct exposure for screw implantation difficult. (d) Computed tomography scan with the cut passing through the right facetal articulation. The articular surfaces of the facets of atlas and axis are positioned vertically. (e) Three-dimensional model of the craniovertebral junction shows the relationship of the lateral masses with the vertebral artery. The sizes of the pedicles can be appreciated clearly

DISCUSSION

Facetal fixation has been identified to be biomechanically the strongest form of atlantoaxial fixation. The facets are the fulcrum sites of all movements of the most mobile joint of the body, namely the atlantoaxial joint. The arms of the pulley that execute the pulls and pushes are the muscles that are attached mainly to the large spinous process of the C2 vertebra and transverse process of the atlas.[8] The technique of transarticular fixation described by Magerl and Grob

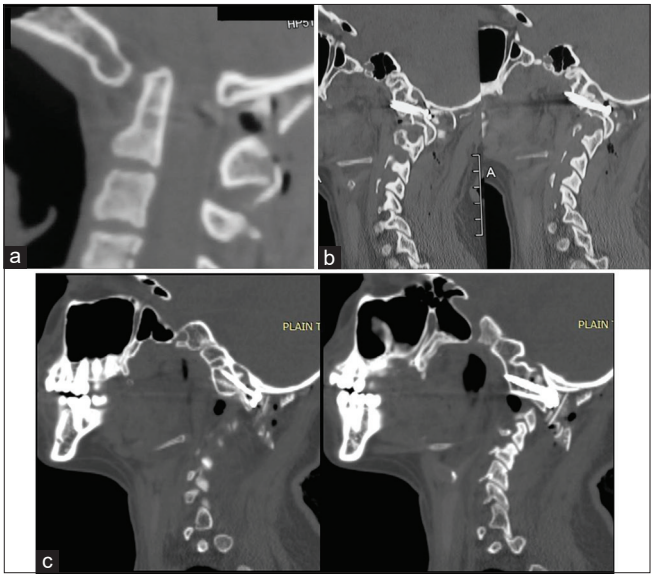

Figure 2: Postoperative images. (a) Postoperative image showing a reduction of basilar invagination and craniovertebral junction realignment. (b) Postoperative computed tomography scan of the left side articulation showing the two screws traversing in a transarticular fashion (Magerl technique). The location of the vertebral artery dome inferior to the traverse of the screws can be seen. (c) Computed tomography scan with the cut passing through the right facetal articulation. Both Goel and Magerl techniques were simultaneously used

in 1986 and lateral mass plate and screw fixation technique described by Goel in 1988 are currently the more preferred modes of atlantoaxial fixation.[1-3]

The anatomical complexity of the region made the conduct of the surgical procedure a challenging endeavor. Three-dimensional model construction was of assistance in guiding the screw insertion individually in C1 and C2 lateral masses (Goel technique) and transarticular screw insertion (Magerl technique).[1-3,9] The model helped in interpreting the size of the pedicle of axis and its suitability for inserting two screws safely and strongly for double insurance Magerl technique on the left side and hybrid Goel and Magerl technique on the right side. Panoramic and wide exposure of the atlantoaxial articulation and identification and isolation of the vertebral artery provides an opportunity to use case-specific landmarks. Direct visualization of the atlantoaxial articulation and facets of atlas and axis allowed insertion of the screw in the rostral aspect of C2 pedicle/facet. Such a rostral site of screw insertion avoided the "high riding" course of the vertebral artery. As the screws now had only a shorter travel course, it was possible to use shorter screws. Wide exposure of the surgical field allowed direct visualization of the traverse of the screw in the articular cavity. In select situations, like that in the presented case, wherein the facet of C1 was located remarkably anteriorly, direct screw insertion into the substance of its facet as is done by Goel technique could be relatively difficult. In such a situation, Magerl technique was identified to be straightforward. The location of the facet of C1 anterior to the facet of C2 provided an opportunity for direct transarticular screw insertion without the need for its acute superior angulation as is normally required while using Magerl technique. The screw insertion was with relative ease and in a comfortable straight line when compared to a situation when the facets of atlas and axis are placed one above the other in a brick over brick fashion.

We had earlier described a "double-insurance" technique of atlantoaxial fixation.[10] This technique is a modification of the conventional Goel technique of atlantoaxial fixation. The technique involved the insertion of the C1 facet screw as has been described in several articles. However, the C2 screw traversed in a transarticular fashion. The technique used the biomechanical strength of both the Goel and Magerl techniques and provided a stable fixation construct. We have also discussed earlier, the use of two screws in the pedicle of C2 for atlantoaxial and C2–3 plate and screw fixation.[11] In the presented case, the special anatomical configuration of the facet of axis, location of facet of atlas anterior to the facet of axis and the high-riding location of the vertebral artery permitted deployment of both Magerl and Goel techniques is a unique and novel fashion. The panoramic visualization of the lateral masses of the atlas and axis following wide exposure with or without the sectioning of the C2 ganglion was essential for the conduct of surgery.

The use of hybrid techniques and deployment of more than one screw in the otherwise feared C2-pedicle is possible only in rare situations. The use of 2.6–2.8 mm diameter screw instead of conventionally used 3.4–3.6 mm screws helps in providing an increased space for two screw insertion. Whenever possible, use of such hybrid and double screw techniques provided a reassuringly strong fixation and a ground for bone fusion. In our experience, with over 2500 cases treated over a 30-year period where atlantoaxial fixation was done with our technique, two screws were inserted in a single C2 pedicle-facet in five cases. Double transarticular fixation as described was done in three cases and simultaneous Magerl and Goel fixation techniques were done as described in three cases.

CONCLUSIONS

Special anatomical situation in cases with complex craniovertebral junction anomalies can be used to advantage and combined or hybrid techniques of stabilization can be done. Wide exposure and viewing of the articulation and the lateral masses of atlas and axis in a panoramic fashion are essential.

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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