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ORIGINAL ARTICLE

Outcomes of Occipitocervical Fixation and Fusion in Post-traumatic Craniocervical Instability

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Abstract

Background: **In recent years, proper management of post-traumatic craniocervical instability has been possible. However, there is a paucity of literature with long-term follow-up of these patients.**

Purpose: **The aim was to assess outcomes after surgical treatment of post-traumatic instability with occipitocervical fixation with or without fusion.**

Materials and methods: **Among 20 patients with post-traumatic unstable craniocervical junction who underwent occipitocervical fixation, there was an equal number females and males, with a mean age of 62.85 ± 17.23 years.**

The outcomes of neck disability index, neck pain visual analog scale, neurological assessment by American Spinal Injury Association score, imaging, complications, and bony fusion were assessed. Radiological assessment of anterior dental interval, posterior dental interval, and posterior occipitocervical angle was done.

Results: **Clinically, all patients presented with neck pain and only one with tetraplegia. The mean follow-up was 90.8 months. A solid bony fusion was achieved in 100% of the patients. The neck disability index and the visual analog scale improved significantly from 26 ± 6.4 and 7.7, respectively, at the presentation to 15.3 and 3.6, respectively, at the final follow-up. The anterior and posterior atlantodental interval and the posterior occipitocervical angle improved significantly. One patient required early revision.**

Conclusion: **Occipitocervical fixation with or without fusion can be considered a valuable option in the treatment of instability with a high fusion rate and fewer complications. Temporary occipital fixation may be considered with later removal but may be associated with unintended occipitoatlantal fusion.**

Keywords: Atlas fracture, Craniocervical, Fusion, Instability, Odontoid fracture

1. Introduction

The craniocervical junction consists of the atlas, the axis, and the occipital condyles which are all connected with strong ligaments that allow for an optimal range of motion with maximum stability.[1] Instability is defined as the loss of ability to maintain the relationships between the vertebrae of the injured spine under physiologic loads. However, the criteria for instability in the upper cervical spine are still widely controversial.[2] There are only a few classification systems that support decision making concerning instability and concluded that ligamentous integrity is the key element affecting the stability of the upper cervical spine.[3] Occipitocervical fixation (OCF) aims to stabilize a mechanically compromised craniocervical area, and correct displacement with the prevention of neurological dysfunction.[4] The posterior midline approach is mainly used for surgical exposure and fixation, but in cases of unstable traumatic spondylolisthesis of the axis, the anterior approach may be used.[5] This study aimed to assess the outcomes of OCF in patients with post-traumatic instability.

2. Materials and methods

A retrospective review of the prospectively collected database of patients with post-traumatic

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instability undergoing occipitocervical fixation with or without fusion was performed. Those who treated only with atlantoaxial fusion were excluded. These patients presented with neck pain or progressive neurological deficit after traumatic events and instability diagnosed by imaging including plain radiographies, computed tomography, and MRI.

2.1. Indications for surgery

Indications for surgery were as follows: unstable atlas fracture in five cases, combined atlas and odontoid in 10 cases, type II odontoid in three cases, combined C2/C3 fracture in an ankylosed patient, and combined atlas with occipital condyle fracture in the remaining one.

Patients with no extension of fixation to the cranium (only atlantoaxial) and who did not complete a minimum postoperative follow-up of 24 months were excluded. Instrumentation included using either bilateral contoured reconstruction plates in six patients or a median occipital plate with contoured rods and polyaxial in the remaining 14.

Ethical approval was obtained from our Institutional Review Board (IRB) before the conduct of the study.

2.2. Surgical technique

After fiber-optic endotracheal intubation, surgery was done in a prone position with the face resting on special foamed pads and the arms tucked by the patient's side. A midline posterior approach from inion to C3 level was used and extended caudally when subaxial pathology was presented. Subperiosteal dissection of paravertebral muscles was performed. A median occipital plate (Fig. 1) or two contoured titanium reconstruction plates (Fig. 2) were applied to the occiput and fixed with bicortical screws. Usually, transarticular C2/C1 fixation was done either through plates, connected to rods when possible, or solely outside rods. Fixation of lateral mass subaxially was applied when necessary, according to described techniques.[6,7] Two C arms were used perpendicularly for the assessment of reduction and fixation. Decortication of the posterolateral spinal elements and exposure of cancellous bone for preparation of fusion which was completed by countered iliac bone graft between the occiput and spinous process of C2, fixed by nonabsorbable sutures. A local closed system negative suction drain was inserted for 48 h.

Postoperatively, a cervical collar was applied for a period of 6–2 weeks, and at least 12 weeks in cases treated with Reco-S constructs.

2.3. Outcomes assessment

The preoperative, intraoperative, and postoperative data were collected, and radiological studies were taken and measured in a digital form. The intraoperative profile assessment included operative time, blood loss, and intraoperative complications.

The clinical and radiographic follow-up was 90.8 ± 43.21 ranging from 24 to 288 months. The neck disability index (NDI) and the visual analog scale (VAS) were recorded as clinical outcome parameters immediately before surgery and at the final follow-up. The neurological status was assessed by American Spinal Injury Association (ASIA) score preoperatively as well as at the final follow-up. Plain cervical spine radiographs were obtained on the first postoperative day and the last day before discharge and regularly over the follow-up period.

The following radiological parameters were measured preoperatively and postoperatively:

(1) Anterior dental interval (ADI): from the posterior aspect of C1 to the anterior aspect of the odontoid.
(2) Posterior dental interval (PDI): from the posterior surface of the odontoid to the anterior surface of the posterior arch of C1.
(3) Posterior occipitocervical angle (POCA) is defined as the angle formed by the intersection of a line drawn tangential to the flat posterior aspect of the occiput between the foramen magnum and occipital protuberance and the line determined by the posterior aspect of the third and fourth cervical facets.[8]

2.4. Radiographic fusion

Fusion was determined according to lateral cervical spine radiographies by the presence of solid mass between the occiput and the C2 vertebra without signs of construct failure (fracture of plate, loosening of plate, or screws).

2.5. Statistical analysis

Analysis of the collected data was done using the SPSS (Statistical Package for the Social Science; IBM Corp., Armonk, New York, USA) release 22 for Microsoft Windows program on an IBM-compatible computer. Demographic data and frequencies were calculated using mean and standard deviation. Clinical and radiological parameters were analyzed using paired *t*-tests. Statistical significance was established at a P value of less than 0.05.

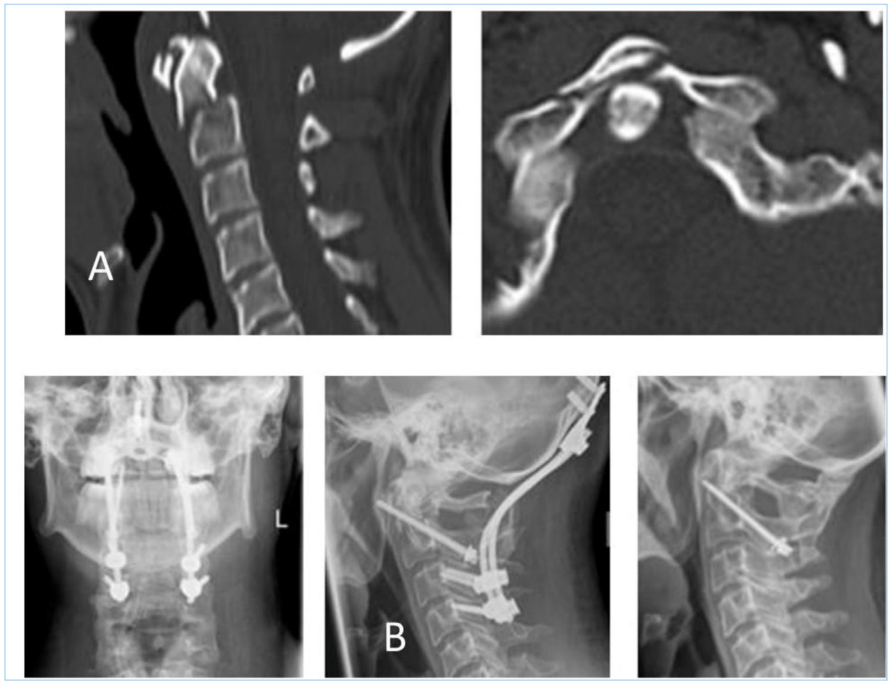

Fig. 1. Computed tomography showing fracture of the odontoid process and atlas fracture (A), postoperative anteroposterior, lateral (B), and at final follow-up.

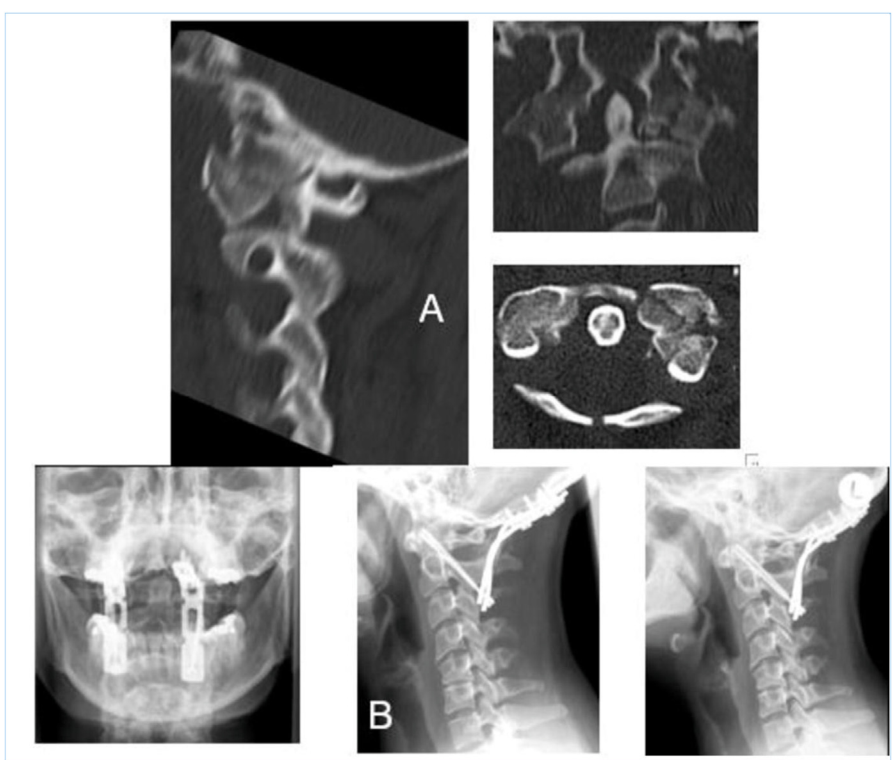

Fig. 2. Computed tomography showing comminuted left lateral mass fracture (A), postoperative anteroposterior, lateral (B), and at final follow-up.

3. Results

3.1. Perioperative data

Of 20 patients, there was an equal number of males and females. The mean age at surgery was 62.85 ± 17.23 years. All patients presented with neck pain except one with tetraplegia. The indication of surgery was unstable atlas fracture in five cases, combined atlas and odontoid in 10 cases, type II odontoid in three cases, combined C2/C3 fracture in an ankylosed patient, and combined atlas with occipital condyle fracture in the remaining one. The neurological ASIA score was E in 14 patients, D in five patients, and C in one patient.

The mean operative time (including graft removal) was 178 ± 49.59 min, and the mean amount of blood loss was 470 ± 196.28 ml. Posterior-only approach was used in all patients with one patient also needing anterior C2/C3 fixation. In 14 patients, occipital plate with contoured rods was used, and in the remaining six, contoured bilateral paramedian titanium reconstruction plates were used.

Lower instrumented vertebrae were C2 in 14 patients, subaxial to C3 in three patients, C4 in one patient, C5 in one patient, and one was to T1.

C2 fixation was achieved through transarticular C1–C2 screws (37 screws were inserted), pedicle (one screw), and in one patient C2 was skipped.

Bone graft was done in 18 patients between the occiput and C2, in one patient between C1 and C2 only with temporary fixation at the occiput, and the remaining one had no bone graft at all.

3.2. Clinical outcome

The neurological status showed no change from the time of presentation to the final follow-up (Table 1).

The mean VAS for neck pain improved significantly from 7.74 ± 0.87 preoperatively to 3.63 ± 2.76 at the final follow-up ($P = 0001$ and $t = -6.19$) and the mean value for the NDI improved significantly from 26 ± 6.44 at presentation to 15.32 ± 5.19 at the final follow-up ($P = 0001$ and $t = -5.62$).

Table 1. Clinical outcomes.

Clinical assessment	Preoperative	Final follow-up	
Neurological status			
ASIA E	14	14	
ASIA D	5	5	
ASIA C	1	1	
Total	20	20	
VAS	7.74 ± 0.87	3.63 ± 2.76	$P = 0.00$ (<0.05)
NDI	26 ± 6.44	15.32 ± 5.19	$P = 0.00$ (<0.05)

ASIA, American Spinal Injury Association score; NDI, neck disability index; VAS, visual analog scale.

3.3. Radiological outcome

All radiological outcomes showed improvement. ADI improved from a mean of 3.47 ± 1.28 to 2.32 ± 0.56 mm and PDI from 11.02 ± 2.28 to 16.84 ± 1.82 mm. POCA changed from a mean of 100.76 ± 12.6 to 98.74 ± 10.72° (Table 2).

3.4. Complications

No intraoperative complications were seen. Early postoperatively, one patient needed early revision and two presented with wound problems, where one needed revision and the other was a superficial infection treated with antibiotics and dressing. The revised patient was presented with a type II odontoid fracture with a history of a previous subaxial anteroposterior decompression and fusion due to subaxial stenosis and developed postoperative loosening of occipital screws that required revision. Implant removal was done after fusion in two patients due to pain, which significantly improved after construct removal.

3.5. Fusion

Fusion was detected in 100% of patients where fusion was the aim of surgery (in 18 patients), but the remaining two patients were temporarily fixed without the aim of fusion.

4. Discussion

The craniocervical junction consists of biomechanically specified structures that allow nearly 50% of flexion and extension and 25% of rotation from the whole range of motion of the cervical spine.[1,9] The most crucial element in determining the stability of occipital condyle fracture, atlas fracture, and AA instability is the transverse ligament integrity. Although the integrity of the tectorial membrane and alar ligament determine the stability of atlanto-occipital dissociation, the integrity of the anterior longitudinal ligament, disc, and facet joint is attributed to the stability of axis fractures.[3] Objectives for OCF are stabilization, decompression, restoration of alignment, and arthrodesis.[10] As a result of the

Table 2. Radiological outcomes.

Radiological parameter	Preoperatively	Postoperatively	P value
ADI (<3 mm)	3.47 ± 1.28	2.32 ± 0.56	0.0001
PDI (>14 mm)	11.02 ± 2.28	16.84 ± 1.82	0.0001
POCA (109 ± 5.7°)	100.76 ± 12.6	98.74 ± 10.72°	0.588

ADI, anterior dental interval; PDI, posterior dental interval; POCA, posterior occipitocervical angle.

nature and location of this surgery, adverse effects such as neurological impairment, vascular injury, wound infection, construct failure, pseudoarthrosis, and persistent instability can occur.[10,11]

A variety of surgical techniques for occipitocervical fusion has evolved, resulting in better alignment, a higher fusion rate, and fewer complications.[5,10,12,13] In this study, we aimed to assess the neurological and radiological outcomes of patients with post-traumatic instability.

This series comprised 20 patients with equal sex distribution and an average age of 62.85 ± 17.23 years.

Although all patients were operated on via a posterior approach, in one patient additional anterior procedure was combined for C2/C3 fixation. Moreover, patients were approached from the posterior only.[14-16]

In 14 patients, an occipital plate with contoured rods was used, whereas six patients were fixed using paramedian bilateral contoured plates. Occipital plate with contoured rods allows a greater degree of intraoperative correction, and reconstruction plates can be contoured to adapt to the morphology of this area but have significant limitations with screw placement and stability.

The lower instrumented vertebrae were C 2 in 70% followed by subaxial in five patients and the only one that was extended to T1 was previously operated on for subaxial stenosis by dorsoventral fusion to T1. Upadhyaya et al.[16] reported that the levels ranged from C2 to C6, mostly ending at C2.

Pan et al.[17] compared one group ending at C2 to another group ending at C3 and reported no statistical difference in fusion between the two groups. They concluded that fixation to C2 should be used when there is no subaxial instability, but in patients with severe osteoporosis or other diseases affecting instrumentation stability, individual planning is necessary for biomechanical study.

Finn et al.[18] proved that C1–C2 transarticular fixation is the best biomechanically method. This mirrors our experience, and it is reflected in the utilization of transarticular fixation nearly in all patients.

In the present study, there was no change between preoperative and final neurological status.

The VAS also improved from 7.74 ± 0.87 preoperatively to 3.63 ± 2.76 at the final follow-up. This is comparable to results obtained by Upadhyaya et al.[16] in which VAS improved from 6.65 ± 1.1 to 2.42 ± 0.49 at the final follow-up. The NDI improvement of the present study was comparable to that of Bhatia et al.,[19] who found significant improvement in patients with trauma.

ADI in this study improved from a mean of 3.47 ± 1.28 to 2.32 ± 0.56 mm, which is in the normal range of 3 mm. Upadhyaya et al.[16] showed improvement in anterior atlantodental interval from a mean of 4.2 ± 1.7 to 2.5 ± 1.9 mm.

PDI, which represents SAC and normally accounts for greater than 14 mm, showed improvement from 11.02 ± 2.28 to 16.84 ± 1.82 mm.

The POCA best biomechanically changed from a mean of 100.76 ± 12.6 to 98.74 ± 10.72°. In the series of Upadhyaya et al.,[16] POCA was changed from a preoperative mean of 118.67 ± 12.29 to 107.15 ± 12.05° postoperatively. In consequence, it seems important to avoid a postoperative increase of the POCA to avoid increased stress on the construct that may lead to caudal adjacent segment disease.

Fusion was achieved in 100% of patients, comparable with fusion obtained in other studies ranging from 88 to 97%.[10,14-18]

Sawin et al.[20] reported an overall rate of bony fusion using iliac crest graft of approximately 91%. In our study, autografts were always harvested from the iliac crest with a fusion rate of 100%.

The mean time to fusion was 10.57 ± 1.43 months, which is similar to the mean of 11.039 months obtained by Upadhyaya et al.[16]

We experienced complications in 15% of patients compared with a range between 10 and 40% in the other reported series.[10,12,14,15]

5. Conclusion

Occipitocervical fixation with or without fusion can be considered a valuable option in the treatment of instability with a high fusion rate and fewer complications. Temporary occipital fixation may be considered with later removal but may be associated with unintended occipitoatlantal fusion.

Authors contribution

M.A.I. study design, data collection, statistical analysis, writing and revision of the manuscript, and reviewing the literature. H.B.: study design, data collection, and critical reviewing of the manuscript. H.A.E.G.: study design and revision of the manuscript. A.A.: study design and revision of the manuscript.

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Conflict of Interest

There are no conflicts of interest.

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