Stable reconstruction using halo vest for unstable upper cervical spine and occipitocervical instability

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Abstract

Introduction Upper cervical or occipitocervical disorders such as rheumatoid arthritis present as atlantoaxial subluxation, vertical subluxation of the axis, and subaxial subluxation, which produce myelopathy and severe pain. In such cases, occipitocervical reconstruction surgery may be indicated, and several reports have described reduction of subluxation by fixing the halo vest before this surgery.

Purpose The purpose of this study was to evaluate the efficacy of using the halo vest before the surgery for unstable upper cervical spine and for occipitocervical instability.

Methods Twenty-eight patients (9 men and 19 women; mean age, 61.8 years at surgery) who presented with atlantoaxial or occipitocervical fusion were studied. In all cases, the halo vest was fixed in the conscious condition, and subluxation was reduced before the surgery. The mean follow-up period was 45 months. Roentgenologic measurement and clinical evaluation were performed before the surgery and at the final follow-up.

Results Using the halo vest resulted in significant reductions in the atlantodental interval, the space available for the spinal cord, and the Ranawat value ($p < 0.05$), and these were maintained until the final follow-up. The mean Japanese Orthopedic Association score significantly improved from 9.5 before surgery to 12.2 at the final follow-up ($p = 0.01$). Nineteen cases (68%) improved by more than 1 grade by Ranawat's classification after surgery and 16 cases (57%) maintained the same at the follow-up visit.

Conclusion Conscious preoperative reduction using the halo vest for occipitocervical disorders is a useful and safe technique.

Keywords Occipitocervical disorders · Occipitocervical reconstruction · Halo vest

Introduction

The upper cervical spine and occipitocervical junction have characteristic embryological and anatomical structures that differ from the middle or lower cervical spine, and are the most mobile sections of the cervical spine. Because of these characteristics, symptoms caused by congenital malformation, rheumatoid arthritis (RA), or trauma appear frequently in this region [1, 4, 6–9]. Disorders such as atlantoaxial subluxation (AAS), vertical subluxation of the axis (VS), and subaxial subluxation (SAS) are frequently present in this region [4, 7, 26]. The instability of this region, which contains the medulla–cervical junction, increases the possibility of local pain, dyskinesia, and severe symptoms including dyspnea. Neurological decompression and occipitocervical reconstruction are recommended for the treatment of these conditions [1, 3].

Although occipitocervical reconstruction is frequently performed using a posterior approach, this technique has the risk of spinal cord injury during intubation under general anesthesia, repositioning from the supine to prone position, and reduction using the Mayfield head holder or instrumentation. Dyspnea and/or dysphagia in the posterior occipitocervical fusion caused by a preexisting reduction of the pharyngeal space and occipitocervical fusion malalignment have been reported [11, 21].

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Perry and Nickel [24] developed the halo vest to provide rigid cervical spine stabilization to treat patients with severe scoliosis or neck muscle paralysis due to poliomyelitis and reported successful clinical follow-up [24]. Since then, the halo vest has been widely used to immobilize the neck in pre- or postoperative settings for cervical spine injuries or deformities and upper cervical or occipitocervical disorders. The use of the halo vest to avoid risks of spinal cord injury and airway obstruction in surgeries for upper cervical/occipitocervical disorders has been reported. Miyamoto reported that attaching the halo vest preoperatively resulted in improved neurological status and activity of daily life (ADL) in patients with occipitocervical junction or upper cervical disorders [20]. However, only a few clinical reports of multiple cases have been published.

We performed occipitocervical reconstruction after conscious reduction of subluxation with the halo vest

before surgery followed by posterior approach surgery without perioperative reduction. The purpose of this study was to evaluate the efficacy of using the halo vest before surgery for unstable upper cervical spine and occipitocervical instability.

Materials and methods

After approval by the investigational review board of our hospital (No. 1619), 28 patients (9 men and 19 women; mean age, 61.8 years at surgery; range, 45–78 years) who presented with atlantoaxial fusion or occipitocervical fusion on the upper cervical spine or other occipitocervical disorders from January 2000 to November 2007 were studied. The pathology included 22 cases of RA, 3 cases of traumatic AAS, 1 case of occipitocervical junction

Table 1 Clinical profile of the patient and details of the surgical procedure

Case	Age (year)	Gender	Follow-up (month)	Diseases	Disorders	Extent of fusion	Complications
1	54	M	96	RA	AAS	C1-2	
2	56	F	96	RA	AAS, VS, SAS	C0-T2	
3	64	M	49	Trauma	AAS	C1-2	
4	63	F	79	RA	AAS, VS, SAS	C0-T1	
5	72	M	48	RA	AAS, VS, SAS	C0-T1	Occipital screw back-out
6	56	M	50	Trauma	AAS	C1-2	
7	62	M	60	RA	AAS, VS	C0-7	
8	70	M	58	Trauma	AAS, VS	C0-3	
9	54	M	60	RA	AAS	C1-2	
10	62	F	42	RA	AAS, VS	C0-5	
11	78	F	48	RA	AAS, VS, SAS	C0-T1	
12	53	M	48	Congenital anomaly	AAS, VS	C0-6	
13	67	F	36	RA	AAS	C1-2	
14	54	F	48	RA	AAS, VS	C0-2	
15	56	F	48	Skeletal dysplasia	AAS, VS, SAS	C0-T3	
16	63	F	48	RA	AAS, VS	C0-2	
17	45	F	24	Down syndrome	AAS, VS	C0-4	
18	53	F	42	RA	AAS, VS	C0-7	
19	51	F	34	RA	AAS	C1-2	
20	78	F	36	RA	AAS	C1-2	
21	51	F	36	RA	AAS	C1-2	
22	58	F	24	RA	AAS, VS	C0-3	
23	69	F	24	RA	AAS, VS	C0-6	
24	72	F	36	RA	AAS, VS	C0-3	
25	76	F	24	RA	AAS, VS	C0-2	Wound infection
26	54	F	36	RA	AAS	C1-2	
27	68	F	24	RA	AAS, VS	C0-3	
28	72	F	36	RA	AAS	C1-2	

RA rheumatoid arthritis, AAS atlantoaxial subluxation, VS vertical subluxation, SAS subaxial subluxation, C cervical, T thoracic, M male F female

abnormality, 1 case of skeletal dysplasia, and 1 case of Down syndrome. The disorders included 10 cases of AAS, 13 cases of AAS + VS, and 5 cases of AAS + VS + -SAS. The mean postoperative follow-up period was 45.4 months (range, 24–96 months) (Table 1).

Reduction technique with the halo vest

The halo vest (Depuy-ACE, Warsaw, IN, USA) was applied to all patients from 2 to 4 days before surgery, and conscious reduction of subluxation was performed in the supine position under an image intensifier in the lateral plane. The reduction procedure was as follows. An appropriate pillow was placed under the head and a neck-band (Depuy-ACE, Warsaw, IN, USA) was hooked around the posterior nape to two anterior rods (Fig. 1a). The band was then placed behind the C2 spinous process, and reduction was performed by pushing the C2 spinous process forward by tightening the band. The halo-tongue position was maintained by hand and slight traction was applied by pulling the chin with the patient in the supine position under an image intensifier in the lateral plane.

During this process, a space greater than 1 cm was maintained between the cervical vertebrae and the mandible to avoid difficulty in swallowing or talking, because these symptoms may appear in the flexion position and result in decreased ADL. The appropriate reduction was adjusted by moving the halo-tongue back and forth (Fig. 1b). These procedures were performed gently because the patient was conscious. After confirmation of the capability of swallowing and talking, the halo-tongue and vest were connected with rods. The patient's condition, including paralysis, improvement of occipital and/or neck pain, breathing condition, swallowing, talking, and downward gaze was observed until the surgery [10, 15]. Because tidal air is sometimes decreased by fixation of the halo vest, breathing-related physiotherapy, including deep breath or expectoration discharge, was provided to prevent respiratory complications, if necessary [19].

Surgical procedure

Surgery was performed under general anesthesia with intratracheal intubation under fibroscope. Under anesthesia,

Fig. 1 **a** A special neckband (arrow) was hooked on two anterior rods and the nape at the C2 level. **b** The halo vest was applied before surgery and conscious reduction of subluxation was performed in the supine position under an image intensifier in the lateral view

Fig. 2 **a** Special adaptor. **b** Operative position. The Mayfield head holder and the halo-tongue were joined by a special adaptor (arrow)

the patient was turned to the prone position, the arm of the Mayfield head holder and the halo-tongue were joined by a special adaptor (Surgical Bed Adapter; PMT, Inc., Chanhassen, MN, USA), and the view of the surgical field for posterior cervical spine surgery was secured by removing the posterior parts and rods of the halo vest [19] (Fig. 2).

At this time, X-ray imaging was performed to check the reduction position and confirm that the mandible and cervical vertebra were not overlapping. Overlap of the mandible and cervical vertebrae results in fixation at the position and could result in aphagia or airway obstruction. If the appropriate reduction position and absence of overlap were confirmed, the head-cervical position was maintained, and reduction was not performed during surgery. Spinal fusion was then performed in situ using the following instrumentation: occipitocervical fusion using occipital plate–cervical rod and pedicle screws in 18 patients and transarticular screw fixation (Magerl's procedure [16]) in 10 patients (Table 1). Decompression was performed in patients who presented with myelopathy due to spinal cord compression. All patients underwent posterior bone graft using autogenous iliac or local bone and, if necessary, supplemental artificial bone. The patients were returned to the supine position after surgery. The halo vest was removed as soon as possible after surgery, and a neck brace was not generally used; however, the halo vest was maintained or a neck brace was used when internal fixation was weak because of osseous fragility. The patients were permitted to get out of bed 1 day after surgery.

Evaluation

All patients were observed until November 2009, and retrospective evaluation was performed. Roentgenological measurements of atlantodental interval (ADI) and space available for the spinal cord (SAC) were performed in all cases, accompanied by AAS [12]. The Ranawat value and the O-C2 angle were measured using a lateral X-ray image in 18 cases, accompanied by VS (for spaces of 13 mm or less before surgery). The Ranawat value was measured as follows: the coronal axis of the C1 vertebra was determined by connecting the center of the anterior arch of the C1 vertebra with its posterior ring. The center of the sclerotic ring in the C2 vertebra, representing the pedicle, was marked. The distance between the spot marking the pedicles of the C2 vertebra and the coronal axis of the C1 was measured [25]. The O-C2 angle was defined as the angle between the McGregor's line and the inferior endplate line of C2 [21]. Plain lateral view radiographs in the standing or sitting position were used for evaluation, and the lateral view in the supine position was used during reduction using the halo vest immediately before surgery. These

parameters were measured before surgery, immediately before surgery, immediately after surgery, and at the final follow-up visit.

The Japanese Orthopedic Association (JOA) scoring system and Ranawat's classification of neurological deficits were used for clinical evaluation. Ranawat's classification is defined as follows: Class I, no neural deficit; Class II, subjective weakness with hyper-reflexia and dysesthesia; Class IIIA, objective findings of paresis and long-tract signs but ambulation is possible; and Class IIIB, quadriplegia with resultant inability to walk or feed oneself [25].

All surgeries were performed by two senior spine surgeons (J.T. and H.H.). These parameters were studied and evaluated statistically by another spine surgeon (first author, N.O.). The Student's *t* test using SPSS14.0J (SPSS Japan Inc., Tokyo, Japan) was used for statistical analysis, with $p < 0.05$ defined as significant.

Results

Roentgenological evaluation

Table 2 shows the radiographic changes in ADI, Ranawat value, and SAC for each case, and Table 3 shows the change in ADI, SAC, Ranawat value, and the O-C2 angle shown as mean $\pm$ standard deviation (SD) at each evaluation time point from the preoperative stage to the final follow-up visit. The preoperative mean ADI of 6.5 ± 4.1 mm (range, 4–12 mm) was significantly improved to 3.4 ± 1.6 mm (range, 2–9 mm) at reduction using the halo vest ($p = 0.0006$).

The preoperative mean SAC of 13.9 ± 3.9 mm (range, 6–23 mm) was significantly improved to 17.1 ± 3.7 mm (range, 11–24 mm) at reduction using the halo vest ($p = 0.003$). The preoperative mean Ranawat value 8.6 ± 2.2 mm (range, 4–12 mm) was significantly improved to 11.0 ± 2.8 mm (range, 6–15 mm) at reduction using the halo vest ($p = 0.01$).

These three measurements were significantly improved at reduction using the halo vest and were maintained as such to the final follow-up. In RA patients, these parameters were also significantly improved at reduction using the halo vest. However, the mean follow-up Ranawat value was decreased ($p = 0.82$).

The mean O-C2 angles were $9.5 \pm 4.9^\circ$ (range, 4–21.5°) at the preoperative neutral position and $13.3 \pm 5.7^\circ$ (range, 6.1–25.5°) at reduction using the halo vest. The mean O-C2 angles showed no significant change by reduction using the halo vest ($p = 0.06$). Complications such as dyspnea and dysphagia were not observed.

Reduction of subluxation by the halo vest was not possible for 5 (AAS: 1, AAS + VS: 4; RA: 4; skeletal

Table 2 Radiographic changes for each case

Case	ADI (mm)			Ranawat value (mm)			SAC (mm)		
	Preop	Post-halo	Postop	Preop	Post-halo	Postop	Preop	Post-halo	Postop
1	4	2	2	13	15	15	18	18	18
2	6	5	2	8	9	8	20	20	20
3	4	3	2	14	15	15	16	16	16
4	5	3	3	11	13	14	14	18	16
5	10	8	3	10	14	14	11	19	17
6	4	3	2	20	20	20	21	21	21
7	5	3	4	9	11	11	12	12	12
8	5	2	3	15	15	15	12	14	20
9	10	4	3	17	20	20	6	20	20
10	4	3	4	10	13	13	14	14	15
11	5	4	5	7	10	11	15	18	16
12	8	3	2	7	14	14	14	16	16
13	6	3	3	16	16	16	10	15	15
14	6	5	4	7	7	9	10	11	13
15	5	3	2	4	6	8	14	15	15
16	9	9	5	12	12	12	11	18	16
17	10	4	3	8	15	15	11	16	16
18	4	1	2	6	9	9	19	22	22
19	11	6	5	15	15	18	16	22	24
20	10	4	5	16	15	16	23	24	23
21	5	2	3	15	15	15	18	23	22
22	7	4	4	8	11	10	14	18	18
23	5	3	2	8	12	13	13	18	20
24	12	4	3	10	13	13	9	14	15
25	8	3	3	10	11	11	13	14	18
26	12	4	4	15	15	15	12	15	17
27	8	5	5	8	10	10	11	14	14
28	8	3	3	16	16	16	15	17	17

ADI atlantodental interval, SAC space available for the spinal cord

dysplasia: 1) of 28 patients. The CT images before surgery showed synostosis between the base of the skull and C1/2 or between C1 and C2 for all these cases (Fig. 5).

Solid union was achieved in all 28 patients.

Clinical evaluation

The mean JOA scores before and after surgery were 9.5 ± 4.4 (range, 3–15.5) and 12.0 ± 2.8 points (range, 6.5–16), respectively, showing significant improvement ($p = 0.01$). At the final follow-up, the mean JOA score was 12.2 ± 3.1 points (range, 9–17) ($p = 0.01$) (Fig. 3).

Nineteen cases (68%) improved by more than 1 grade by Ranawat's classification after surgery, and 16 cases (57%) maintained the same until the final follow-up. Six of the seven patients who could not walk (IIIB) before surgery could walk (IIIA or II) after surgery. Thirteen (59%) of 22 cases from the RA group improved by more than 1 grade after surgery and 10 cases (46%) maintained the same until the final follow-up (Table 4).

Complications

No complications due to the halo vest, including infection, skull perforation, or loosening of the pin, were observed. Complications not related to the halo vest occurred in two cases (7%) after surgery (Table 1). An occipital screw back-out occurred in one patient (case 5), and revision surgery was performed. Wound infection occurred in one case (case 25). Two patients died during the follow-up period at 42 months (case 10) and 79 months (case 4) after the surgery because of pulmonary disease not related to the cervical spine disease. However, cervical spine stability was preserved in both cases.

Case presentation

The patient was a 72-year-old woman with RA (case 24). She was diagnosed with AAS and VS, and MRI revealed severe spinal cord compression at the C1 level. The halo vest was fixed 2 days before surgery and conscious

Table 3 Changes in the ADI, SAC, Ranawat value, and O-C2 angle shown as mean $\pm$ standard deviation (SD) at each evaluation time point from preoperation to follow-up

	Patients	Preop	Post-halo vest	Postop	Final follow-up
ADI (mm)	All 28	6.5 $\pm$ 4.1	3.4 $\pm$ 1.1 ($p = 0.0006$)	3.3 $\pm$ 1.3 ($p = 0.0003$)	3.6 $\pm$ 1.4 ($p = 0.0008$)
	RA 22	6.8 $\pm$ 4.4	3.7 $\pm$ 1.7 ($p = 0.03$)	3.4 $\pm$ 1.1 ($p = 0.001$)	3.6 $\pm$ 1.3 ($p = 0.002$)
SAC (mm)	All 28	13.9 $\pm$ 3.9	17.1 $\pm$ 3.7 ($p = 0.003$)	17.0 $\pm$ 3.5 ($p = 0.002$)	16.7 $\pm$ 3.4 ($p = 0.006$)
	RA 22	13.7 $\pm$ 4.0	17.4 $\pm$ 3.8 ($p = 0.0004$)	17.3 $\pm$ 3.5 ($p = 0.003$)	17.0 $\pm$ 3.2 ($p = 0.005$)
Ranawat value (mm)	All 16	8.6 $\pm$ 2.2	11.0 $\pm$ 2.8 ($p = 0.01$)	11.3 $\pm$ 2.4 ($p = 0.004$)	10.5 $\pm$ 2.8 ($p = 0.04$)
	RA 14	8.9 $\pm$ 1.9	11.1 $\pm$ 2.4 ($p = 0.009$)	11.3 $\pm$ 2.4 ($p = 0.009$)	10.6 $\pm$ 2.9 ($p = 0.82$)
O-C2 angle (degrees)	All 16	9.5 $\pm$ 4.9	13.3 $\pm$ 5.7 ($p = 0.06$)	13.4 $\pm$ 6.1 ($p = 0.05$)	13.7 $\pm$ 5.9 ($p = 0.04$)
	RA 14	9.9 $\pm$ 5.4	13.8 $\pm$ 6.1 ($p = 0.2$)	13.1 $\pm$ 5.0 ($p = 0.11$)	14.1 $\pm$ 6.6 ($p = 0.07$)

ADI atlantodental interval, SAC space available for the spinal cord, RA rheumatoid arthritis

Fig. 3 The Japanese Orthopaedic Association (JOA) score is shown as mean $\pm$ SD before surgery, after surgery, and at the final follow-up

reduction of subluxation was performed. ADI, SAC, and Ranawat values improved by the halo vest fixation. Resection of the posterior arch of the atlas and occipito-cervical fusion from C0 to C2 were performed (Fig. 4). The patient showed improvement from Class IIIA (preoperatively) to Class II according to the Ranawat classification at 36 months postsurgery.

Discussion

Lesions at the upper cervical spine or the occipitocervical junction caused by conditions such as RA affect the medulla–cervical junction and can result in severe symptoms, including occipital/neck pain, dyskinesia, or dyspnea [1, 4, 6–9]. Such pathological conditions are treated by neurological decompression and occipitocervical reconstruction to maintain the quality of life (QOL) and ADL. The natural course of conservative therapy for RA patients accompanied by myelopathy is unfavorable and reportedly

Table 4 Neurological deficit class before surgery, during halo vest immobilization, after surgery, and at follow-up

Case	Preoperation	Post-halo vest	Postoperation	Follow-up
1	IIIA	II	II	IIIA
2	IIIB	IIIA	IIIA	IIIB
3	IIIA	IIIA	IIIA	IIIA
4	IIIB	IIIA	IIIA	IIIB
5	IIIA	II	II	II
6	II	I	I	II
7	II	II	II	II
8	IIIA	II	II	II
9	IIIA	IIIA	IIIA	IIIA
10	IIIA	IIIA	IIIA	IIIA
11	IIIB	II	II	II
12	II	I	I	I
13	IIIA	IIIA	IIIA	IIIA
14	II	II	II	II
15	IIIB	IIIA	IIIA	IIIA
16	IIIA	II	II	II
17	IIIB	II	II	II
18	IIIB	IIIA	IIIA	IIIA
19	II	II	II	II
20	IIIA	IIIA	IIIA	IIIA
21	II	I	I	I
22	IIIA	II	II	II
23	IIIB	IIIB	IIIB	IIIB
24	IIIA	II	II	II
25	II	II	II	II
26	IIIA	II	II	II
27	II	I	I	I
28	IIIA	IIIA	II	II

results in persistent paralysis and bedridden state [28]. In a study of 134 RA patients, Casey et al. [2] reported that patients of Ranawat's Class IIIB did not benefit from surgery except for pain alleviation [2]. However, Takahashi

Fig. 4 **a** A 72-year-old female with RA (case 24). **a** Lateral radiograph shows AAS and VS before surgery. **b** The halo vest was fixed and AAS and VS were improved. **c, d** C0-2 fusion was performed and occipitocervical spine alignment was maintained 36 months after surgery. **e** Preoperative sagittal MRI shows severe

spinal cord compression at the C1 level. **f** Sagittal magnetic resonance image (MRI) shows decreased compression of the spinal cord after halo vest immobilization. **g** Postoperative sagittal MRI shows complete decompression of the spinal cord

et al. [29] reported possible improvement of neurological symptoms for Class IIIB patients [29].

In this region, disorders such as AAS, VS, and SAS are frequently present [4, 7, 26]. The objectives of surgical treatments for these patients are to immediately remove cervical instability and obtain long-term stability. The important factors to be considered when determining the surgical procedure include etiology, the direction of spinal cord compression, and feasible reduction of abnormal bone position [18]. Generally, anterior and posterior decompression is indicated for lesions of the anterior and posterior spine, respectively. However, anterior procedures such as the transoral approach carry the risk of infection and respiratory tract disorders and present difficulty for internal fixation [5, 13, 14]. Reduction by posterior instrumentation is feasible in many cases, because compression caused by bone can be resolved by reduction of abnormal bone position [27]. Therefore, posterior surgery is presently employed with increasing frequency.

Several reports showed that the anterior approach was not necessary when the subluxation was reduced by the halo vest, because spinal cord compression was resolved [20, 27]. We performed conscious reduction of subluxation with the halo vest followed by in situ posterior reconstruction surgery for all our patients with upper cervical or occipitocervical disorder. This procedure results in both

Table 5 Clinical results from literature review

Study	Patients	Improvement of Ranawat's class (%)	Halo vest complications
Miyamoto et al. [19]	19	21	5-Pin tract infection
Matsuyama et al. [17]	20	60	1-Pin tract infection
Takahashi et al. [29]	21	57	None
Ogihara et al. [22]	23	61	None

neurological and ADL value improvements and the patients felt relief from the posterior neck pain and neurological symptoms. The procedure also has the advantage of easy obtainment of informed consent because the effect of the surgery can be confirmed before the actual surgery. Three-dimensional analysis by Ohnishi et al. revealed that halo vest fixation resulted in changes in the walking pattern [23].

The rates of recovery of 1 grade or more of Ranawat's classification after use of the halo vest for occipitocervical surgery were reported as follows: 21% by Miyamoto et al., 60% by Matsuyama et al., 57% by Takahashi et al., and 61% by Ogihara et al. [17, 19, 22, 29] (Table 5). In our series, 19 (68%) of the 28 cases improved by more than 1

Fig. 5 a A 53-year-old female with RA (case 18). Sagittal CT image shows osseous fusion among the skull clivus and the front of the atlas. **b** Axial CT image shows osseous fusion among the lateral mass of the atlas and odontoid process

grade by Ranawat's classification after surgery, and 16 cases (57%) maintained the same until the final follow-up visit. Six of the seven patients who could not walk before surgery (Class IIIB) could walk postsurgery (Class IIIA or Class II), and improvement was maintained in five patients until the final follow-up visit.

This method allows safe performance of position change under general anesthesia, and reduction is possible without in situ fixation by instrumentation. Thus, the risks of postoperative tetraplegia or airway obstruction can be avoided [19, 20]. Airway obstruction after the posterior occipitocervical fusion caused by the preceding reduction of the pharyngeal space and the occipitocervical fusion malalignment was reported by Ichinose et al. [11]. Miyata et al. reported that when the O-C2 angle of the occipitocervical spine is fixed in an excessively flexed position, the middle and lower cervical spine could not compensate for the upper cervical kyphosis, resulting in a higher risk of upper airway obstruction and dysphagia [21]. In our case series, the postoperative O-C2 angle was larger than that before operation, and because in situ fixation was performed after confirming the patient's capability for breathing, talking, and swallowing, we observed no dyspnea or dysphagia.

Complications that can be caused by the procedure with the halo vest include pin tract infection, skull perforation, dural tear caused by osseous fragility, and decubitus by the vest [15]. In addition, fitting the halo vest is painful to the patient. To reduce the problems from halo vest fixation, we fixed the halo vest from 2 to 4 days before the surgery and removed it as soon as possible after the surgery. There were no complications caused by the halo vest in our case series. Reduction of subluxation by the halo vest was not accomplished in 5 of the 28 cases. CT images revealed osseous fusions from the base of the skull to the anterior parts of the atlas or axis, and these fusions could be a factor that inhibited the reduction (Fig. 5).

In this study, all patients were significantly improved roentgenologically and clinically at reduction using the

halo vest, which was almost maintained until follow-up. However, the follow-up mean Ranawat value was decreased in RA patients. Osseous fragility might result in reduced height of the vertebra or intervertebral disc in RA.

This study has the limitations of being a retrospective study with a small number of patients and that the outcome of a procedure that did not use the halo vest was not considered for comparison (no control). In addition, the technique of attaching a halo vest for occipitocervical disorders is not novel. However, although perioperative reduction techniques using the Mayfield head holder or instrumentation can achieve the reduction more easily, and the use of the halo vest requires additional cost, we propose that the excessive reduction resulting from the use of instrumentation leads to inferior neurological findings. Conscious preoperative reduction using the halo vest has advantages that include realization of paralytic improvement by the patient, avoidance of unnecessary surgical choice by the surgeon, a major contribution to the procurement of informed consent, and a high degree of safety. Despite its relatively higher cost, we believe that this technique has more advantages than reduction with instrumentation.

Conclusions

In posterior occipitocervical reconstructions, we performed preoperative conscious reduction of subluxation with the halo vest. This procedure achieved persistent optimal postoperative occipitocervical alignment and improved neurological symptoms; it was a useful and safe technique.

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Conflict of interest None.

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