

Complications in the Use of the Halo Fixation Device[†]

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Since its introduction in 1959 by Perry and Nickel,¹⁵ the halo fixation device has become the most common means used to immobilize the unstable cervical spine. Although it was initially designed to be used after surgery on patients paralyzed by poliomyelitis, its current use is primarily related to spinal trauma or reconstructive procedures on the cervical spine. The advantages include early mobilization of the patient and avoidance of the complications associated with prolonged bed rest, psychological benefits to the patient in terms of being able to walk or more fully participate in the rehabilitation program, and a shorter hospital stay. Compared with conventional orthoses, the halo vest or halo body jacket offers more rigid immobilization of the cervical spine, the ability to more precisely position the neck to obtain or maintain cervical alignment, and less interference with mandibular motion and eating.^{1, 7-12, 14-17} However, the majority of the reviews in the literature concerning the halo have concentrated on its ease of application, the tolerance of the device by the patient, the degree of immobilization obtained, and its success in maintaining reduction and achieving healing after a fracture or arthrodesis.^{3, 6-10, 12-14, 16-20}

Although other authors have reported complications in their patients, no prior report has concentrated specifically on the complications that may be associated with use of the halo fixation device. The purpose of this study is to evaluate the problems that we have observed.

MATERIALS AND METHODS

The medical records from the University of California at San Diego and affiliated hospitals and the Rancho Los Amigos Medical Center, Downey, California, of all patients with a diagnosis of fracture, dislocation, or instability of the cervical spine that occurred during the period from 1973 to 1983 were reviewed. Requirements for inclusion in the study included: (1) a history of continuous treatment with a halo device for a minimum of two weeks, (2) availability of the hospital chart and radiographs, and (3) a minimum follow-up of three months after the halo was removed. Emphasis was placed on identifying specific complications that resulted from the placement and use of the halo device. These included infection at pin sites,

loosening of pins, radiating pain or numbness around pins, pain with mastication, localized discomfort about a pin, residual scars left by pins, and pressure sores beneath the vest or cast.

The charts of 512 patients were reviewed. Due to lost charts or radiographs, incomplete records, or patients moving or being transferred to other facilities, only 179 charts were considered to have adequate documentation to be included in the study. Eighty-seven of these patients were from the Rancho Los Amigos Medical Center and 92 were from the University of California at San Diego Medical Center and affiliated hospitals. Fifty-nine of the 179 patients were contacted by telephone and asked to subjectively evaluate their pin-site scars and to classify them as either minimum, moderate, or severe. A minimum scar was defined to the patient as being unnoticeable or barely perceptible by close examination. A moderate scar was defined as noticeable, but shallow and not disfiguring. A severe scar was considered as disfiguring, deep, and associated with patient dissatisfaction.

These 59 patients were also questioned as to whether they had had pain at the pin sites while the halo was in place. Their replies were placed in four categories: no discomfort; minimum discomfort, which was tolerable; moderate discomfort, painful at times; and severe, prolonged discomfort.

One hundred and forty-three patients were male and 36 were female. The patients' ages ranged from 2 to 90 years, with a mean of 28.3 years. The length of follow-up ranged from three months to ten years after removal of the halo. The most common cause of cervical spine injury was a motor-vehicle accident (47%), followed in frequency by a diving injury, fall, motorcycle accident, or other trauma. Twelve patients had a congenital defect of the cervical spine.

Fifty-four patients (30%) had no neurological impairment, 53 (30%) had quadriplegia, and 61 (34%) were quadriplegic. Eleven patients (6%) had an isolated nerve-root injury.

Complications Associated with the Halo Immobilization Device in One-Hundred and Seventy-Nine Patients

Complication	No. of Patients	Percent of Patients
Pin-loosening	64	36
Pin infection	35	20
Pressure sores	20	11
Bleeding at pin sites	2	1
Nerve injury	3	2
Dural puncture	1	1
Dysphagia	3	2
Severe scars*	5	9
Severe pin discomfort**	18	18

Table I.

*Fifty-nine patients evaluated.

**One hundred and one patients evaluated.

RESULTS (Table I)

Pin-Loosening

Loosening was considered to be present when a pin could be freely twisted by the examiner without resistance, or the tip of the pin was visible at the edge of the skin, rather than being secured against the skull. Loosening of one or more pins occurred in 64 patients (36%). A total of 716 pins (four per patient) had been used, of which 180 (25%) became loose. A loose pin was treated by either removing the pin and placing a new pin into a new site (75 pins) or tightening the existing loose pin *in situ* (105 pins). Of the 75 pins for which the site was changed, 55 remained tight, 13 loosened again, and seven became associated with infection. Of the 105 pins that were tightened *in situ*, 88 remained tight, ten re-loosened, and seven became associated with infection.

Forty-three percent of the loose pins were diagnosed during the first month after application and 42%, during the second. Fifty-three percent of the pins that

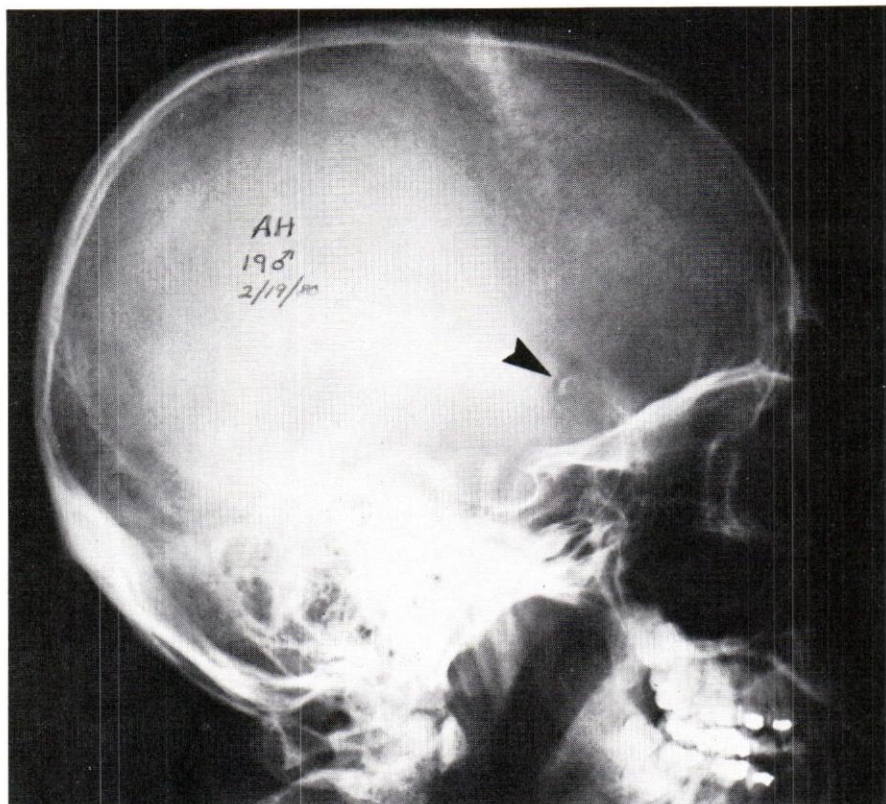


Figure 1. Lateral radiograph of the skull of a nineteen year old man in whom osteomyelitis developed (arrow) from a halo pin-site infection. A craniotomy was required to drain the resulting subdural abscess.

became loose were located anteriorly. Four of the six patients in whom the halo became completely dislodged gave a history of falling or sustaining a direct blow to the halo. In the other two, the dislodgement was noted when the patient arose in the morning.

Pin-Site Infection

Thirty-five patients (20%) had an infection at one or more pin sites. Sixty-seven pins (9%) were involved. Pin-site infection was diagnosed by either a positive culture or surrounding cellulitis. There were 26 superficial infections and ten deep infections. The deep infections included three cases of osteomyelitis (one resulting in a subdural abscess) (Figure 1) and two cases of septicemia.

The treatment of the infected pin sites varied. Thirty-three pins were changed and a new pin was placed at a different

location. Thirty-one of these pin sites showed no further evidence of infection after the change, but two became infected a second time. Nine of the ten pin-site infections that were treated with systemic antibiotics, without changing the pin, healed. Eleven patients required removal of the halo device because of multiple pin-site infections. Seven of these infections healed, but four had persistent, chronic drainage from the pin sites. Nineteen percent of the infected pin sites were detected during the first month; 44%, during the second month; and 19%, during the third month. Sixty percent of the infections were observed around the anterior pins. Three of the 35 patients in whom a pin-site infection developed were treated with intravenous antibiotics, and eleven were given oral antibiotics. Surgical débridement was required in three patients with a pin-tract infection, including one craniotomy for drainage of a subdural abscess.

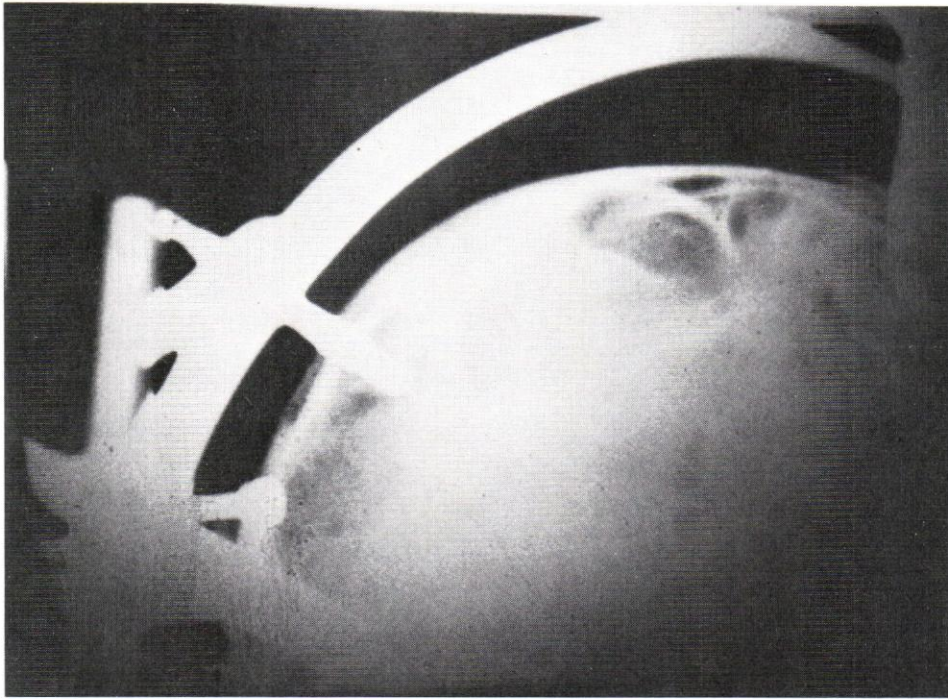


Figure 2. Lateral radiograph of the skull of a seventy year old man, showing penetration of a halo pin through the inner table of the skull.

Pin Penetration

A halo pin penetrated through the inner table of the skull in a 72-year-old man with a type-II fracture of the odontoid process (Figure 2). Nine weeks after application of the halo, the patient fell onto the left side. He felt minor pain around the anterior left pin, and a radiograph showed that the pin had penetrated through the inner table of the skull. When the pin was removed, a small amount of cerebrospinal fluid was noted. The patient was hospitalized and treated with antibiotics and elevation of the head, and a new pin was placed in a different site. The original pin site healed uneventfully, and no detectable neurological sequelae from the pin penetration were noted. No other patient had penetration of the pin through the inner table.

Pressure Sores

Twenty patients (11%) had the development of pressure sores under a halo

plaster cast or a prefabricated vest. Fifteen sores developed under 83 casts and five, under 96 prefabricated vests. The sores were located on the trunk, usually in the region of the scapula or sternum. Of the 20 patients, 11 were completely quadriplegic, six were incompletely quadriplegic, two were neurologically intact, and one patient had a head injury with impaired mental status. Four patients had the halo removed to aid in the treatment of the pressure sore. One patient required débridement only, one had a split-thickness skin graft, and one had a transfer of a local skin flap. All subsequently healed.

Nerve Injury

Injury to the supraorbital or supratrochlear nerve occurred in three patients. These patients all had the anterior pin placed above the medial one-third of the eyebrow. The complication was manifested by severe pain and paresthesias in

the region of the forehead and scalp above the anterior halo pin. All of these patients obtained relief after the pin was removed and the application site was changed to a slightly more lateral position. One patient had persistent paresthesias for six weeks, which then gradually resolved.

Pin-Site Bleeding

Two patients had sustained bleeding at all four of the pin sites while receiving heparin for the treatment of thrombophlebitis. In both patients, the bleeding subsided after the heparin dosage was decreased. None of these pin sites became infected.

Dysphagia

Three patients required readjustment of the position of the head in the halo because of dysphagia. In all three, the cervical spine initially was immobilized in hyperextension. Repositioning of the neck to less extension was performed without loss of reduction of the cervical spine fracture-dislocation for which the halo had been applied and resulted in immediate improvement in the ability to eat and swallow.

Pin Scars

Fifty-nine patients were contacted by telephone and asked to comment on the appearance of the pin scars. Five patients stated that they had obtrusive, severe scars and were dissatisfied with the appearance. Seventeen patients felt that they had moderate, noticeable scars, but that they could tolerate them. Thirty-seven patients reported minimum or no scars and had no complaints. One patient, a 21 year old black woman, had the development of keloids at both anterior pin sites; the keloids were treated successfully by surgical revision.

Pin Discomfort

Evaluation of pin discomfort while in the halo was made either by telephone contact (59 patients) or from statements included in the medical records (42 patients). Seventeen (17%) of the patients stated that the

pain had caused severe discomfort. Twenty-two patients (22%) reported moderate discomfort; 23 (23%), slight discomfort; and 38 (38%) reported no pin discomfort.

Two patients complained of pain at the anterior pin sites while eating or laughing. In both of these patients the anterior pins were located in the temporal fossa, behind the temporal hairline. Placing new pins more anteriorly, over the eyebrows, and removing the existing pins led to immediate relief of the symptoms.

DISCUSSION

We have identified some of the major problem areas that are directly related to the halo immobilization device used for stabilization of the cervical spine. The largest percentage of complications were related to loosening and infection. At Rancho Los Amigos Hospital, loose pins have routinely been tightened rather than changed. No obvious negative consequences have been observed from this practice. We have noted, in the laboratory, that in cadaver skulls that have had halo pins applied experimentally at the recommended six-inch-pound (0.69-newton-meter) application torque the outer cortex of the skull is only partially penetrated by the halo pins. There is a solid margin of cortical bone to allow safe retightening. We have concluded, therefore, that it is safe to tighten loosened pins, assuming that some resistance is met during that procedure. Since loosening is often a forerunner of infection, its elimination or early correction is beneficial in the prevention of pin-tract infections and their sequelae. If no resistance is noted after a few turns of the pin, the pin should be removed, and a new one should be placed in a different site.

If infection at a pin site does develop, it seems prudent to administer systemic antibiotics and initiate early local wound care. If drainage, cellulitis, or other signs of infection do not improve, the site of the pin should be changed and more aggressive local, and perhaps parenteral, anti-biotic treatment should be instituted. Certainly, the prevention of infection would be preferable, and pin-site-care techniques, in-

cluding cleaning the pin sites with Beta-dine (providone-iodine) or hydrogen peroxide every other day, should be performed in the hospital and taught to the patient before discharge from the hospital. More frequent cleansing is not desirable and may lead to a low-grade infection caused by constant manipulation of the wound site. We do not know why the anterior pins are more apt to become infected.

The literature on the use of the halo device has paid little attention to the problems of loosening or infection of the halo pins, although these complications have been described.^{3, 8, 9, 14} Four of the eleven patients with an injury of the cervical spine whose cases were reported by Thompson had loosening of the pins, and one had an infection. Nickel, et al. reported on 204 patients who had been treated with the halo device.¹² All of the patients who had been in a halo for more than two months had loosening of some of the pins. Most patients required at least one change in pin site. Many patients also had inflammation or infection in at least one pin site that required a change in the site. In two patients the halo dislodged, and three patients had osteomyelitis of the skull. Other authors have listed the same complications.^{1, 3, 5, 8, 9, 12, 16, 17, 21} These findings, although incidental to the major emphasis of these other reports, are consistent with ours.

Pressure sores under the halo cast or vest have also been reported previously.^{1, 9, 17, 21} In our series, 11% of the patients had pressure sores. The majority of patients with this problem were quadriplegics who lacked sensation in the area of the skin breakdown. This problem decreased markedly in our patients as awareness of this complication heightened, and early prophylactic medical and nursing care was initiated. Only five patients had pressure sores in the last four years of this review. A halo cast is now used less frequently, a prefabricated or molded vest being preferred. These allow easier inspection of the skin, perhaps more uniform pressure distribution, and better padding. Because of the problem of pressure sores and their effect on rehabilitation and health, early surgical stabilization of patients with a spinal

cord injury should be considered when possible. Although this may lead to an entirely different set of complications, pressure sores in patients with a spinal cord injury can be devastating. Therefore, if possible, we now recommend early internal fixation and fusion of the cervical spine, particularly in elderly patients, quadriplegics, and quadriparetics, to eliminate the need for the halo and replace it with a more limited immobilization device which hopefully can be confined to pressure-sensitive areas.

Prolonged bleeding at pin sites occurred in two patients who had been receiving heparin for thrombophlebitis. Neither of these patients responded to packing or dressing of the pin sites, but the bleeding ceased after a decrease in the dosage of heparin. This possibility must be considered in those patients who require anti-coagulative treatment while in a halo device.

Three patients in this series sustained an apparent compression of the supraorbital or supratrochlear nerve.⁹ These nerves exit over the medial one-third of the orbit, and involvement occurs because of too medial a placement of the anterior pins. If the anterior pins are placed over the middle portion of the orbit, or slightly lateral, this complication should not occur.

Nine percent of the patients in this series were markedly dissatisfied with the scars. In general, most of the patients felt that the scars were acceptable or were a necessary outcome of the treatment of the spine injury. The older patients and the more severely injured patients were less likely to express concern about the presence of residual halo-pin scars. In the majority of patients there was only a small residual dimple.

Some authors have reported no complications with the use of the halo device.⁴ However, we have found the overall complication rate to be relatively high. Loosening and infection are particularly common and imply that further basic research in halo-pin design and application is needed. To date, only changes in the suprastructure of the halo have been made since its first description by Perry and

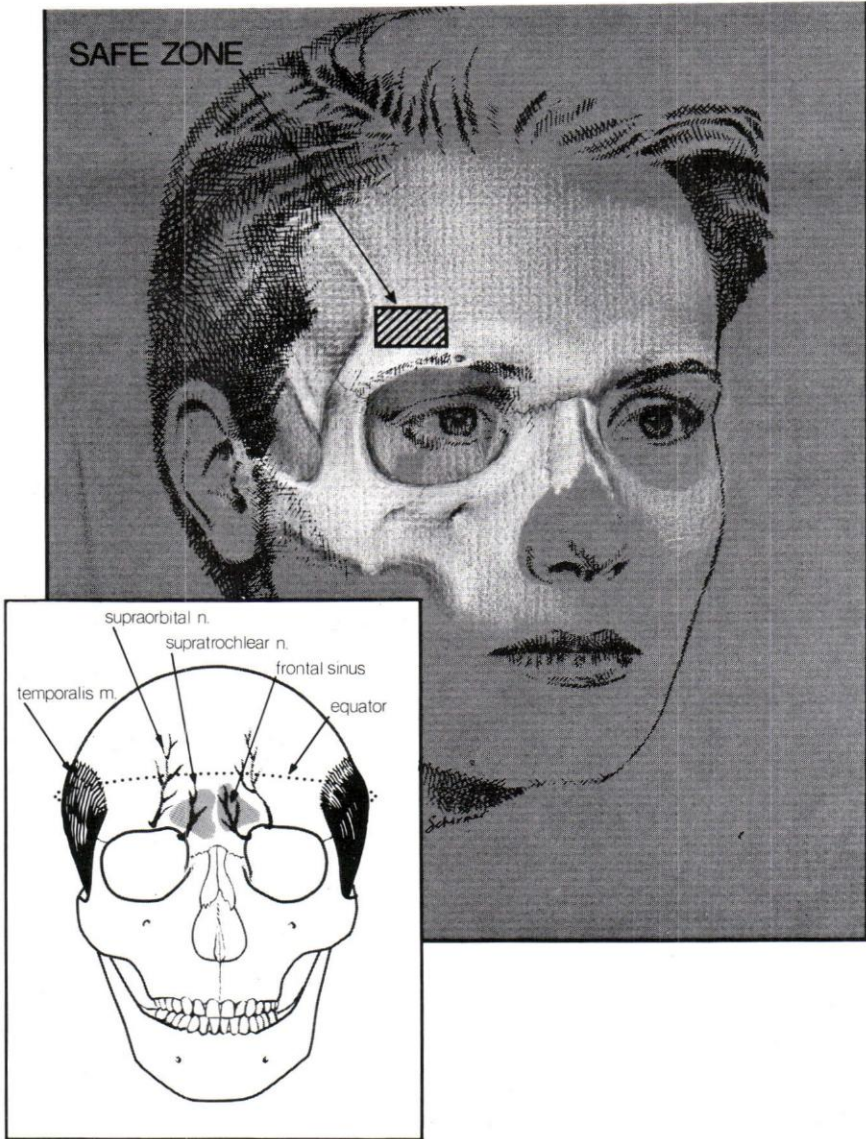


Figure 3. Drawing depicting the safe zone for anterior halo-pin placement. Laterally, the pin should be placed anterior to the temporalis muscle and fossa, to avoid possible painful mastication or penetration through thin cranial bone. Medially, the pin should be kept lateral to the middle portion of the superior orbital rim, to avoid the supraorbital and supratrochlear nerves or the frontal sinus. Superiorly, the pin should be kept below the level of the greatest skull circumference (skull equator), to avoid cephalad migration of the pin. Inferiorly, the pin should be kept above the supraorbital ridge to prevent displacement or penetration into the orbit.

Nickel¹⁵ in 1959. The high-profile design has been modified to lower the uprights, in some cases four uprights or an interdigitating ratchet system have replaced the two high-fixation parts, and materials have been altered. However, the basic ring-and-pin design, as well as the recommendations for application, have not been altered. These concepts, also, have never been rigorously scientifically tested or challenged.¹¹ Our review is the initial step in an evaluation of the halo, and it does delineate areas in need of further investigation. We would like to emphasize, however, that no permanent serious sequelae from these complications occurred despite the documentation of problem areas.

Based on our experience, we recommend that the following strict guidelines be followed when applying and treating adult patients in a halo orthosis. The initial application torque in placing the pins in adults should be at least six to eight inch-pounds (0.69 to 1.12 newton-meters). We routinely tighten the pins 24 to 48 hours after the halo is first applied. Local pin care should be standardized, but not overly aggressive or disruptive to the pin site. If a pin is noted to be loose, an attempt at re-tightening to the original application torque should be performed, assuming that resistance is met during this procedure. The pin site should be changed and a new pin should be used if osseous engagement does not occur after a few complete turns. If infection or drainage is seen, cultures should be grown and the antibiotic sensitivity of the organism should be determined. If the patient's response to the antibiotics is not rapid, a change in the pin site should be considered. Anterior pins should be placed superior to the middle or lateral one-third of the orbit, below the greatest circumference of the cranium, to minimize the risk of loosening, dislodgment, and nerve damage. Also, the pin should not be placed over the temporal fossa or in the temporalis muscle. The cranial cortex is thin in that area, and penetration of the temporalis muscle may cause pain during mastication² (Figure 3).

Care and awareness should be exercised in applying a halo jacket or cast in the quadriplegic patient to avoid pressure sores. Although the halo is a very useful immobilizing device to apply initially to the patient with a spinal cord injury, consideration should be given to early surgical stabilization with internal fixation, thus avoiding the risk of pressure sores under the vest or cast.

By following these recommendations, we think that the risks of employing the halo cervical immobilizer may be minimized, although not completely eliminated.

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