Review Article:
Complications of Halo Vest Orthosis: A Narrative Study

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ABSTRACT

Background and Aim: Perry and Nickel introduced the halo vest in 1959. It is the most common immobilization device for the unstable cervical spine. In the literature review, most articles review the beneficial effects of the halo vest, and a few report its complications. This study aims to evaluate the complications associated with halo orthosis.

Methods and Materials/Patients: This is a narrative study about halo vest complications. To provide up-to-date information, we reviewed the articles written about halo complications. All relevant articles were retrieved from Google Scholar, Medline, PubMed, etc., using the keywords of "halo vest orthosis", "unstable cervical spine fracture", "halo vest complications", "halo vest immobilization", "pin-site-related complications", and "vest-related complications". Afterward, we reviewed and critically analyzed the articles.

Results: At first, the halo vest was used for postoperative paralyzed poliomyelitis patients, and later, it was also used for traumatic injury of the cervical spine or postoperatively in cervical spine reconstructive surgery. Compared to other orthoses, the halo vest provides a more effective external fixation and maintains normal anatomic alignment of the cervical spine without impacting jaw motion and resulting in eating problems. However, it has many temporary complications. To prevent halo vest complications, experienced people should apply it, and the patients should be regularly followed up for early detection and treatment of complications.

Conclusion: Our review is the starting point for the evaluation and investigation of halo vest complications. Because of the high incidence of pin loosening and infection, it is better to evaluate the design and application of halo pin. Since the initial design of the halo vest, only its superstructure has been redesigned without any significant change in other parts of it.

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Highlights

- Halo vest orthosis is used for cervical spine fractures.
- The most common complications of halo vest orthosis are pin-site related infections and loosening.
- There are many complications of halo vest that are related to halo vest placement.

Plain Language Summary

Halo vest orthosis is used for variable cervical spine fractures. In this narrative study, we review the complications of halo vest orthosis. It has many different complications. The most common complications are related to pin-site infection and loosening. Some complications are related to halo vest orthosis placement.

1. Introduction

About 60% of spinal injuries occur in the cervical spine, and 20% of its fractures occur in the upper cervical spine. We can use different orthoses such as halo vest, Minerva, CTLSO (cervicothoracic lumbosacral orthosis), etc., for nonoperative treatment of cervical spine fractures. In many centers, the halo vest is the first choice for nonsurgical treatment and external fixation. However, the halo vest has some complications (with a relatively high rate). So for the usage of the halo vest in these conditions, we must consider these disadvantages. We conducted this study to evaluate the associated complications of halo vest immobilization [1-10].

Halo vest can protect against neurological damage in posttraumatic cervical spine instability. Still, because of incomplete immobilization, there is a chance of progressive deformity that may result in surgical treatment for spinal instability. Also, restriction of halo vest for three months is not tolerable for some patients [11]. Complications of halo vest are relatively high and include pin loosening, migration, penetration, scalp infection, skull fracture, cerebral hemorrhage, paresthesia, and pressure sores [12]. The fracture healing rates with halo vest in the cervical spine are about 67% to 93.9% [13-15]. Overall, the halo vest has a failure rate of 39.1%, with complications in 60.9% of patients and an intolerability rate of 68.4%. Pin-site problems are the most prevalent complications of halo. Because of the many complications and high failure rate of halo vest immobilization, the clinicians must rethink before applying halo. To prevent these problems, physicians must consider pin-site problems for early detection and treatment [15]. This narrative study aims to evaluate and search the rate and type of complications of halo vest orthosis.

2. Methods and Materials/Patients

This article is a narrative study about the halo vest complications. To provide up-to-date information on the complications of the halo vest, we briefly reviewed its complications in related articles. We retrieved all relevant articles from Google Scholar, Medline, PubMed, etc. using the keywords of “halo vest orthosis”, “unstable cervical spine fracture”, “halo vest complications”, “halo vest immobilization”, “pin-site-related complications”, and “vest-related complications”. Finally, the extracted papers were reviewed and critically analyzed.

3. Results

The halo vest is a rigid orthosis with a ring and four pins attached to the outer cortex of the cranium. It has a complication rate of 0%-100% because of its rigid ring that attaches to the outer cortex of the cranium. We briefly reviewed the halo complications and classified them based on the etiology (pin, vest, underlying pathology, etc.) of complications.

Pin-related complications

Pin loosening: This is the most prevalent complication in adults, occurring in as many as 36% of patients. In adults, loosening is slightly more common with anterior pins than with posterior pins. In children, anterior pin loosening also is predominant, occurring in up to 87% of cases. A loose pin without signs of infection can be retightened one to two turns. When the pin remains loose after this maneuver, a new pin should be placed in another location. It is essential to place the new pin

within the safe zone [16, 17]. The loose pin must be re-tightened, but if loosening is not fixed, the pin must be removed and placed in another location [18]. Loosening is considered when any of the following conditions occur: first, if a pin is freely twisted and moved by the examiner without any restriction or pin tip is visible at the edge of the skin rather than at the edge of the skull. In these circumstances, first of all, tighten the loosened pins. If there is some resistance during tightening of the pin, there is no need for its removal. However, the pin must be removed and placed in another location if there is no resistance to the pin turning [3].

Supraorbital and supratrochlear nerve palsy: Ideal pin-site placement for anterior pins prevent this complication. If anterior pins of the halo vest are inserted at the medial third part of the eyebrow, there is a high risk of damage to the supraorbital and supratrochlear nerve. This complication clinically manifests with pain and paresthesia in the forehead area above the anterior pins. After removing anterior pins and changing the pin-site area at the more lateral position, the patient's clinical manifestations should be improved [3].

Pin-site bleeding: In patients who require anticoagulant therapy while using a halo device, pin-site bleeding must be considered [3].

Pin scars: [3].

Pin discomfort: Severe pin discomfort is reported in 18% of patients with a halo vest [3].

Pin-site infection: Pin-site infection is more prevalent in children than adults, with reported rates between 39% and 57%. There are two types of pin-site infections: superficial infections that may not be associated with pin loosening and deep infections that may be associated with osteomyelitis or rarely intracranial abscess.

Diagnosis of infection is initially based on the presence or absence of cellulitis at the pin-site and then positive or negative culture results. Superficial infections can be treated with oral antibiotics (e.g., oral cephalosporin), with or without pin removal, but deep infections require pin removal with a new pin at a new site, debridement, and systemic antibiotics. If the infection is resistant to treatment with permanent drainage, cellulitis, or other signs of infection, the pin-site must be changed and placed in another location with the initiation of more potent local and possibly intravenous antibiotic therapy.

Regarding the prevention, at the initial stage for pins placement, all pins must be inserted under aseptic conditions. After pin insertion, they must be cleaned every other day with betadine or hydrogen peroxide at a hospital and after discharge at home. Because of low-grade infection, more frequent cleansing is not suitable. The risk of infection in anterior pins is more than other pins without any known reasonable cause. The usefulness of wound cultures is not known, and these cultures are not part of routine practice. Nemeth and Mattingly reported that a six-pin construct increased stability without increasing the rate of pain-related complications; however, this is currently not considered standard practice in adults [16-19].

Overpenetration of pins: Skull has an outer and inner table, and all pins must only penetrate the outer table. If pins traverse through the inner table of the skull, they cause dural puncture, and if infection occurs, it can cause a brain abscess. Titanium conical pins are gradually blunted. Even newly replaced pins can be blunted in four weeks. Reusing halo rings and vests after cautious examination to rule out any defect is possible, but reuse of skull pins should be avoided. Pin loosening can occur because of microfractures and creep of the outer cortex of the skull around the pin tip after insertion of conical pins. The risk of pin loosening and penetration to the inner cortex increases whenever a blunt or hooked pin tip is rotated during the checking of poundage or routine re-torquing. The routine practice of re-torquing skull pins beyond three weeks should be revised. Whenever patients have pin-site pain, and the pin tip is deformed, it should be changed rather than re-torquing [20, 21].

Pneumocranium: If pins penetrate the frontal sinus, pneumocranium occurs. Halo vest anterior pins must be placed at about 1 cm superior to the orbital rim and at the lateral half of the eyebrow for preventing frontal sinus penetration and supraorbital and supratrochlear nerve injury. However, there is a variation of normal anatomic landmarks of the frontal sinus, and these typical anatomic landmarks for halo vest pin placement are not always safe, especially on the left side, in which the frontal sinus is potentially larger. So it is obligatory to take a skull x-ray with a marker in the pin insertion area or CT-scan of the skull and frontal sinus before halo vest pin placement. Furthermore, tactile evaluation during insertion is critical to detect penetration. If there is a loss of resistance during pin insertion, the surgeon must consider potential cranial penetration and pneumocranium [22, 23].

Pin-site myiasis: Maggots are parasites and are classified into two types of obligatory and facultative. Obligatory maggots are invasive and affect the living tissue, but

facultative consume the necrotic dead tissue. It most commonly affects the lower limbs ulcer and wounds with necrotic dead tissues. Based on Park et al., because of the dead necrotic tissue around the pin, pin-site myiasis can occur. For effective improvement of this complication, maggots must be completely removed [24-27].

Brain abscess: This is a rare fatal complication of halo vest. Overpenetration of pins that traverse through the inner skull table and enter the cranium increase the risk of intracranial infections. Standard correct pin-site placement is crucial to prevent minor complications with resulting cerebral abscess. So, it is better to avoid pin placement at the temporalis muscle area. Pins are designed with a broader body and sharp tip to prevent overpenetration through the inner table. As mentioned, it is better to avoid pin placement in the temporalis muscle area because it is painful, causes difficulty in chewing, and underlying bone is thin and susceptible to puncture and overpenetration. The ideal good position for posterior pins is at the area of the 4 and 8 o'clock of calvaria as 12 o'clock is glabella, and 6 o'clock is occipital protuberance.

Due to the difficulty of achieving firm pin placement, the use of halo traction devices must be prohibited in the following cases because of the loose pin placement: prior craniotomy, recent skull fractures, and soft bone as in Rheumatoid Artheritis (RA) or multiple myeloma. All pins must be retightened 24 hours after pin placement and then after one week and again during 4-6 weeks follow-up periods. Delayed and excessive pin tightening must be prevented because of the pin overpenetration. If the patient has purulent discharge with or without neurological complaints, a brain CT scan must be done.

For detection of brain abscess in early stages, in all patients with halo device and neurological manifestations in favor of cerebritis or brain abscess, brain CT with contrast must be done immediately. Early recognition is mandatory because, at an earlier stage with only cerebritis, intravenous antibiotic treatment will be more effective. However, a well-developed abscess at the late stage has a firm fibrous capsule with necrotic material and debris resistant to parenteral antibiotic therapy. So the only available option for treatment is surgical evacuation followed by antibiotic treatment. Following pin penetration through the inner table with continuous pressure and irritation of the dural surface and an associated inflammatory process, infectious organisms enter into the subdural space. Deeper cerebral abscesses can occur because of retrograde thrombophlebitis through the dural veins with halo fixation devices [28-36].

Infectious cavernous sinus thrombosis: Infectious Cavernous Sinus Thrombosis (CST) was initially reported as an uncommon complication of facial infections. Infectious CST is an invasive infectious condition with a high fatality rate. Rahimizadeh et al. reported a case of septic CST secondary to a halo pin-site infection. In this case, CST occurred because of unrecognized pin-site infection and presented with proptosis and ipsilateral eyelid edema; however, with early consideration of CST and aggressive antibiotic and anticoagulant therapy, the patient had a favorable outcome [37-44].

Orbital roof fracture and orbital cellulitis: It is a rare halo complication caused by pin penetration into the orbit. It is followed by the inflammation of extraocular muscles and other orbital soft tissue, and this causes severe proptosis, ptosis, and diplopia. If anterior pins are placed too lateral and inferior, they can enter the orbit. The management is nonsurgical as parenteral antibiotics and topical antibiotic (ofloxacin eye drop) instillation into the eyes for ten days [45].

Acute subdural hematoma: This is a rare complication of the halo vest. To prevent this complication, it is obligatory to consider the bone quality, the patient's coagulation status, and other comorbidities [46].

Vest-Related complications

Pressure sores: This complication most commonly occurs in quadriplegic patients that have disordered skin sensation. Pressure sores commonly occur in the area of the scapula and sternum under the halo cast or vest. Early surgical stabilization with internal fixation effectively prevents pressure sores in patients with spinal cord injury [47-49].

Pulmonary complications: This is more common in older adults over 65 years with a halo vest. Because of reduced pulmonary compliance and following pulmonary infections, respiratory failure can mainly occur in the elderly with halo vests [5, 50].

Problems related to original pathology

Immobilization created by halo vest is not complete and absolute; thus, graft failure, implant migration, loss of reduction, over distraction, and snaking motion can occur. Rotation in opposite directions, hyperextension of the upper cervical spine, and hyperflexion of the subaxial cervical spine can cause snaking motion. This issue is especially prominent when the patient moves from prone to supine position. Therefore, the halo vest strap and pins must be checked and retightened. If this com-

plication continues, consider a form-fitting cast vest. Snaking motion can cause inadequate healing and non-union of the fractures/injured site [51, 52].

Miscellaneous complications

Abducens and trochlear nerve palsy: The most prevalent cranial nerve injury with halo is the sixth cranial nerve injury because of pin placement and traction. Because the sixth cranial nerve supply ipsilateral lateral rectus muscle, the patient presents with diplopia (double vision) and loss of the lateral gaze on the affected side. Watch and wait is the preferred treatment, and the condition will resolve itself. The fourth nerve palsy may be underreported because of masking by a coinciding sixth nerve palsy [53].

Transient hearing loss: [54].

Visual disturbances: [54].

Dysphagia: Overextension of the neck can cause dysphagia and improve with the halo adjustment [16]. Difficulty swallowing (dysphagia) occurs in 2% of the patients [55].

Failure to thrive (elderly): [56].

4. Conclusions

Based on this review, more evaluation and investigation about halo complications is obligatory, and our study delineates topics in need of further research. The most prevalent problems of the halo vest are pin loosening and infection, so it is better to change halo design and use. Halo vest cannot completely fix the cervical spine and prevent progressive deformity. Pin overpenetration is a serious complication of halo. For its prevention, only trained personnel with up-to-date information about the anatomy of this region can insert and place the halo in the right area. Regular exam after halo placement is obligatory for timely diagnosis and treatment of halo complications.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

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