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Chapter 3

Outcomes of Cervical Spine Injuries Following Non-Operative Management

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Abstract

Over the past decade, surgical fixation of cervical spine injuries has gained popularity due to better imaging and improved surgical techniques. Despite these advances, surgery is not indicated for all patients. Conservative treatment, with the use of a spinal orthoses, still has an important role to play. In this chapter, we will explore the outcomes of non-operative treatment, and compare it with the outcomes of surgical treatment to determine which treatment options benefit the patient most. The indications, efficacy and complications will be discussed in detail.

1. Introduction

Successful outcomes following non-operative treatment for cervical injuries are dependent on many factors. These include fracture configuration, stability, neurological deficits, the age of the patients and their comorbidities. The type of external mobilization also contributes to final outcome. With the vast amount of options available, it is important for the treating clinician to understand which specific orthosis will provide the best support for the particular injury being managed. A wrong choice will not only be ineffective, but may be also

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predispose the patient to unnecessary complications [1]. Therefore, a combination of the proper patient selection and the type of immobilization device used for non-operative management is vital for an optimal outcome. While literature has proven that there is a significant variation in surgeons' preferred treatment for cervical fractures [2], more research has been published in the past decade that can help us to make a more evidence-based decision. Some authors have also developed scores to aid in the decision making process [3,4].

2. Options for Non-Operative Treatment

Most Cervical Spine Injuries without neurological deficits can be managed definitively without surgical treatment. Since Nickel and Perry pioneered the use of the Halo retractor, clinicians have been able to successfully treat patients with both upper and sub-axial cervical spine injuries non-operatively [5]. These days, newer products (Non invasive halo, Philadelphia collars, Cervical Thoracic Orthoses) also offer less invasive options for the patient.

Cervical orthoses are worn externally to limit intervertebral motion in the injured patient, preventing further injury to the spine. This results in the formation of a biomechanical environment that is efficient in promoting and facilitating bony fusion. Motion is limited via an external load-sharing bridge that spans across the region of the spine, connecting the base of the orthosis to the skull with the upper torso at several points around the neck, shoulders, chest and back, as seen in the example of a hard cervical collar.

However, no cervical orthosis can completely immobilize the cervical spine. This is due to the scarce surface area available for contact with the orthosis, a result of anatomical challenges posed by the cervical spine. Unlike cast immobilization of the extremities, soft tissue structures in the neck limit the amount of external pressure that can be applied to this region. Significant motion at multiple levels of the spine segments further discourages rigid immobilization.

2.1. Classification

Spinal orthoses are generally classified under 2 broad categories. They can be classified according to the region of the spine where it immobilizes (Cervical or Cervical Thoracic Orthosis) or according to their rigidity (soft or rigid). The more rigid and extensive the orthosis, the greater the restriction of motion. Cervical orthoses may be classified into soft or rigid types. While the soft collars lack substantial motion control, the rigid collars provide meaningful restriction in flexion and extension in the middle and lower cervical regions. However, they are less effective in limiting rotation and lateral bending. Control of flexion-extension in the occiput to C2 region is also limited.

Cervical-thoracic orthoses (CTO) are indicated when a greater magnitude of motion restriction is desired in the middle to lower clerical spine region. They typically attach the trunk to fixation points at the chin and occiput using straps or rigid circumferential supports. Examples of a CTO include the Minerva, SOMI, or the most rigid form being the Halo Vest.

2.2. Specific Cervical Orthoses

2.2.1. The Soft Cervical Collar

Soft collars are constructed using firm foam covered with soft fabric such as cotton and fastened with a Velcro strap. These soft materials allow soft tissues to rest and provide warmth to the strained muscles. However, they provide minimal motion restriction in any region of the spine and offer negligible mechanical stability. A soft cervical collar is primarily used to treat whiplash injuries and muscular strains within the neck that has no unstable bony or ligamentous injury, where proprioceptive tactile feedback serve as a reminder to voluntarily restrict head motion.

2.2.2. The Rigid Cervical Collar

Rigid collars are available in several forms, differing in the firmness of the bracing material as well as the quality of the padding material. Though the different types may vary, all rigid collars must conform to one characteristic i.e., being able to accommodate the vital soft tissue structures within the neck, while simultaneously providing rigid immobilization of the cervical spine. Rigid cervical collar is generally used to stabilize the mid-cervical spine. It is effective in motion restriction in the sagittal plane, but is less effective in reducing rotation and lateral bending. This is due to the lack of a firm grasp of the head or thorax, resulting in no end-point control. Proximally, the rigid collar comes into contact with the mandible anteriorly and the occiput below the inion posteriorly. Distally, this brace rests on the trapezial areas and on the clavicle and the suprasternal notch anteriorly and with approximately the level of the T3 spinous process posteriorly. 3 common examples of rigid cervical orthoses include the following Philadelphia collar, Miami J collar and the Aspen Collar.

2.2.3. The Sternal Occipital Mandibular Immobilizer (SOMI Brace)

The SOMI brace derives its name from its points of attachment. It comes with a padded sternal plate that secures the occipital and mandibular rests (chin pads) to the thorax, via rigid bars that are adjustable. Due to the absence of a posterior thoracic plate, metal uprights from the sternal plate lend support to the occipital rests. This gives rise to its typical three-post design, which effectively helps to reduce upper cervical spine flexion. However, the SOMI brace does not completely restrict all cervical motion; The SOMI brace is less effective in restricting extension, rotational motion and lateral bending because of its swivel-type occipital pad. The SOMI brace is the preferred choice of cervical-thoracic orthosis for patients who are bed-bound as the absence of a back plate allows comfort when the patient is lying supine. However, they are associated with high-resting pressures at the chin and occiput.

2.2.4. The Minerva Brace

The Minerva brace is constructed using padded thermoplastic material that is contoured to connect the sternum and the anterior chest with extensions to attach to the mandible and occiput. The occipital cervical support encircles the lower skull and supports the chin, while being attached to an adjustable vest. Unlike the SOMI brace, the Minerva brace consists of a back plate that secures the upper thoracic and peri-scapular regions of the back. In general, the Minerva brace and the Halo vest offer more effective immobilization of the cervical spine as compared to the other cervical-thoracic orthoses, because they allow better end-point control of the head.

2.2.5. Aspen Cervical-Thoracic Orthosis System

The Aspen cervical orthosis system consists of a cervical orthosis attached to a thoracic vest, via 2 or 4 post. It is has gained popularity due to its ease of use and being comfortable for patients.

2.2.6. The Halo Vest Orthosis

The Halo brace orthosis is the most rigid form of cervical thoracic orthosis available and restricts motion of the cervical spine by fixing the skull in reference to the chest by means of an external mechanical apparatus. It consists of a snug-fitting padded hard plastic vest that is fleece-lined and attached to adjustable vertical rods and bars that are connected to a rigid ring that is fixed about the periphery of the skull. The ring may be opened or closed at the back, and it comes with holes that allow four or more pins to contact the skin and engage the outer table of the skull.

The Halo brace provides end-point control of the cervical spine, thereby immobilizing it in all 3 planes, and is the most effective orthosis in restricting cervical motion, especially the upper cervical region. Thus, the Halo brace is particularly useful for the treatment of upper cervical fractures, especially C1-C2.

Two large studies have proven the efficacy the Halo Vest orthosis. Recently, Branson and Chapman [8] and Vieweg [9] analyzed the survivorship of patients with cervical spine injuries treated non-operatively with the Halo Vest. An overall success rates of 85% and 86% respectively were found when used as definitive treatment. Other earlier studies also echoed this success rates [10 -12].

Though superior in immobilizing the upper and lower cervical segments, the Halo brace is generally not more effective in restricting the mid cervical spine compared to the rigid collars. In the mid cervical spine, the Halo brace may allow some inter-segmental motion with attempted flexion extension of the neck, due to the ‘snaking’ [13] phenomenon. In addition, not all cases are suitable for Halo Vest treatment.

The Halo brace is generally not preferred to be used in the elderly due to higher complications and mortality rates in this age group than in younger patients [14,15]. Also, it is also not preferred in patients with severe RA, hip or knee OA, or patients with severe ankylosing spondylitis. Such patients experience difficulties with ambulation, balance, feeding, and self-care. In such patients rigid internal fixation of the spine to avoid halo use is the preferred treatment when feasible.

2.2.7. Biomechanics of Cervical Orthoses

In a well-quoted study by Johnson and Colleagues, the authors evaluated the effectiveness of various orthoses in immobilizing the cervical spine. [6]. They found that a soft collar offered no restriction of motion in any plane. The best conventional braces restricted only 45 per cent of flexion-extension at the atlanto-axial joint, compared with the halo restricted at 75 per cent. Conventional braces were more effective in the middle and lower portions of the cervical spine. They also demonstrated increased motion between the occiput and C1 in all the braces compared to the unbraced state.

Similarly, Sneider colleagues recently [7] evaluated seven contemporary cervical orthoses (see Table 1) and found that CTOs were more effective in limiting motion than cervical orthoses. Of the rigid collars, the Philadelphia was the most effective in limiting sagittal, coronal, and rotational movement, while the Miami J and the Aspen collar were the most comfortable for the patient. Halo was the most effective in preventing overall sagittal plane motion, and the Minerva was the most effective in limiting intervertebral motion the sagittal plane at all levels.

Table 1. Percent of Subjects with intervertebral rotation greater than 3 degree from flexion to extension for each brace and all levels*

	C1-C2	C2-C3	C3-C4	C4-C5	C5-C6	C6-C7
No brace	88.5	97.8	97.8	100.0	100.0	94.1
Miami J	21.9	63.6	84.1	95.5	90.5	63.3
Aspen	32.4	56.8	79.5	88.6	81.0	55.2
PMT	17.2	51.1	80.0	86.7	74.4	55.2
Philadelphia	13.8	38.6	72.7	90.9	78.6	74.1
SOMI	25.0	18.2	52.3	70.5	54.8	34.6
Pinless halo	18.2	17.8	48.9	64.4	46.3	11.5
Minerva	10.8	13.3	26.7	40.0	25.6	17.2

*Adapted with courtesy of Schneider AM, Hipp JA, Nguten L, Reitman CA. Reduction in head and intervertebral motion provided by 7 contemporary cervical orthoses in 45 individuals. Spine 2007; 32(1):E1-E6.

2.3. Summary Recommendations for Cervical Orthoses

- Most Cervical Spine injuries can be managed conservatively
- Spinal orthoses can be classified according to their region of immobilization or rigidity.
- For successful outcomes, proper patient selection and type of immobilization orthoses is important
- Halo vest are particularly useful in immobilization the upper cervical spine, but may not be appropriate for the elderly patient or those severe joint problems.

3. Atlas Fractures (C1)

The treatment for fractures of the atlas has traditionally been non surgical. When Jefferson G first described burst Fractures of the atlas in 1920, he advocated non-operative therapy, using initial immobilization techniques consisted of prolonged bed rest, with or without traction unless the surgeon believed that bone fragments were pressing on the medulla, an uncommon occurrence in clinical practice [16].

Burst fractures usually present without neurological deficits because the neural canal diameter is relatively wide at the C1 level and the lateral masses splay away from the cord [17,18]. Because there is no neurology, the expected treatment is largely based on maintaining stability, instead of surgical decompression, giving the treating surgeon the option of non-surgical treatment.

Our understanding has evolved because of Spence and colleagues [19] and the accuracy of the MRI at analyzing the integrity of the transverse ligament. Spence studied the axial load and lateral mass displacement required to disrupt the transverse ligament in 10 human specimens. Based on the results, they suggested that if the displacement of lateral masses exceeds 6.9 mm after an atlas burst fracture, the transverse ligament is probably torn. Based on this, atlas fractures are now commonly classified as either stable or unstable and treated accordingly.

Unstable Jefferson fractures are a more severe injury type of the atlas that occur when the transverse ligament is also ruptured, secondary to the extent of spread of the C1 arch. These fractures are more difficult to manage because they are associated with atlanto-axial instability. Appropriate diagnosis and management of Jefferson fractures is imperative because mismanagement can lead to acute or chronic myelopathy, or sudden death. Instability at the atlanto-axial joint and subsequent subluxation can occur with further axial loading or unprotected flexion and extension movements.

3.1. Bony Union Rates

Radiographic outcomes following non-operative treatment for isolated atlas fractures have been good, and cases of nonunion or instability has been rare. Kesterson et al., reported 17 patients with a Jefferson burst fracture. In all 13 cases of isolated Jefferson burst fractures, treatment was successful with external immobilization [18]. Levine and Edwards also reported similar rates of success [20]. In a prospective review of isolated fractures without displacement in 13 patients, Kontautas found that isolated atlas fractures without displacement healed well with a cervical collar alone, with up to 96.4% attaining solid fusion [21].

Hadley [17] reported 57 patients with atlas fractures. Isolated C1 fractures occurred in 32 (56%) patients, none of whom presented with neurological deficits. All patients were treated with external orthoses. At a median follow-up duration of 40 months, none of the patients developed nonunion of the fracture, instability on dynamic flexion-extension radiography, or neurological deficits.

3.2. Patient Outcomes

While union rates are acceptable, the patient outcomes are generally mixed. Hadley [17] reported 57 patients with atlas fractures. Isolated C1 fractures occurred in 32 (56%) patients, none of whom presented with neurological deficits. All patients, including 47% who had a LMD more than 6.9mm, were managed with external immobilization. At late follow- up, 3 (10%) patients reported neck pain. Similarly, Kesterson found good results as well. [18]

In the study by Levine and Edwards [20], 12 of 15 patients with a Jefferson or lateral mass fracture reported neck pain after treatment with halo-brace immobilization, but none required surgery for pain or instability (defined as ADI >5 mm on flexion-extension x-rays). They also reported that 80% of their patients experienced some degree of neck pain, although none required treatment.

Dvorak et al. retrospectively reviewed 34 patients with Jefferson fractures. They found that when managed non-operatively, patients < 5.6 years poorly, compared to > 5.6 years. This suggested that function and symptoms might continue to improve beyond 5 years after injury. As they found that patients did not perceive that they had regained their pre-injury health status, until 5.6 years. Most patients (91%) with follow-up were treated with external immobilization. In this study, patients with an LMD greater than 6.9 mm had poorer long-term outcomes than patients with less displacement. These findings question whether external immobilization is the best treatment for isolated atlas fractures [22]

3.3. Type of Orthoses

As with most fractures, the stability of a fracture determines the extent of immobilization provided. Most stable fractures where the TAL is intact can be treated with cervical orthosis, while unstable fractures that require most rigid immobilization may do better with a Halo vest orthoses. Bony Avulsions can also be treated with a rigid collar. [23,24].

However, some authors feel that unstable fractures can also be treated in a collar orthoses. They believed that with vigilant follow up, successful outcomes can be achieved while negating the complications for a halo vest [25]. This being said, Hadley's 2002 review, [26] concluded that there was insufficient evidence to support treatment standards and guidelines.

3.4. Summary Recommendations for Atlas Fractures

- Most isolated C1 Fractures can be managed conservatively with good outcomes.
- Its is important to evaluate the stability of the fracture by assessing the TAL
- Stable fractures can be treated with a Cervical collar
- Unstable fractures should be treated with a Halo Vest orthosis or Surgery.
- Functional outcomes have been mixed, although unstable fractures are reported to have higher rates of neck pain.

4. Axis Fractures (C2) – Odontoid Fractures

About 25% of all cervical injuries affect the axis. 2 common forms of fracture patterns exist - odontoid fractures and Hangman's fractures. The majority of these cases can be treated non-operatively, although certain subgroups may benefit surgery.

Odontoid fractures are classified using the Alonso and Anderson classification [27]. Type 1 are avulsion fractures, involving the alar ligament. This is the least common and occurs near the tip of the odontoid process, above the transverse ligament. Type 2 fractures are the most common, and occur at the base or "neck" of the odontoid, between the level of the transverse ligament and the C2 vertebral body and are considered relatively unstable. A type 3 fracture extends into the vertebral body and is relatively stable.

4.1. Type 1

These fractures are usually stable and managed with a cervical collar. Successful outcomes with a rigid collar has been reported to achieve 100% unions rates [28], [29] Halo vests are not typically recommended for type I injuries because of the possible detrimental effects of introducing distraction to the fracture site. In an evidence-based review, Julien [30] demonstrated healing in all type I fractures, regardless of treatment.

4.2. Type 2

Odontoid fractures are the most common Axis fracture and are known to have a high rate of pseudoarthrosis. This nonunion rate might be related to decreased vascularity at the watershed region of the odontoid base, which reduces healing potential.

The management of type II odontoid fractures is controversial, with no consensus. Previous reviews in the years 2000 and 2002 indicated that no treatment guidelines could be determined based on a review of the literature [30,31]. Halo vests have traditionally been used; however, the morbidity associated with these braces has been well documented. Because of the reported high rates of pseudarthrosis with this fracture pattern, type II odontoid fractures have been managed surgically more often than not. However, retrospective studies have demonstrated high rates of complications resulting from these procedures as well.

Some pertinent questions must be asked before the surgeons embark on non-operative treatment. (i) What are the expected fusion rates of "conservative treatment" (ii) What Type of immobilization device should be chosen? (iii) Are these results comparable with Surgery? iv) Are there any special patient groups to consider?

4.2.1. Outcomes following External Immobilization – Fusion Rates

The most common primary outcome tool used in the literature has been assessment of the patient's ability to obtain bony fusion [32]. Successful outcomes have been demonstrated with conservative management of odontoid fractures. In a recent systemic review of 407 patients with type 2 odontoid fractures, Longo and Colleagues demonstrated that healing occurred in 290 of 407 patients (71%) with type 2 fractures. [29]. However, like all cases of fracture healing, these are highly dependent on several variables.

Undisplaced fractures: Müller [33] et al. reported the results of immobilization with a rigid cervical orthosis in 19 patients with type II odontoid fracture that was relatively undisplaced. This was defined as a displacement of < 5mm and a gap < 3mm. They found that 74% of fractures achieved radiographic union. These authors concluded that in stable type II odontoid fractures, rigid cervical collar treatment can contribute to successful clinical outcomes. Greene [34] et al., and Polin et al. [35] found similar results if the fractures was minimally displaced, with union rates of 82% and 79% respectively.

Displaced Fractures: Koivikko [36] reviewed 69 patients with type II fractures treated nonsurgically, of whom only 32 (46%) healed. Nonunion was associated with posterior displacement >5 mm, fracture gap >1 mm, 4-day delay to the start of treatment, and loss of position >2 mm. Greene [34] et al. looked at 120 patients with type 2 odontoid fractures. Amongst those who were treated non-operatively, those with a fracture displacement >6mm had an 86% non union rate, as compared to 18% non union rate if the displacement was <6m ($p<0.005$). A recent meta-analysis by Nourbakhsh [37] found similar results. The fusion rate of conservatively treated fractures with < 4–6 mm displacement was significantly better than the fusion rate of fractures with > 4–6 mm displacement (76 vs 41%, $p = 0.002$).

Elderly Patients: These groups of patients have shown poorer fusion rates, and a higher incidence of pseudoarthrosis. Platzer et al. [38] reported the clinical results of two patient cohorts, one with patients aged <65 years and one with patients aged >65 years. Although patients in both cohorts returned to their pre-injury activity level, the elderly group had a significantly higher rate of nonunion (12% versus 4%, respectively) Other systemic reviews and Meta-nalysis showed similar results [32,37,39]

4.2.2. Halo Vest or Collar for Immobilization – For Stable Fractures

It has been established that displaced fractures perform poorly *regardless* of the type of external immobilization device [34,36,37]. However, for undisplaced fractures, the ideal orthosis has still not been defined. Proponents for the cervical collar argue that this type of immobilization is better tolerated and has fewer complications compared to the halo vest [14,15] Others however feel that the cervical collar yields inconsistent results, citing the lack of immobilization as the cause for a high degree of instability and pseudoarthrosis rate [39], preferring the Halo vest instaed.

Butler [40] et al. reviewed the long term functional outcome of 66 patients with a type 2 odontoid fracture managed conservative. He separated them into 3 groups – using either a non-rigid cervical orthosis, a custom made cervical orthosis or a halo device. At a mean follow up go 66 months, 92.42% of fractures united, and they found that the use of cervical orthosis devices had the best outcomes with regards to neck pain, shoulder and arm pain, physical symptoms and psychological distress, followed by the Halo and finally the custom made orthoses. It should be noted however that the cervical orthosis group comprised only of 9% of the patient group and as the authors acknowledge, may be used to treat the more stable fractures which may result in better outcomes.

In a Study by Muller [33], the rigid collar alone was used to treat undisplaced fractures with a good outcome. 74% achieved bony union. Even in those patients who sustained a pseudoarthrosis, which was more prevalent in the elderly, the authors said that in spite of this, a stable situation there is no need for internal fixation, negating the risk of surgery and the morbidity of a Halo vest orthosis.

When Polin [35] retrospectively reviews odontoid fractures type 2, with an average displacement of <5mm, Among 36 individuals with Type II fractures, 20 were treated in the halo vest and 16 were managed in the Philadelphia collar or similar orthoses. The overall rate of late surgical intervention, the stability to flexion and extension, and the rate of bony fracture healing were not statistically different between the methods of immobilization. The rate of bony union was not significantly higher in the halo vest group (74 versus 53%), even though patients managed in the Philadelphia collar were significantly older than those in the halo vest (mean, 68 versus 44 yr). The lack of a significant difference in the need for late surgical procedures or late instability, improved patient comfort with the cervical orthosis, and elimination of the risk of halo-related complications favored the use of the rigid cervical orthosis in the majority of these cases.

In short, the cervical collar has shown that satisfactory outcomes can be achieved for undisplaced fractures. While union rates may be better with the halo vest orthosis [41] the clinician should weigh properly if this increase outweighs the complications associated with the halo vest.

4.2.3. Non Surgical Outcomes versus Surgical Outcomes

In an attempt to compare the outcomes of conservative versus surgical treatment, Nourbaksh and team [37] performed a meta-analysis of mainly level 3 studies to determine which was the optimal management. They found that 1) surgery was more beneficial for older patients age > 45-55 year, having a better fusion rate 85 vs 60% p<0.01. There was no difference in fusion rates were found for those < 45 -55 years. 2) For displaced fractures >4-6mm, surgery resulted in a significantly better fusion rate (90% vs 41%, p=0.003). 3) For Undisplaced fractures, surgery also resulted in a significantly better fusion rate (93% vs 76%, p=0.004). The authors concluded that operative management provides better fusion than external immobilization, although conservative management for younger patients with less severe displacement can be just as effective.

It is interesting to note that surgical group had a high union rate > 90%, making the results for operative management more favorable than non-operative management. However, not much is described about the complications following surgery. Also, whether the 20-30 % improvement in union rates correlates with a better outcome. The authors also commented that the 50% loss in reduction of rotation and some lateral flexion might influence long-term clinical outcomes.

In another study comparing surgical fusion versus conservative treatment, Kim et al. [42] found that eventhough the surgical group had a Higher fusion rate and a shorter bone healing time, the alignment based on kyphosis, translation, and patient outcome was similar in both groups.

Shears et al., in a Cochran review on this subject matter published in 2008 concluded, “there is no evidence available from adequately controlled trials to inform the decision on whether the surgical treatment of odontoid fractures gives a better outcome” than nonoperative management. More studies are required to see if the patient outcome correlates with fusion. Surgeons should individualized each patient and manage them appropriately. [43]

4.2.4. Special Considerations in the Elderly

The elderly patient deserves special attention because they are predisposed to unfavorable outcomes of conservative treatment. Many of the patients encounter problems with prolonged immobilization in a halo vest (difficulties swallowing, comorbidities of prolonged bed rest, pin site care, personal hygiene, and balance and gait impairment with increased fall risk). Conversely elderly patients inherently carry an increased operative risk and significant post-operative morbidities. Thus, when treating an elderly patient with this fracture, regardless of the treatment modality, it is important that the clinicians be aware of these challenges.

Mortality rates: Müller [44] reported a 35% in- hospital mortality rate following odontoid fractures in patients aged >70 years. Several reasons have been postulated for this finding, including the mechanism of trauma, the poor rehabilitative potential, the presence of co-morbidities, and the consequences of fracture management. Other authors have also found similar increased mortality rates ranging from 26–47% in this cohort. [41], [45 -47]

Problems with Halo Vest in Elderly: As discussed, elderly patients also have higher rates of non-union and pseudoarthrosis. While the temptation to deal with this problem is to provide a more rigid fixation with a halo vest, several studies have proven that this may be detrimental. Tashjian [15] reported that patients aged >65 years who were treated in a halo vest had a higher mortality rate (42% versus 20% p =0.03) compared to those who were treated with CO or surgery. This high mortality rate the high mortality rate was attributed to a significant increase in cardiopulmonary complications. In fact, aspiration pneumonia and cardiac arrest occurred in 34% and 26%, respectively, of patients treated with a halo vest. Similarly, the authors [15] also found that those treated also had a higher rate of complications compared to the Non halo group (66 vs 34%). With the problems such as pneumonia and cardiac arrest predominating, apart form the common problems already associated with the Halo device. They concluded that odontoid fractures are treated with HV appear inferior to those achieved with CO or surgery, particular for elderly patients.

Cervical Orthosis as an alternative: Given the complications of the Halo Vest, immobilization with a cervical orthoses has been advocated by others. Polin et al. [35] retrospectively reviewed 36 patients with Type II odontoid fractures and found that the union rates, though better in the halo vest group (74% vs 54%) was statistically insignificant, questioning the benefit of the halo vest in obtaining fracture healing in exchange for a higher complication rate.

A recent retrospective study by Muller et al. [33] suggested that non-rigid immobilization of type II odontoid fractures may be an acceptable alternative to halo vest immobilization in a stable injury. In spite of demonstrating that elderly patients had a higher rate of psuedoarthrosis with it was concluded that in a “stable non-union” is an acceptable risk when considered against the potential morbidity of surgical intervention. Several review articles have also suggested hard collar instead of HV for the geriatric population. [32,39]

Of note, Hart [48] reported in his retrospective review of elderly patients treated without surgery for chronic mobile non-unions of the odontoid process. Patients were observed on an annual basis with clinical examinations and flexion/extensions plain film radiographs. He suggested that clinical outcomes involving chronic, unstable, dens nonunions are acceptable provided that the patient does not have myelopathic symptoms.

4.3. Type 3

Conservative treatment has remained the mainstay of management of stable type III odontoid fractures, which have demonstrated high healing rates. These tend to heal well with external immobilization because of the large cancellous fracture surface [27]. When closed reduction can be achieved, immobilization in a halo vest for 12 weeks is a highly successful treatment, with a fusion rate of 84% - 100% [28 -30].

Muller [33] and Polin [35] has also showed that treating patient with a cervical collar instead of yield good fusion rates 85.7% - 100%. In a recent review of seven publications, Hsu [41] showed that the halo vest orthosis immobilization and cervical orthosis offered similar rates of healing (95% versus 92% respectively). The authors advocated that a cervical orthosis was sufficient for type 3 fractures.

4.4. Summary Recommendations for Axis Fractures – Odontoid Fractures

- Type 1 and Type 3 have good healing potential and can be treated with a cervical orthosis
- Type 2 undisplaced fracture has a satisfactory fusion result and can be managed conservatively.
- Type 2 undisplaced fractures can be immobilized with a cervical orthoses.
- Type 2 displaced fractures perform poorly regardless of the immobilization method.
- There is no conclusive evidence to suggest surgery is better than conservative management for type 2 fractures.
- Elderly patients do not tolerate the Halo vest well and may benefit form surgery

5. Axis Fractures (C2) – Hangman's Fracture

Traumatic Spondylolisthesis of the axis, also known as the Hangman's fractures are classified using the Effendi classification, as modified by Levine and Edwards [49]. Type I injuries are considered stable and consist of a fracture through the neural arch with no angulation and up to 3 mm of displacement. Type II fractures have both significant angulation and fracture displacement (3mm). Type IIA injuries show minimal displacement but are associated with severe angulation as a result of a flexion- distraction injury mechanism. This injury may not be recognized until a radiograph is obtained in traction. Type III injuries combine severe angulation and displacement with a unilateral or bilateral facet dislocation between C2 and C3. Hangmans fracture can also be divided based on the stability. Stable injuries, defined as Levine type 1 or <3mm of displacement and normal disco-ligamentous signals on MRI.

5.1. Fusion Rate

In General, outcomes following non-operative treatment with an external immobilization have shows good success. Longo and colleagues [29] conducted a systematic review of 47 studies found that treatment using a Halo vest achieved a 93% healing rate (276/297). Greene et al., 1997 also reported a similar high fusion rate [34]. However not all cases of hangmans fracture have produce good outcomes if managed non-operatively. Li Showed that the fracture configuration, or stability, correlated with the fusion rates. Type 1 fractures had a 100% union rate, whereas the success rate declined with type 2 (60%) and even worst outcomes with type 3 cases (<50%) [50]. However, given the high prevalence of these type 1 fractures, the majority of patients will have good healing rates.

5.2. Functional Outcomes

While most studies report good fusion rate, functional Outcomes and not frequently reported. Watanabe [51] reported that in his small series of 9 patients, 44% had persistent neck pain at a 5 year follow up. These patients were all treated with external immobilization and fusion was complete in all cases. There was also a significant association of neck pain with fracture displacement and angulation. Muller [52] reported that 57% of patients with type 1 injury had residual neck pain at 4 years, even though solid fusion had occurred.

5.3. Collar versus Rigid Immobilization

In a systemic analysis by the Spine Trauma Study Group, Rampersaud and co workers [53], found no significant difference in pooled analysis in any measure of outcome for rigid versus non rigid immobilization. However, unstable injuries as (as defined by Levine Edwards type 2a and 3) did demonstrate a higher incidence of late radiographic displacement and clinical results. The authors suggested that given the low risk and high patient preference, stable fractures should be managed with a non-rigid collar whereas unstable be managed with rigid immobilization such as a Halo vest.

5.4. Surgery versus Immobilization for Unstable Fracture

Type 3 injuries are typically managed surgically [53]. For all other unstable injuries, The optimal treatment for unstable fractures remains controversial [50, 53]. While a pooled analysis showed no difference in outcomes, systemic reviews showed many surgeons 35-50% would choose for surgery due to instability. Furthermore, Li showed that patients with unstable fractures managed non-operatively had poorer chance of bony union. Nevertheless, this risk has to be weighed against the morbidity of surgery and also the low risk of healing as well (posterior 39%, anterior 42%). Some authors choose a more practical approach for unstable fractures, citing that with modern cervical spinal surgery and within otherwise 'healthy' patients, there is no place to apply a Halo device for 12 weeks or tong traction to treat unstable fractures [54].

5.5. Summary Recommendations for Axis Fractures – Hangman's Fracture

- Hangman's Fracture can be classified as according to the Levine and Edwards modification of the Effendi classification, or based on stability.
- Stable fractures (Type 1) have good union rates (80-100%) and can be managed with a cervical Orthoses.
- Unstable fractures have poorer union rates (<50%) and can be managed with either a Halo vest orthoses or Surgery.
- Apart for Type 3 Fractures, there is no conclusive evidence to suggest surgery is better than conservative management for all other unstable fractures (Type 2 and 2a).

6. Sub-Axial Fractures

Sub-axial Spine injuries are not uncommon and many of these isolated injuries are stable can be treated non-operatively (Lamina, transverse process, ligamentous injuries). However when these injuries occur in combination, instability of the cervical spine may occur requiring more aggressive treatment. The Allen Ferguson classification [55] is a mechanistic classification that describes six specific injuries patterns, and allows helps to categorize the fracture into specific groups based on the most severe spinal column injured (e.g., burst, teardrop, dislocation). This is useful because treatment is often similar among fracture types in each category. The recent SLIC classification designed by Dvorak and colleagues [3] expands on the morphological classification and includes information on the posterior ligamentous complex and the patient's neurological status. This may be useful in helping the clinician decided on the best course of treatment plan.

6.1. Facet Dislocations

Facet Fracture dislocations are relatively uncommon but are associated with a high incidence of neurological deficits, with up to 90% of cases reported. [56]. These are considered to be distraction type injuries [55] with varying levels of severity: facet subluxation (stage 1), unilateral facet dislocation (stage 2), bilateral facet dislocation with 50% displacement (stage 3), and complete dislocation (stage 4). They represent a spectrum of bony and ligamentous injury, with failure of the posterior elements. Facet dislocations can be divided into unilateral or bilateral facet dislocations. Only if successful reduction is achieved, facet dislocation can be managed non-operatively.

6.2. Clinical Outcomes

Outcomes following non-operative treatment have not been favorable, ranging from poor to average at best [56-58]. Sears and Fazl reviewed 173 patients with acute spinal injury of which 70 patients had facets dislocations. They found that only 44% achieved stability with the halo vest, and half of these patients failed to retain a "good" anatomic alignment – having a residual subluxation of >20% or angulation of >15% [57].

This suboptimal alignment has been shown to correlate with a poor patient outcome. Beyer [59] conducted a long-term follow up of 24 patients and reported that when managed non-operatively, they had both high rates (42%) of poor alignment and persistent pain. Rorabeck [60] reported that in his cohort of non operatively managed patients, 70% of patients will experience significant disabling pain at follow up if the fracture was poorly reduced. Other authors have reported similar outcomes advocating surgery for anatomical reduction produced better outcomes [58, 61]

6.3. Surgery versus Non-Operative Treatment

The outcomes for non-operative treatment appear to be inferior compared to surgery. Dvorak and Fisher compared the outcomes of 90-isolated unilateral facet dislocation with a follow up of more 12-27.6 months [62]. They found that the non-operative group reported worst scores for Pain and Disability, Bodily Pain, Physical Component Score compared to the operative group, despite having a more benign fracture pattern. They recommended that surgery be strongly considered in these patients.

In a similar study, Koivikko reviewed of 106 conservatively and operatively treated patients [58]. 33 patients were managed with skull traction of halo vest (for 34 days average followed by a philadephia collar, compared with surgical treatment. The authors found that patients in the surgical group had significantly better anatomical alignment, shorter hospital stay and less neck pain. In fact, 29% of patients managed conservatively required surgery because of chronic instability of unacceptable anatomical results like kyphosis.

6.4. Burst Fractures and Teardrop Fractures

Burst fractures are considered a compression type injury with axial loading being responsible for the fracture. A burst fracture affects both the anterior and middle column, but spares the posterior ligamentous complex. This should be differentiated from Flexion-compression type injuries, such as teardrop fractures, where there is posterior inter-spinous widening.

Controversy regarding optimal management of cervical burst fractures is related to neurologically intact patient in whom the surgical decision is based primarily on mechanical stability. This concept of stability as described by White and Panjabis [63] cannot be over-emphasized, taking into consideration the competence of the anterior and posterior spinal elements and the extent of static and dynamic displacement. Both burst and teardrop fractures and are considered unstable injuries and will require some form of stabilization, either with surgery or external immobilization. There are no well-designed prospective randomized studies to guide the management of such injuries.

Koivikko et al. reported on a retrospective comparison of 69 patients with a combination of burst or teardrop fractures treated either surgically with anterior decompression and stabilization or nonsurgical with skull traction and halo bracing. The surgical group had markedly better post injury occlusion of the spinal canal, neurologic recovery and overall sagittal alignment than conservatively treated patients (mean 12.6 degrees of kyphosis for conservative vs 2.2 degrees of lordosis for surgical group). [64]. 9% of those managed conservatively required late surgical intervention.

Fisher et al. conducted a retrospective cohort study on 45 patients with cervical teardrop fractures to determine whether surgery or non-operative treatment provided better outcomes [65]. The surgical group (21/45) were managed with or anterior corpectomy and fusion while the non-surgical group were braced with a halo vest (24). The authors found that the surgical fixation was superior to halo bracing for alignment, Kyphosis was improved in the surgical group (11.4% vs 3.5%). The Halo group had 5 failures (20%) requiring surgery because of neurological deterioration and unsatisfactory alignment. Interestingly, there was no difference in the QOL, SF 36 in both groups. They concluded that while surgery was superior to Halo

Vest treatment for sagittal alignment and minimizing treatment failures, although function outcome may actually be the same.

6.5. Summary Recommendations for Sub-Axial Fractures

- Sub-axial spine injuries that are stable can be managed conservatively.
- The SLIC classification may guide clinicians on optimal management.
- Facet dislocations can be managed conservatively if reduced, however outcomes have been poor.
- Poor alignment, Kyphosis has been shown to correlate with residual neck pain
- Surgery has proven to have better results.
- Well designed, outcome studies for Burst and Teardrop fractures are lacking.
- Conservative treatment with a Halo vest yields poor alignment
- However patient outcomes has not been proven to be inferior

Conclusion

Despite the recent advance in surgery, non-operative treatment still has an important role in the management of cervical spine injuries. With the vast options of spinal orthoses available, fractures can now be immobilized with greater confidence and patient satisfaction. Successful outcomes for non-operative treatment require an understanding of the fracture configuration, stability, and patient co-morbidities. Therefore, it is important for the treating clinician to appreciate that a combination of the proper patient selection and the type immobilization device used for non-operative management is vital for an optimal outcome.

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