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Cervical spinal cord injuries: A comprehensive review of pathophysiology and quality of life

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Abstract

Background: Cervical Spinal Cord Injuries (CSCIs) are a significant and complex health issue with profound implications for individuals affected by them. These injuries occur as a result of trauma or damage to the spinal cord in the cervical region, leading to various neurological impairments and functional limitations. Understanding the causes, mechanisms, and consequences of CSCIs is crucial for developing effective treatment strategies, rehabilitation approaches, and support systems to improve the outcomes and quality of life for those affected by these debilitating injuries.

Methodology: This review adhered to the PRISMA guidelines. An international research effort was conducted using databases such as PubMed, Cochrane Database of Systematic Reviews, and Google Scholar. The search encompassed various types of research studies focusing on SCI in both Greek and English languages.

Results: The comprehensive search yielded 430 publications, which were subsequently narrowed down to 46 articles after a rigorous selection process. These articles were categorized into two distinct groups, addressing the impact of Spinal Cord Injuries (SCI) on individuals and exploring the mechanisms and frequency of such injuries.

Conclusions: The findings revealed that contact sports and traffic accidents were the primary causes of various types of injuries, including atlanto-axial rotatory hyperextension, apical and medial odontoid fractures, and body fractures. With advancements in medical science and a better understanding of spinal biomechanics, healthcare professionals can now diagnose and treat SCI injuries more effectively. Early detection of both the injury and its effects on patient health has become feasible, making it less challenging to manage.

Keywords: Spinal column; injuries; cervical spine; physiotherapy

Introduction

In the past five decades, significant advancements in the field have led to effective treatment of Spinal Cord Injuries (SCI), marking a notable breakthrough. In ancient times, although SCI were recognized, successful treatment methods were lacking. Healthcare professionals have been able to offer improved assistance to individuals with such injuries, thanks to their enhanced understanding of the anatomical and biomechanical aspects of the musculoskeletal system. Nonetheless, there are still crucial matters pertaining to cervical SCI that require further exploration, particularly their etiology and the impact they exert on patient health. Despite the progress made in comprehending and enhancing the treatment of cervical injuries, they continue to pose a significant challenge. These injuries not only affect the patients who endure them but also significantly impede their overall quality of life. The present study investigates the causative factors, prevalence, and the consequential impact on health and quality of life associated with cervical injuries. To gain deeper insights into these injuries and devise optimal treatment approaches, researchers are examining their impact on patients' lives. The ultimate objective is to develop more effective methods for treating such injuries.

Briefly, the SCI is divided into upper and lower sections. These fractures most often occur in patients who are already injured and cause the patient to lose consciousness. After blunt trauma, the incidence of SCI injuries ranges from 2-5%. If there is also a head injury, the injury rate increases. In the upper part, there are fractures of the occipital bone, atlas and odontoid bone.

In the lower part, the remaining vertebrae are affected, including the spinal cord. An atlantooccipital dislocation can occur in spinal injury and is involved in most cases of fatal fractures. Approximately 800,000 radiographs are obtained in the US each year in patients with SCI (Hoffman *et al*., 1998) [48]. X-rays are one of the most readily available methods for diagnosing SCI injuries. However, like many other diagnostic methods, X-rays do not always give a clear picture of the problem or show an injury that would not cause real neurological problems for the patient.

About 1 in 18 thousand people per year suffer from a spinal cord injury according to global studies. Men are at higher risk of injury at this point (60%) and most occur in car accidents or falls. The age range is between 18 and 40 years. These injuries can lead to paraplegia, quadriplegia, and other serious problems (Ki-Chul Park *et al*. 2014) [47]. After breaking a bone, there is a significant risk of developing other complications, such as joint stiffness, muscle atrophy, swelling, and more. The patient must be carefully retrained after the bone has healed to avoid these complications.

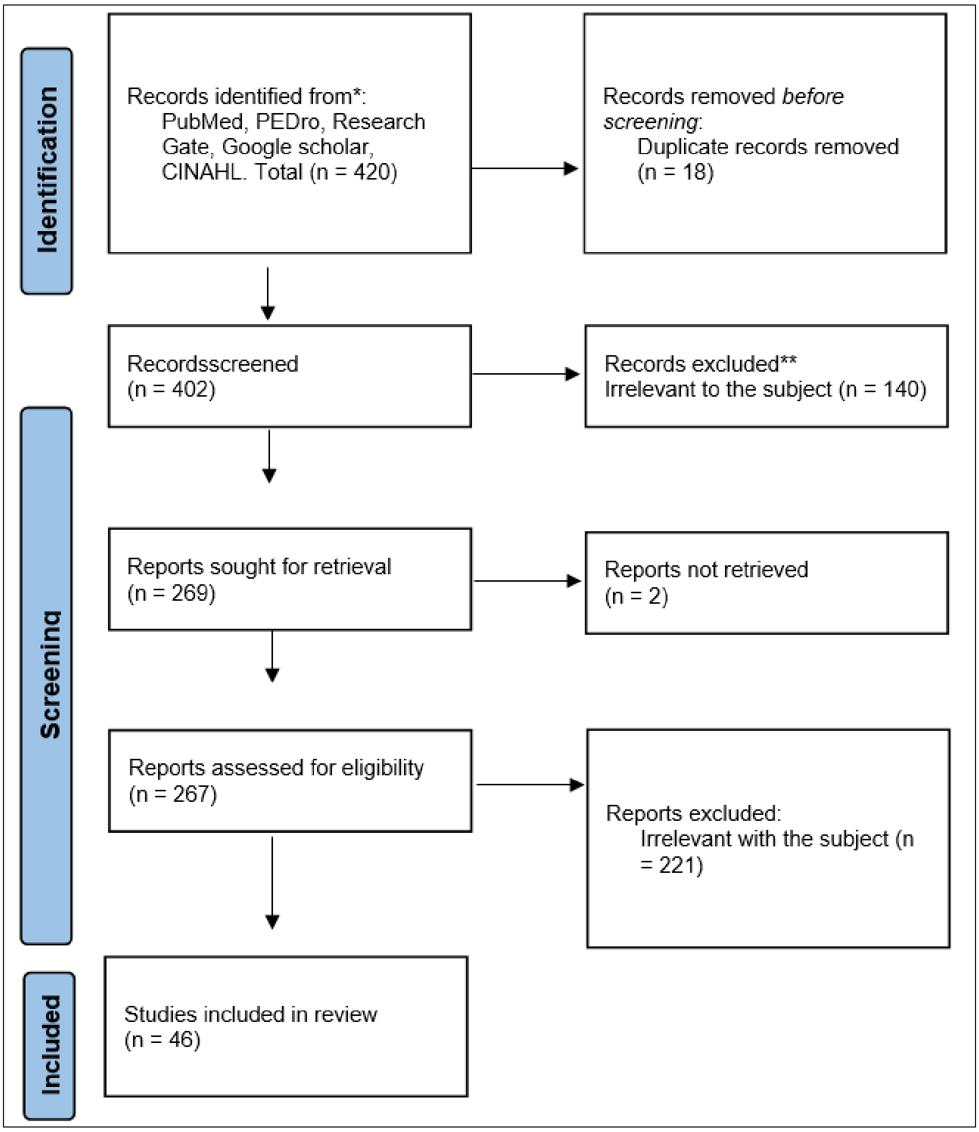
Methods

Data Collection: This review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. An international research effort was conducted using databases such as PubMed, Cochrane Database of Systematic Reviews, and Google Scholar.

Inclusion criteria: The search encompassed various types of research studies focusing on SCI in both Greek and English languages. During the literature review, the inclusion of individual words as well as combinations of words was considered, as mentioned by Galanis (2009) [45]. The keywords utilized included cervical squadron, spine, injuries, biomechanics, trauma, and quality of life.

Study Process: Following an extensive search of both international and domestic literature, a comprehensive total of 430 publications were identified. Through a meticulous selection process that involved applying predetermined criteria, a refined set of 46 articles were deemed suitable for inclusion. These articles were categorized into two distinct groups focusing on SCI. The first category comprised papers elucidating the impact of these injuries on individuals, encompassing the effects on spinal cord function, overall health, and quality of life. Furthermore, this category explored the etiology of chronic pain associated with SCI and the corresponding treatment modalities. Within this category, a total of 22 studies adopted an empirical approach, while an additional four studies consisted of review articles. The second category of publications centered on elucidating the mechanisms and frequency of SCI.

Table 1: Flow diagram of the review.



Results

Winkelstein and Myers (1997) [40] reviewed injuries to the AMC and found that most catastrophic injuries were caused by impacts to the head. The impact causes the neck to recoil, stopping the moving trunk. The neck is very fragile and at speeds of 3.1 m/s only a small amount of the trunk's mass in the spine absorbs the load, causing immediate damage. These injuries are usually caused by traffic accidents, so the researchers recommend that car manufacturers build special head restraints into the seats. The types of injuries listed above not only affect patients physically, but can also have a negative impact on their quality of life and mental health (e.g. depression). Many researchers have studied the psychological effects of MSD injuries, post-traumatic stress, and self-care and self-image. Other symptoms were also present, but in smaller proportions: 10% weakness, 11% difficulty concentrating, 13% dizziness, 15% numbness, 16% tinnitus, 17% blurred vision and 19% headache. Many researchers have studied the effect of SCI injuries on the overall health and quality of life of patients. About 52% of patients who had been injured in an accident also developed a psychological disorder. Only 18% of the injured showed improvement, while 28% showed deterioration after 10-15 years after the accident.

Mechanisms of CSCI injuries

SCI is divided into upper and lower sections. In the upper part, there are fractures of the occipital bone, atlas and odontoid. In the lower segment, the remaining vertebrae are affected, including the spinal cord (Hadley *et al*., 2002) [18-49]. In the upper spine, there is often damage to the occipital condyle, along with atlanto-occipital dislocation. These fractures most often occur in patients who are already injured and cause the patient to lose consciousness. It is important to note that an atlanto-occipital dislocation can occur in a spinal injury and is involved in most cases of fatal fractures and even if the person survives, it can indicate that the nerves have been damaged where most of the permanent damage occurs, in many cases. Spinal injuries can occur as a result of atlantoaxial rotatory subluxation, such as atlas fractures. Explosive fractures such as the Jefferson fracture have also been documented. Other types of injuries are apex fractures, mid-dental fractures or A2 vertebral body fracture, and traumatic spondylolisthesis of the shaft also known as Hangman's fracture (Hadley *et al*., 2002) [18-49]. Alker *et al.* (1978) [2], Effendi *et al*. (1981) [11], Hadley *et al*. (1985) [19], Blackmore *et al*. (1999) [6] and Goldberg *et al*. (2001) [15], according to their classification by largest percentage, it is in the A6 and A7 vertebrae with the same percentage respectively 39.3%, in the A2 vertebra with a percentage of 24%, axial spondylolisthesis with a percentage that varies between 15-23% and atlantooccipital dislocation with a percentage of 10%.

Crosby and Lui (1990) [9] conducted an epidemiologic study of injuries and found that after blunt trauma, the incidence of SCI injuries ranges from 2-5%. If there is also a head injury, the injury rate increases. Hackl *et al*. (2001) [17] also conducted a study of 3,083 patient cases and found that facial injuries often lead to damage to the AMS, therefore recommending that health professionals include in their examinations the examination of patients who have sustained a traumatic brain injury or a facial injury/AMS. Holly *et al.* (2002) [50] reviewed 209 patient cases and found that because patients are often unconscious when injured, injury rates are higher (4-8%) and more difficult to identify and treat.

The atlas connects the skull to the TMJ and is in a vulnerable position due to its connection to the head. This bone is injured in a large proportion of injury cases, according to Goldberg *et al*. (2001) [15], whose study dealt with the clinical picture of 34,069 blunt trauma patients admitted to medical centers. The 6th and 7th vertebrae are also frequently injured in many cases, according to Blackmore *et al*. (1999) [6], involving 472 patients. In their study, Levine and Edwards (1991) [28] reported that 26% of injury cases involved atlas fracture, 10% referred to SCI and 1-2% to all spinal injuries.

After a car accident, for example, the AMC can be overstretched and compressed, causing damage. In addition to axial compression and hyperextension of the neck, researchers report other injury mechanisms involving the atlas bone. The classification of atlas injuries is divided into atlas injuries in rotator cuff dislocation, atlantooccipital joint dislocation, and cardiac ligament rupture. Hadley *et al*. (1988) [20] in their study presented 57 cases of patients with an atlas fracture and estimated that 7% of fractures in the SCI region were related to the atlas bone, which has been caused by violent trauma or collisions from motor vehicle accidents.

According to Hanson *et al*. (2002) [21], 19% of neck/head trauma cases result in occipital condyle fracture. Maserati *et al*. (2009) [29] reviewed 100 patients who had occipital condyle fractures and concluded that these fractures are more common in situations where a vehicle runs over a pedestrian, in motor vehicle accidents and when a person falls from a height. Researchers believe that the type of fracture and its displacement have something to do with both how the injury was caused and whether surgical fixation is needed.

Aulino *et al*. (2005) [3] recorded data on 76 patients with an occipital condyle fracture and found that its stability can be maintained by many other bones in the region. These bones include the scapula, pterygoid ligaments, odontoid bone, lateral atlantotuberos, and transverse ligament. These can limit joint movement between the atlas bone and the vertebra behind it. According to Alker *et al*. (1978) [2], bending and twisting as a result of hyperextension of the neck can cause excessive extension of the neck, causing dislocation of the atlanto-occipital joint. In fact, 10% of car accident victims suffered this injury. An SCI fracture is not common, but occurs more often in car accidents and falls from heights, and can also occur in children when the airbag deploys in a car accident. Of all neck injuries, it is considered one of the most serious fractures.

Subach *et al*. (1998) [35] studied the cases of 20 patients with atlas-axial rotational hyperluxation or injury due to combined rotational and bending forces, as seen in motor vehicle accidents and other violent collisions. Floman *et al*. (1991) [13] analyzed vertebral apex and midbone fractures, or A2 fracture, caused by the force of a fall or direct trauma to the cervical region. Many researchers have considered the possibility of spondylolisthesis of the shaft bone. Wood-Jones (1913) [41] was the first to document this injury and it is considered a hanging injury. It occurs in persons who have died by hanging and occurs due to violent cervical hyperextension. Francis *et al*. (1981) [14] studied 123 patients who had traumatic axial spondylolisthesis and explained how the fracture occurred on both sides of the A2 bone in the vertebral arch, either due to flexion or hyperextension, or due to weight on the SCI.

Effendi *et al*. (1981) [11] reviewed the cases of 131 patients who had axial spondylolisthesis. They found that 15% of anterior median spine fractures were caused by this injury. It is most often located between the A2 and A6 vertebrae. The victim either fell or was in a car accident. Of all bone fractures associated with an SCI fracture, Hadley *et al*. (1985) [19] found that 23% also had spondylolisthesis. It is the second most common injury associated with CSCI. Some physicians have considered injuries to the upper SCI by dividing the injuries into three (3) categories: a) external compression, b) neck extension, and c) combined external compression and neck extension (Cusick *et al*., 1982; Benzel *et al*., 1991; Torg *et al*., 1986; 1995) [10, 4, 36].

The impact of CSCI injuries on health and quality of life

Many researchers have studied the impact of SCIon patients' overall health and quality of life. Winkelstein and Myers (1997) [40] reviewed injuries to the CSCI and found that most catastrophic injuries were caused by impacts to the head. The impact causes the neck to recoil, stopping the moving trunk. The neck is very fragile and at speeds of 3.1 m/s only a small amount of the trunk mass at the spine absorbs the load, causing immediate damage.

In 1996, Squires *et al*. (1996) [51] studied the impact of whiplash injuries in 40 patients. Neck symptoms and pain had been present for more than 15 years in 70% of participants. The pain is similar to when the injury first occurred, but the back pain is of a lower intensity that has developed over time. About 52% of patients who had been injured in an accident also developed a psychological disorder, according to a study that examined patients' years after the accident that caused their injuries. Only 18% of injured people showed improvement, while 28% showed deterioration after 10-15 years after the accident.

Another study was conducted by Treleaven *et al*. (2003) [38] with the participation of 102 patients who had suffered an injury to the SCI. The researchers attributed the dizziness and vertigo to the neck injury which was similar to a "whiplash" injury. Another study was conducted by Mazzaroglou (2008) [44], which included 42 participants among others. It has been found that in addition to headache, neck injuries cause dizziness or vertigo. The types of injuries listed above not only affect patients physically, but can also have a negative impact on their quality of life and mental health (e.g. depression).

According to the findings of Suissa *et al*. (1995) [56], Treleaven *et al*. (2003) [38], Krause *et al*. (2007) [27], Schönenberg *et al*. (2014) [34] and Velanaki (2016) [43] the symptoms documented after a "whiplash" injury are: 70% of people experience headaches, 46-52% of people have psychological disorders, a lack of energy occurs in 30% of people and difficulty concentrating in 10% of people.

Many researchers have studied the psychological effects of SCI injuries, post-traumatic stress, and self-care and self-image. Agar *et al*. (2006) [1] conducted a study involving 50 patients who had injuries of the lower SCI. Their findings showed that levels of post-traumatic stress (PTSD) were closely related to the patient's social support, injury severity, and self-image and self-care. Carstensen (2012) [8] conducted a review study focusing on the psychological status and patient's quality of life after SCI injury. His findings showed that patients who experienced persistent pain after their injury showed reduced levels of quality of life in several domains (social, economic, psychological). Tournier *et al*. (2015) [37] studied 167 injured individuals and found that 39.4% of them were dissatisfied with the progression of their injury due to chronic neuropathic pain. The pain caused enormous psychological and social problems.

In addition to the 60 chronic neck pain patients surveyed in the study conducted by Velanaki (2016) [43], the participants' quality of life was also negatively affected by their chronic pain. The research results showed that many of the participants were still experiencing neck and head pain six months after their injury and that the severity of their pain was higher than when they were first injured. In addition, the review study by Nolet *et al*. (2019) [33] noted that approximately half of car accident victims still experience severe neck pain one year after their accident. Berglund *et al*. (2000) [5] looked at 232 cases of injury in the AMS and found that people who had been injured in the past were more likely to be injured again. In addition, the review study by Nolet *et al*. (2019) [33] noted that approximately half of car accident victims still experience severe neck pain one year after their accident. Berglund *et al*. (2000) [5] looked at 232 cases of injury in the AMS and found that people who had been injured in the past were more likely to be injured again. Nolet *et al*. (2010) [31] studied 919 randomly selected patients who had sustained an injury to the SCI and found that those who had been injured in the past were at higher risk of injury. The researchers' conclusions suggest that previous SCI injury is a factor in predicting future injuries to the region.

Nolet *et al*. (2012) [32] looked at data from 922 patients to see how chronic neck pain was associated with a patient's heart problems. They found that there is a fairly weak correlation between these two variables (the standard deviation is below the mean), related to patients' overall health and heart problems. Another study by Johnson (1996) [23] showed that in addition to back pain, injuries to the jaw joints, eyes, ears and temples can cause other health problems that are not immediately visible. These injuries are usually caused by traffic accidents, so the researcher suggests that car manufacturers build special head restraints into the seats as a preventive measure.

In addition to other injuries, Subach *et al*. (1998) [35] studied 20 juvenile patients and found that the children also had clavicle fractures caused by downward movement of the skull. Fielding and Hawkins (1977) [12] studied 17 patients who had an A1 rotator cuff injury. Their findings included limited neck mobility and persistent facial, oral, and vocal fold deformities due to pressures placed on the pharynx. Govender and Kumar (2002) [16] also noted these complications in their own research as well as vertebral artery thrombosis.

According to Fielding and Hawkins (1977) [12], Subach *et al*. (1998) [35] and Govender and Kumar (2002) [16] the effects of A1 rotator cuff injuries can be briefly described as including inability to move the neck, facial deformity, difficulty opening the mouth, vocal cord problems, vertebral artery thrombosis, even broken keys.

Krantz (1980) [26] studied 2 patients who had a ruptured cruciate ligament and found that there was significant neurological damage in both cases where the patient had sustained vertebral artery compression, they also had visual, motor and sensory disturbances. Bogduk and Yoganandan (2001) [7] looked at smaller injuries to the SCI and found that although there were no fractures and the head and neck did not exceed normal limits, there was a sigmoid deformity due to abnormal rotational movement of the neck around an excessively high axis and rotation resulting in the separation of the anterior parts of the cervical spine.

For their part, Watkinson *et al*. (1991) [39] investigated 35 patients with soft tissue injury of the CSCI, recording symptoms of paresthesia and back pain. Symptoms lasted more than 10 years and were described by the majority of patients (86%) as bothersome, while 23% of participants described them as severe. A similar conclusion was reached by Jull *et al*. (2002) [24] who examined 200 injured people. According to the researchers, headaches are directly related to craniospinal instability and also manifest as paresthesia, nausea, dizziness, hearing and vision disturbances, general malaise and disorientation. In the same study, neck pain improved after physical therapy and chiropractic.

Momjian *et al*. (2003) [30] studied 14 cases of young victims with occipital fractures and found that 53% of patients had cranial nerve damage. Both Momjian *et al*. (2003) [30] and Cirak *et al*. (2000) [52] noted that cranial nerve damage can be either temporary or permanent. In fact, in the latest research, two patients suffered permanent cranial nerve damage after a car accident, due to delayed recognition of the injury. In addition, in both cases the patients complained of changes in their voice (impaired speech) and difficulty in swallowing. According to Momjian *et al*. (2003) [30], secondary displacement of fracture fragments can damage cranial nerves in a delayed manner, even resulting in death due to brainstem compression.

Zalez-Cruz and Nanda (2006) [42] reviewed deaths that occurred as a result of atlanto-occipital dislocation. This injury is uncommon, but very dangerous. It can cause multiple neurological problems, from loss of nerve function to loss of consciousness. Horn *et al*. (2007) [22] studied the condition of 28 patients who had atlantooccipital dislocation. They looked at spinal instability caused by trauma, bone fractures at the base of the head and mandible, aortic rupture, rib injuries, and subarachnoid hemorrhage.

According to Zalez-Cruz and Nanda (2006) [42], Horn *et al*. (2007) [22] and Karam and Traynelis (2010) [25], atlantooccipital dislocation injuries can cause: spinal instability, aortic rupture, skull and jaw bone fractures, rib cage fracture, and subarachnoid hemorrhage. Research by Karam and Traynelis (2010) [25] also shows that spinal instability can also be present when there is a tear between the atlantooccipital and atlantoaxial ligaments.

Discussion

Several studies are focusing on the biomechanics of SCI injuries and others combined studies addressing the impact that SCI injuries have on patients' quality of life and general health. The present review included 46 international articles, relative on the mechanism, frequency of occurrence and symptoms caused by CSCI in patients with SCI. Symptoms of these injuries can be detected early and treatment initiated to limit secondary issues such as hypotension, hypoxia, ischemia, blood flow problems, lipid peroxidation, oxidative stress, and impaired autoregulation. These secondary problems can lead to long-term illnesses such as paralysis or even death. The majority of SS injuries are the result of motor vehicle accidents, falls, or even violent assaults.

The regions of the SCI most commonly affected are the atlas-axial rotator cuff bone (Blackmore *et al*., 1999; Hadley *et al*., 1988; Levine & Edwards, 1991) [6, 20, 28]. From the study by Goldberg *et al*. (2001) [15], it appeared that the 6th and 7th vertebrae were involved in 1/3 of all injuries, while in the study by Blackmore *et al*. (1999) [6], this number was higher - 39.3%. The way an injury occurs can depend on which part of the spine is affected. Different types of injuries include atlanto-axial rotational hyperexcitation, apical and medial odontoid fractures, and A2 body fracture (Floman *et al*., 1991; Subach *et al*., 1998) [13, 35]. These injuries occur when there is a fall or direct blow to the back of the neck, causing the SCI to be subjected to bending forces. Other spinal injuries include traumatic axial spondylolisthesis, which can occur when there is extreme extension or flexion of the spine, combined with pressure on the axial ligament of the SCI (Effendi *et al*., 1981; Hadley *et al*., 1985; Francis *et al*., 1981) [11, 14, 19]. One of the most fatal injuries of the spine is the fracture of the occipital condyles. These injuries occur as a result of lateral bending or twisting or axial compression after falls from a height, in traffic accidents, etc. (Alker *et al*., 1978; Aulino *et al*., 2005; Maserati *et al*., 2009) [3, 2, 29].

There are several categories of lower spinal cord injuries that cause neurological problems, such as quadriplegia, hemiplegia, apnea, respiratory disorders, monoparesis, and paresis of different parts of the brain. These injuries cause damage to the soft tissues of the ligaments and muscles (Benzel *et al*., 1991; Cusick *et al*., 1982; Torg *et al*., 1986; 1995) [10, 4, 36]. Impact on the SCI is the most common cause of injury (70% of people who have had a neck injury report pain in and around their head/neck area). These injuries can be severe and long-lasting, causing psychological disturbances. There are many psychological disorders that can occur in patients who have chronic pain. Lack of independence and socialization can lead to depression.

In addition, many patients who have injuries to the upper part of the AMC have reported pain there as well (Johnson, 1996) [23]. Distortions of the face and mouth, vocal cords, eyes, ears and temples have also been noted as a symptom of the disorder (Cirak *et al.* 2000; Fielding & Hawkins 1977) [52, 12]. Krantz (1980) [26] documented that nausea and headaches may occur in association with visual, sensory, and motor problems. Watkinson *et al*. (1991) [39] noted back pain associated with paresthesia. Jull *et al*. (2002) [24] showed that craniospinal instability can cause paresthesia, dizziness, disorientation, nausea, visual and auditory disturbances, and a general feeling of discomfort.

There are also several injuries that can occur to the patient's abdominal, musculoskeletal, cardiovascular, and sensory systems. Some of these injuries include head base fractures, spinal instability caused by trauma or aortic rupture, chest injuries, and subarachnoid hemorrhage (Horn *et al*., 2007; Karam & Traynelis, 2010) [22]. It is thought that some of the researchers link SCI injuries with patients reporting heart problems (Nolet *et al*., 2012) [32], while others believe that a previous injury to the area is a risk factor for a new injury (Berglund *et al*., 2000 Nolet *et al*., 2010) [5, 31]. Finally, regarding the lower SCI, they can affect the patient's gastrointestinal, urinary and reproductive systems, as well as their sexual life (D' Hondt & Everaert 2011; Faaborg *et al*., 2008; Hagen 2015) [53, 54]. Nonetheless, further investigation is needed to address remaining aspects in this field (Korres, 1993) [46].

Conclusion

Spinal injuries, particularly those involving the Spinal Cord Injuries (SCI), can have significant consequences for patients, directly impacting their lives. This study aimed to examine spinal injuries resulting from accidents and investigate the physiotherapeutic management of chronic pain. The research focused on understanding the causes, frequency and impact of SCIs on health and quality of life. Findings revealed that many injuries were attributed to contact sports or traffic accidents, encompassing various types such as atlanto-axial rotatory hyperextension, apical and medial odontoid fractures, and body fractures. Advances in medical science and improved understanding of spinal biomechanics have enhanced the ability of healthcare professionals to diagnose and treat SCI injuries more effectively. While historically challenging to manage, early detection of both the injury and its effects on patient health has become feasible.

References

1. Agar E, Kennedy P, King NS. The role of negative cognitive appraisals in PTSD symptoms following spinal cord injuries. Behavioural and Cognitive Psychotherapy. 2006;34(4):437-452.
2. Alker Jr, GJ, Oh YS, Leslie EV. High cervical spine and craniocervical junction injuries in fatal traffic accidents: a radiological study. Orthopedic Clinics of North America. 1978;9(4):1003-1010.
3. Aulino JM, Tutt LK, Kaye JJ, Smith PW, Morris JA. Occipital condyle fractures: clinical presentation and imaging findings in 76 patients. Emergency radiology. 2005;11(6):342-347.
4. Benzel EC, Lancon J, Kesterson L, Hadden T. Cervical laminectomy and dentate ligament section for cervical spondylotic myelopathy. Journal of spinal disorders. 1991;4(3):286-295.
5. Berglund A, Alfredsson L, Cassidy JD, Jensen I, Nygren Å. The association between exposure to a rear-end collision and future neck or shoulder pain: A cohort study. Journal of clinical epidemiology. 2000;53(11):1089-1094.
6. Blackmore CC, Emerson SS, Mann FA, Koepsell TD. Cervical spine imaging in patients with trauma: determination of fracture risk to optimize use. Radiology. 1999;211(3):759-765.
7. Bogduk N, Yoganandan N. Biomechanics of the cervical spine Part 3: minor injuries. Clinical biomechanics. 2001;16(4):267-275.
8. Carstensen TB. The influence of psychosocial factors on recovery following acute whiplash trauma. Dan Med J. 2012;59(12):B4560.
9. Crosby ET, Lui A. The adult cervical spine: implications for airway management. Canadian Journal of Anesthesia/Journal canadien d'anesthésie. 1990;37(1):77-93.
10. Cusick JF, Myklebust J, Zyvoloski M, Sances A, Houterman C, Larson SJ. Effects of vertebral column distraction in the monkey. Journal of Neurosurgery. 1982;57(5):651-659.
11. Effendi B, Roy D, Cornish B, Dussault RG, Laurin CA. Fractures of the ring of the axis. A classification based on the analysis of 131 cases. The Journal of bone and joint surgery. British volume. 1981;63(3):319-327.
12. Fielding JW, Hawkins RJ. Atlanto-axial rotatory fixation. (Fixed rotatory subluxation of the atlanto-axial joint). The Journal of bone and joint surgery. American volume. 1977;59(1):37-44.
13. Floman Yizhar, Kaplan Leon, Elidan Josef, Umansky FELIX.) Transverse ligament rupture and atlanto-axial subluxation in children. The Journal of Bone and Joint Surgery. British volume. 1991;73(4):640-643.
14. Francis WR, Fielding JW, Hawkins RJ, Pepin J, Hensinger ROBERT. Traumatic spondylolisthesis of the axis. The Journal of Bone and Joint Surgery. British. 1981;63(3):313-318.
15. Goldberg W, Mueller C, Panacek E, Tigges S, Hoffman JR, Mower WR, *et al*. Distribution and patterns of blunt traumatic cervical spine injury. Annals of emergency medicine. 2001;38(1):17-21.
16. Govender S, Kumar KPS. Staged reduction and stabilisation in chronic atlantoaxial rotatory fixation. The Journal of Bone and Joint Surgery. British. 2002;84(5):727-731.
17. Hackl W, Hausberger K, Sailer R, Ulmer H, Gassner R. Prevalence of cervical spine injuries in patients with facial trauma. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2001;92(4):370-376.
18. Hadley MN, Walters BC, Grabb PA, Oyesiku NM, Przybylski GJ, Resnick DK, *et al*. Management of acute central cervical spinal cord injuries. Neurosurgery. 2002;50(3 Suppl):S166-72.
19. Hadley MN, Browner C, Sonntag VK. Axis Fractures: A Comprehensive Review of Management and Treatment in 107 Cases. Neurosurgery. 1985;17(2):281-90.
20. Hadley MN, Dickman CA, Browner CM, Sonntag VK. Acute Traumatic Atlas Fractures: Management and Long Term Outcome. Neurosurgery. 1988;23(1):31-35.
21. Hanson JA, Deliganis AV, Baxter AB, Cohen WA, Linnau KF, Wilson AJ, *et al*. Radiologic and clinical spectrum of occipital condyle fractures: retrospective review of 107 consecutive fractures in 95 patients. American Journal of Roentgenology. 2002;178(5):1261-1268.
22. Horn EM, Feiz-Erfan I, Lekovic GP, Dickman CA, Sonntag VK, Theodore N. Survivors of occipitoatlantal dislocation injuries: imaging and clinical correlates. Journal of Neurosurgery: Spine. 2007;6(2):113-120.
23. Johnson G. Hyperextension soft tissue injuries of the cervical spine--a review. Emergency Medicine Journal. 1996;13(1):3-8.
24. Jull G, Trott P, Potter H, Zito G, Niere K, Shirley D, *et al*. A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache; c2002.
25. Karam YR, Traynelis VC. Occipital condyle fractures. Neurosurgery. 2010;66(Suppl 3):56–59.
26. Krantz P. Isolated disruption of the transverse ligament of the atlas: an injury easily overlooked at post-mortem examination. Injury. 1980;12(2):168-170.
27. Krause JS, Brotherton SS, Morrisette DC, Newman SD, Karakostas TE. Does pain interference mediate the relationship of independence in ambulation with depressive symptoms after spinal cord injury? Rehabilitation Psychology. 2007;52(2):162.
28. Levine AM, Edwards CC. Fractures of the atlas. The Journal of Bone and Joint surgery. American. 1991;73(5):680-691.
29. Maserati MB, Stephens B, Zohny Z, Lee JY, Kanter AS, Spiro RM, *et al*. Occipital condyle fractures: clinical decision rule and surgical management. Journal of Neurosurgery: Spine. 2009;11(4), 388-395.
30. Momjian S, Dehdashti AR, Kehrli P, May D, Rilliet B. Occipital condyle fractures in children. Pediatric neurosurgery. 2003;38(5):265-270.
31. Nolet PS, Côté P, Cassidy JD, Carroll LJ. The association between a lifetime history of a neck injury in a motor vehicle collision and future neck pain: a population-based cohort study. European Spine Journal. 2010;19(6):972-981.
32. Nolet PS, Côté P, Cassidy JD, Carroll LJ. The association between self-reported cardiovascular disorders and troublesome neck pain: a population-based cohort study. Journal of manipulative and physiological therapeutics. 2012;35(3):176-183.

33. Nolet PS, Emary PC, Kristman VL, Murnaghan K, Zeegers MP, Freeman MD. Exposure to a motor vehicle collision and the risk of future neck pain: a systematic review and meta-analysis. Pm&r, 2019;11(11):1228-1239.
34. Schönenberg M, Reimitz M, Jusyte A, Maier D, Badke A, Hautzinger M. Depression, posttraumatic stress, and risk factors following spinal cord injury. International journal of behavioral medicine. 2014;21(1):169-176.
35. Subach BR, McLaughlin MR, Albright AL, Pollack IF. Current Management of Pediatric Atlantoaxial Rotatory Subluxation. *Spine* (Phila Pa 1976). 1998;23(20):2174-2179.
36. Torg JS, Pavlov Helene, Genuario SE, Sennett B, Wisneski RJ, Robie BH, Jahre C. Neurapraxia of the cervical spinal cord with transient quadriplegia. The Journal of bone and joint surgery. American. 1986;68(9):1354-1370.
37. Tournier C, Hours M, Charnay P, Chossegros L, Tardy H. Five years after the accident, whiplash casualties still have poorer quality of life in the physical domain than other mildly injured casualties: analysis of the ESPARR cohort. BMC Public Health. 2015;16(13).
38. Treleaven J, Jull G, Sterling M. Dizziness and unsteadiness following whiplash injury: characteristic features and relationship with cervical joint position error. Journal of rehabilitation medicine. 2003;35(1):36-43.
39. Watkinson A, Gargan MF, Bannister GC. Prognostic factors in soft tissue injuries of the cervical spine. Injury. 1991;22(4):307-309.
40. Winkelstein BA, Myers BS. The biomechanics of cervical spine injury and implications for injury prevention. Medicine and science in sports and exercise. 1997;29(7 Suppl):S246-55.
41. Wood-Jones F. The ideal lesion produced by judicial hanging. Lancet. 1913;181:(4662):53.
42. Gonzalez-Cruz J, Nanda A. Occipito-atlantal dislocation: an uncommon case of cervical spine injury. The Journal of the Louisiana State Medical Society: official organ of the Louisiana State Medical Society. 2006;158(6):297-8.
43. Velanaki K. Clinical Course of Patients With Chronic Cervical Syndrome After Whiplash Injury. Thesis. Technological Educational Institution of Western Greece. School of Health and Welfare Professions. Physical therapy department; c2016.
44. Matzaroglou X. Injuries of the lower cervical spine: clinical course of patients - algorithms - neurological scales - depression scales - quality of life and personality scales. Doctoral thesis. University of Patras. School of Health Sciences, Department of Medicine; c2008.
45. Galanis P. Systematic review and meta-analysis. Archives of Greek Medicine. 2009;26(6):826-841.
46. Korres D. Cervical Spine Injuries. Litsa Medical Publications, Athens; c1993.
47. Park K, Park Y, Seo W, Moon J, Kim B. Clinical results of early stabilization of spine fractures in polytrauma patients. Journal of Critical Care. 2014;29(4):694.e7-694.e9. https://doi.org/10.1016/j.jcrc.2014.03.003
48. Hoffman JR, Wolfson AB, Todd K, Mower WR, Nexus Group. Selective cervical spine radiography in blunt trauma: methodology of the National Emergency X-Radiography Utilization Study (NEXUS). Annals of emergency medicine. 1998;32(4):461-469.
49. Hadley MN, Walters BC, Grabb PA, *et al*. Treatment of subaxial cervical spinal injuries. Neurosurgery. 2002 Mar;50(3 Suppl):S156-65. DOI: 10.1097/00006123-200203001-00024. PMID: 12431300.
50. Holly LT, Kelly DF, Counelis GJ, Blinman T, McArthur DL, Cryer HG. Cervical spine trauma associated with moderate and severe head injury: incidence, risk factors, and injury characteristics. Journal of Neurosurgery: Spine. 2002;96(3):285-291. Retrieved Jun 26, 2023, from https://doi.org/10.3171/spi.2002.96.3.0285
51. Squires B. Soft-tissue injuries of the cervical spine. The Journal of Bone & Joint Surgery British. 1996;78-B(6):955-957. https://doi.org/10.1302/0301-620X.78B6.0780955
52. Cirak B, Akpinar G, Palaoglu S. Traumatic occipital condyle fractures. Neurosurg Rev. 2000;23:161-164. https://doi.org/10.1007/PL00011949
53. D'Hondt F, Everaert K. Urinary Tract Infections in Patients with Spinal Cord Injuries. Curr Infect Dis Rep. 2011;13:544-551. https://doi.org/10.1007/s11908-011-0208-6
54. Faaborg P, Christensen P, Finnerup N, *et al*. The pattern of colorectal dysfunction changes with time since spinal cord injury. Spinal Cord. 2008;46:234-238. https://doi.org/10.1038/sj.sc.3102121
55. Jazayeri SB, Beygi S, Shokraneh F, *et al*. Incidence of traumatic spinal cord injury worldwide: a systematic review. Eur Spine J. 2015;24:905-918. https://doi.org/10.1007/s00586-014-3424-6.
56. Suissa S. The case-time-control design. Epidemiology. 1995 May 1;6(3):248-53.