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Improvement in ASIA-score for traumatic spinal cord injured individuals

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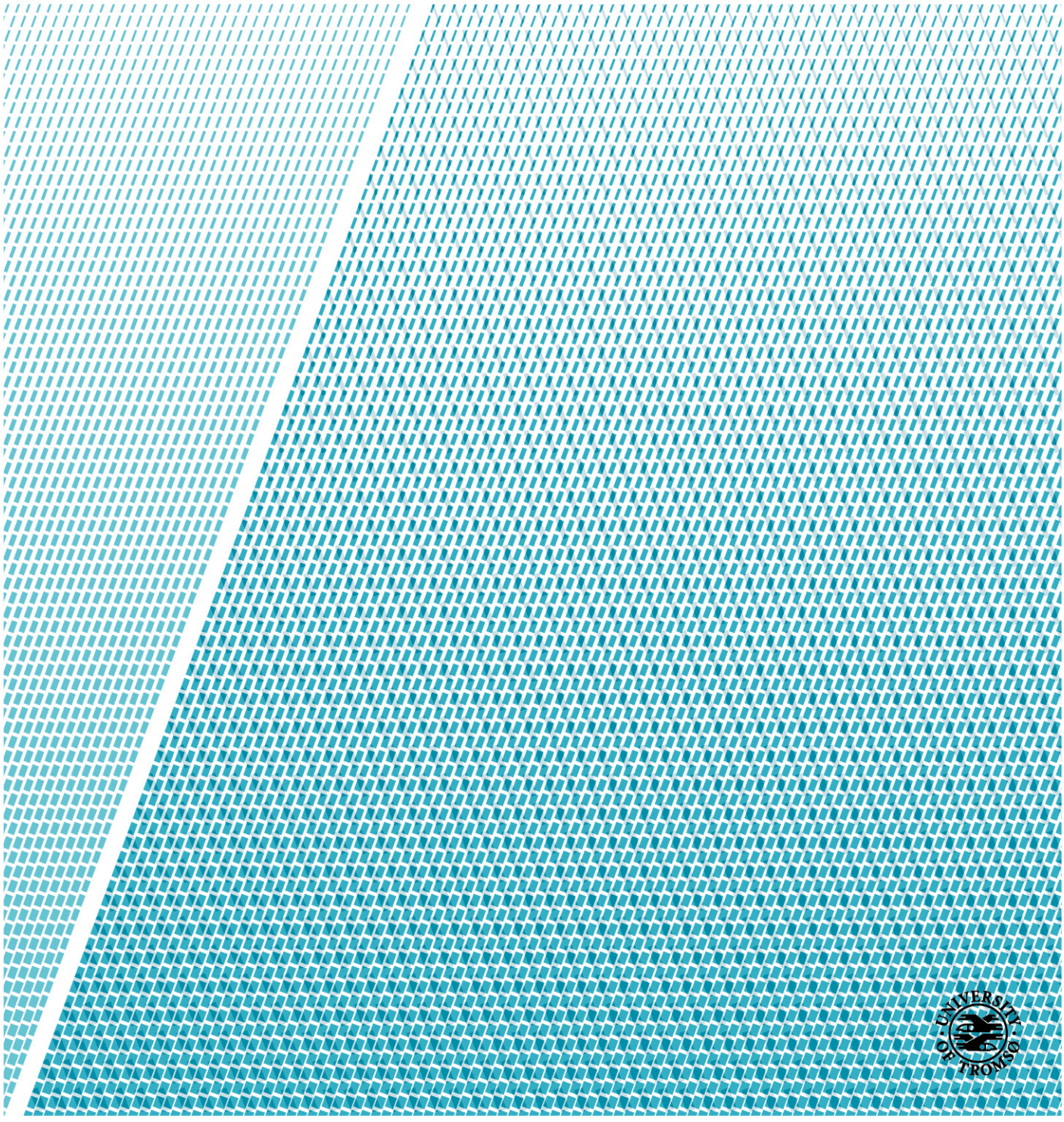

Preface

In April 2015 I was in a skiing accident., which resulted in a burst fracture in my L2 vertebra and was initially paralyzed from my waist and down. In the time that followed all my time was focused on rehabilitation and recovering, and at the same time I continued my studies. Throughout my rehabilitation I met many other spinal cord injured, and I heard many histories of spinal cord injuries and learned of many destinies. This nursed a growing interest for the condition, especially since spinal cord injuries causes completely different impairments with regards to which part of the spinal cord which is affected.

Intentionally this thesis was supposed to be a register study, extracting data from NORSCIR (the Norwegian spinal registery), and analyze neurologic recovery in spinal cord injury. However, practical challenges resulted in making me change the objective and choose to instead find out what is already known about neurologic recovery. Because of this change of objective, just two months before deadline, I had to work hard to finish this thesis. Anyway, I found the theme quite interesting and I have learned a lot through this process. It is my first scientific thesis, and I are satisfied about the result.

Since I am a spinal cord injured person myself, this also has impacted my interest of the condition, but it may also have affected my interpretation of the result. Anyway, it is now four years since my accident and I am now walking, running, bicycling and skiing again, so I am no longer in the group of patients which I study in this thesis.

I would like to express my gratitude to my supervisor Gunnar Leivseth with helping me develop the objective and help me with the inclusion/exclusion criteria, as well encouraging me to write in English and helping me with making the language correct and precisely. It has been quite a challenge to write in English. However, this process has brought learning through discussion, feedback and guidance.

Thanks to Eirik Reierth, librarian at the University library of the artic university of Tromsø, who helped me building a correct literature search to find as many relevant articles as possible.

At last a great thanks to my mother and father for helping me with language, discussion and encouragement. Their help has been priceless.

Signature: _____ Place/date: 2/6-19 Tromsø

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Figures and tables

Summary

Traumatic spinal cord injury is an injury which affect the patient on a functional, mental, social and economic level (1, 2). An injury to the spinal cord can affect motor, sensory and autonomic systems (1). From injury through rehabilitation process, neurologic recovery is seen (3). Hence it is interesting to find out what already is known about neurologic recovery in SCI and find what to expect with regards to prognosis. To assess neurologic recovery, the American spinal injury association impairment scale (AIS) was used (3). A literature search was conducted. The search words used were; spinal cord injuries (MeSH term), spinal cord injury, Traumatic spinal cord injury, prognosis (MeSH term), recovery of function (MeSH term), neurologic recovery, American spinal cord injury association impairment scale and ASIA impairment scale. Of the total 52 articles found, only three had recorded neurologic recovery in a five-year period with a 12-24 months follow-up period. These three articles were included in this thesis. The results imply that complete injuries have a low rate of neurologic recovery and incomplete injury has a better chance of neurologic recovery. Hence, increase in AIS. Knowledge about the neurologic recovery process is important for both the patient and rehabilitation team. From this knowledge it is possible to individualize the rehabilitation program with training and technique practice. As well give good information to patient and family about what to expect after an injury to the spinal cord (3).

Abbreviations

SCI – spinal cord injury; is an injury to the spinal cord which is has a traumatic (accidents) or nontraumatic (disease or degeneration) cause (4).

CEI - cauda equina injury; is an injury to the cauda equina, either from traumatic or nontraumatic cause.

CES – cauda equina syndrome, is if an injury to the cauda equina include impairment of the bowel, bladder or sexual function and perianal or “saddle” numbness (5).

CMI – conus medullaris injury, is an injury to the conus medullaris, originating from trauma or non-trauma cause.

ASIA – American spinal injury association, is a North American organization which focuses on spinal cord injury care, education and research (6)

ISNCSCI - International Standards for neurological classification of spinal cord injured; It is a systematic examination of dermatomes and myotomes and allows to determine the neurological level of injury and AIS (6)

AIS – ASIA impairment scale; is a final score of the examination, with ISNCSCI, which classify the injury as complete (ASIA-A) or incomplete (ASIA-B, C, D or E) (1).

SCIM - Spinal cord independence measure; is a functional outcome measurement developed for SCI individuals (2).

1 Introduction

Spinal cord injury (SCI) refers to an injury to the spinal cord which has either a traumatic (accidents) or nontraumatic (disease or degeneration) cause (4). The spinal cord is situated within the vertebral canal and transmits and process sensory, motor and autonomic information between the brain to visceral and somatic structures (1). It has origin from foramen magnum and ends at the first lumbar vertebra (7). An injury to the spinal cord results in impairment in motor, sensory and visceral functions, characterized by inability for volitional voiding and defecation, paralysis, impaired sensibility and spasticity (1). It is a life-altering condition which affect both the physical, social and personal level of life (1, 2). It is associated with significant morbidity (lower life expectancies), psychological stress, continued disability, need for help from public services and altered financial situation (3, 8, 9).

In literature cauda equina injury is often mentioned together with SCI. Cauda equina is an anatomical structure which consist of spinal nerves which exits in the lumbar, sacral and coccygeal region (1). It´s origin is the conus medullaris and ends at S2, where the dura mater ends (10). A cauda equina injury (CEI) has different symptoms than a SCI. An injury to the cauda equina is characterized by areflexia of the bladder, bowel and lower limbs, flaccid paralysis, impaired sensibility and no spasticity (1). Areflexia of the bowel and bladder gives urine retention and incontinence for stool, and the sexual function might also be impaired. An injury to the cauda equina might also give bilateral sciatica (5).

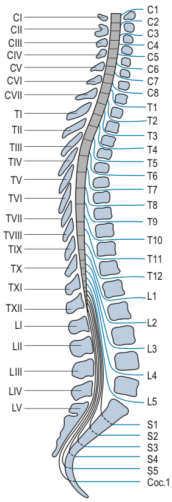

Figure 1 - this figure shows the anatomical location of the spinal cord and the cauda equina (2)

1.1 Spinal cord injury

The typical patient with a SCI are a young man in his thirties, tetraplegic either incomplete or complete (8). Typically mechanism of injury is fall (2, 11). Because of a relatively young population affected, which probably need help from both the health care system and the social security system throughout life, SCI is thought to be the world's most expensive condition (6, 8). This is why it is important to know more about this condition. SCI are classified according to which segments of the spinal cord which is injured, and therefore which part of the body which is paralyzed; i) tetraplegia means paralysis in all four extremities, trunk and thoracic- and pelvic organs, and includes C1 to Th1, ii) paraplegia means paralysis in lower extremities, and includes SCI (Th2 to L1), Conus medullaris injury (CMI) and CEI (6). Another factor which affect the level of impairment after a SCI, CMI or CEI, is whether the injury is complete or incomplete. The term incomplete is used when there is preservation of motor and/or sensory function below the neurological level. Neurological level is the lowest level where the function is normal. The term complete injury is used when there is absence of both sensory and motor function below the neurological level and in the lowest sacral segments (6).

SCI is a heterogenous group because the impairment is dependent of the level of injury. E.g a high tetraplegia injury, C1-C5, have impairment of the diaphragm as well as impairment of arms, trunk, pelvic organs and legs (12). Whereas a low paraplegic Th10-Th12 have impairment of the legs and pelvic organs, but normal function in the trunk and arms (1, 12).

In contrast to CEI, SCI is an injury to the upper neurons. This results in different impairments when it comes to reflexes, and the function of both the bladder and bowel. Upper motor neuron injuries often result in spasticity. According to Lance , spasticity is "a motor disorder characterized by a velocity dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex, as one component of the upper motor neuron syndrome" (13). Spasticity result in unpredictable jerking movements of the extremities associated with or without pain, and impaired range of motion (14).

The bowel impairment in SCI is characterized by preserved peristalsis, but loss of cortical control of the pelvic floor muscles and external rectal sphincter with inability to volitional defecation. The characteristics of bowel impairment vary largely between each SCI individual; hence it depends of the neurologic level of injury. If bowel challenges in a SCI individual is kept untreated, constipation and incontinence can be observed (14).

In the management of the bowel dysfunction it is important with a frequent intervention, daily or every other day. The baseline recommendations are adequate fluid (1,5-2L daily) and fiber intake (15-30g daily). This helps to promote optimal regularity and consistency of the stool. Administration of systemic or local drugs, such as laxatives, is also an option. Rectal stimulation might facilitate stool expulsion, since the reflex arcs is intact. Another solution for complicated situations can be irrigation techniques or colostomy. Irrigation is intermittent retrograde irrigation of warm water within the rectum. This technique breaks up impacted stool and stimulate peristalsis. It is administered through an enema continence catheter (14).

The bladder is also impaired by an SCI. Because of a disruption of the medulla, the cortical inhibition of the reflexive voiding is impaired and absent ability for volitional voiding (14). This results in incontinence due to involuntary reflexive emptying. However, in cases of incomplete injuries, detrusor disinhibition or urge incontinence might occur. This is because of impaired communication between the micturition center in the brain stem and the sacral micturition center. Therefore, the detrusor contracts reflexive but the outlet is obstructed due to contracted internal and external sphincters and this leads to increased bladder pressure. This is called detrusor-sphincter dyssynergia. In the long term this might result in vesicourethral reflux, hydronephrosis, recurrent pyelonephritis and reduced renal function (14).

The bladder challenges in SCI is managed by different options. For individuals with hand function, they may learn to perform self-intermittent catheterization. For individuals with reflexive contractions of the detrusor, the contractions may be suppressed by anticholinergics, with or without a tricyclic antidepressant, or injections with botulinum A toxin. In this way self-intermittent catheterization can be completed without a risk for renal complications or the risk for incontinence. The last resort of management is indwelling catheters because of the risk of urine tract infections, bladder cancer and bladder stones. Another option to long term indwelling catheter is a suprapubic catheter which is related to less complications, e.g. urethral strictures, fistulas and erosions is prevented (14).

An important concept about SCI is that injury above Th6 results in autonomic dysreflexia. This is a vasoconstriction and severe systemic hypertension which is caused by the intact spinal reflex mechanisms below level of injury (14). It might result in life-treating complications when severe, e.g. stroke, but it might also just give uncomfortable symptoms. However, this phenomenon occurs after the spinal shock phase, when reflexes are restored, and spasticity occurs (14). Episodes with autonomic dysfunction are triggered by painful or nonpainful sensory stimuli below the neurologic level of injury. This might be stimuli like full bladder or bowel. The management of autonomic dysfunction is about removing the inciting stimuli, like emptying a full bladder. In more severe cases it might also be necessary with medication or hospitalization (for observation) (15).

1.2 Cauda equina injury, cauda equina syndrome and conus medullaris injury

Symptoms of cauda equina injury reflect a pathologic process in the lumbar vertebral canal which affects multiple lumbar and/or the sacral nerves and causes dysfunction of these nerves. A dysfunction causes a combination of the symptoms mentioned above, and if the symptoms include impairment of the bowel, bladder or sexual function and perianal or “saddle” numbness, it is called cauda equina syndrome (CES) (5). CES has a low incidence in the population, and the numbers are ranging from 1:33 000 to 1:100 000 (16). However, this disease still generates a high public healthcare cost (16).

Disc herniation is the main cause of cauda equina syndrome, however only 1-3% of all lumbar herniations causes CES (17). Other etiologies CES includes; fractures or subluxation in the lumbar-sacral spine, spinal neoplasms (either metastatic or primary cancer), infections, iatrogenic and nerve derived tumors (5, 18). Anyway, burst fractures is the most common way for conus medullaris injury and CEI (19).

There is more space for neural structures in the lumbar and cervical regions than the thoracic region (20). Due to the increased space in the lumbar spinal canal, and the robustness and the potential for nerve regeneration of the spinal nerves, CES have a better prognosis compared to SCI (21). An injury that has an gradual onset, non-traumatic injury, shows better prognosis compared to traumatic injury with an acute onset (19). The neurological recovery potential, however, is unpredictable (20).

Recovery of sexual and bladder function may vary between a few months to a few years until normalization (22). Long-term management of bladder impairment after CES, if recovery doesn't occur, is most often self-intermittent catheterization or permanent catheters (14). For sexual function, the long-term management is different between the sexes. For men, over 80% will respond well with use of PDE5i with improved erection. Other treatment options are use of vacuum device, penile ring, intracavernosal injections and surgical penile prostheses (23). On the other hand, for women there are fewer options. Small but significant improvement in subjective arousal has been shown with use of sildenafil, especially combined with visual and manual stimulation (23). The management for sexual function for CEI is equal to management in SCI individuals, but SCI will have intact reflexes (23).

CES might affect both the bowel and the bladder. An injury to this anatomical location will abolish autonomic and somatic reflex arcs. The diminished reflexive spinal-colonic connection to the rectum and descending colon gives flaccidity and compromise the ability for propulsion and expulsion in combination with affection of the sphincter tone, which might be reduced. Other sacral reflexes, like the bulbocavernosus reflex, might be absent as well (14).

CMI is a special type of injury, with regards to elements from both SCI and CEI appearing, depending of which parts of the conus is injured (20). This is because of the anatomical location of conus medullaris, which are the end of the spinal cord and where cauda equina originates. So, an injury here might both affect the spinal cord and the spinal nerves of cauda equina (1, 20). It is also important to mention that conus medullaris has variable location in the population. It varies from TH11-12 disc space to L4 vertebra, but the most common location is at L1-L2 disc space (14).

1.3 Differences between CEI and SCI

	CEI	**SCI**
Injury to	Lower neurons	Upper neurons
Location of injury	Between conus medullaris and S2	Between C1 and conus medullaris
Bladder function	Areflexia, urine retention	Incontinence and inability for volitional voiding
Bowel function	Areflexia, incontinence	Preserved peristalsis, but inability to volitional defecation. But preserved anal reflex.
Sexual function	Impaired	May both be impaired and preserved
Motor function	Flaccid paralysis	May have spasticity
Sensibility	Impaired	Impaired
Reflexes	Absent	Preserved
Autonomic dysfunction	None	Present if injury above Th6

Table 1 – Differences between CEI and SCI

1.4 Epidemiology of SCI, CMI and CEI

SCI has an incidence between 10 to 80 per million per year in developed countries (1). The prevalence ranges from 236 to 1298 SCI per million in different countries (3). The majority of SCI is at the cervical level (C1-C7), approximately 55%. The remaining is composed by thoracic (Th1-Th12), thoracolumbar (Th11-12 to L1-2) and lumbosacral (L1-S5) regions, all occurs at approximately 15% (24).

In Norway NorSCIR (Norwegian spinal cord injury registry) registered 126 new cases of SCI in 2016 (25). It is recorded more men than women, who are suffering from SCI in Norway, by 70% (25). Hagen et al. (26) found a prevalence of 36,5 per 100 000 inhabitants in Norway. The mean age in that study was 42,9 years and males were injured 4,7 times more than females (26). It is estimated that traumatic SCI has a higher incidence than non-traumatic SCI in Norway (61/39%) (25), and this is coherent with international numbers (1). Anyhow in females, non-traumatic has a higher incidence than traumatic, and the opposite way for males (25). Traumatic SCI is defined as external trauma that directly or indirectly injures the spinal cord. Non-traumatic SCI is defined as an injury that occurs from a non-traumatic cause, e.g. infections, tumors, bleeding or thrombosis (25).

1.5 Classification system for SCI

The international standard for characterization of neurological impairment after a SCI is the International Standards for neurological classification of spinal cord injured (ISNCSCI). It is a systematic examination of dermatomes and myotomes and allows to determine the neurological level of injury (6). From the examination a couple of output variables are calculated/determined; motor and sensory scores, neurological level of injury (the most caudal level with normal neurologic function), complete/incomplete injury, zones of partial preservation and finally the American Spinal Injury Association Impairment Scale (AIS) (27).

AIS is a final score of the examination which classify the injury as complete (ASIA-A) or incomplete (ASIA-B, C, D or E) (1). ASIA-A means a complete spinal cord injury with no motor or sensory function is preserved in the sacral regions (S4-S5). ASIA-B means a motor complete but sensory incomplete. Sensory function is preserved below the neurologic level of injury and includes also the sacral segments (S4-S5). ASIA-C means a motor and sensory incomplete injury. Motor function is preserved below the neurologic level of injury, and more than half of the key muscles has a grade below 3. ASIA-D means an incomplete injury with motor function preserved under the neurologic level and have muscle grades equal or greater than 3. AISA-E means normal function in both motor and sensory systems (27, 28).

A scoring system like the ISNCSCI has its pros and cons. An important advantage is that it is possible to conduct this examination early after a SCI. It is important to have an early examination for keep track of later improvement. Another advantage is that AIS is an international common language between clinicians and scientists (6). It has also been proven to be interrater reliable if the clinicians are experienced and well trained in use of the ISNCSCI (29, 30). A disadvantage is the multidimensional measure that originates from summation from different dimensions, and thereby it might fail to link neurological changes to functional improvements (6).

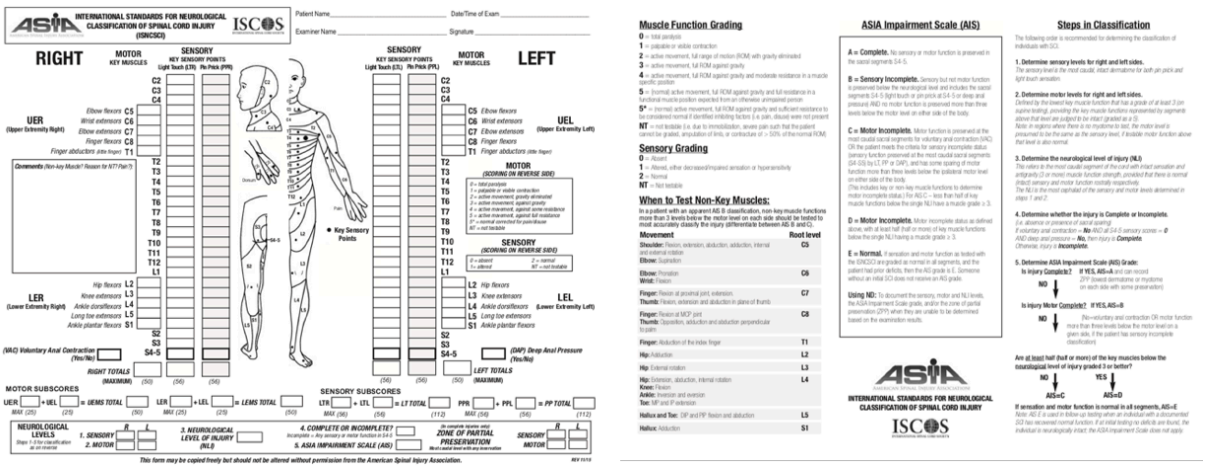

Figure 2 - ASIA-score scheme (31)

1.6 Aims of study

The objective for this study was to examine the rate of neurological recovery, measured with AIS (American spinal injury association impairment scale), in SCI individuals, in traumatic SCI, from baseline to after 12- to 24-months. Several studies have shown that AIS is one of several factors for predicting neurologic recovery, and this is why this variable is chosen for this literature study (2, 3). The follow-up time of 12-24 months is chosen to include most of the neurologic recovery in SCI individuals. With a shorter follow-up period, some of the recovery might fail to be registered because studies show that recovery also happens after 6 months (3). However, the most rapid rate of recovery is observed during the first three months post-injury (3). A recent published meta-analysis (3) found that most of published studies uses follow-up shorter than 6 months, and they emphasized the importance of longer follow up periods. Hence, studies with longer follow up, record significantly more neurologic recovery than studies with shorter follow-up (3).

The objective of this literature study is to examine the long-term prognosis of SCI. This is important to know early in the rehabilitation process for the newly-injured, for family and for the rehabilitation process. Knowledge about the prognosis in SCI could lead to better adapted individual rehabilitation for the SCI individuals. Studies that examine the prognosis is also important for other studies, especially experimental studies, so the intervention could be carefully reviewed.

2 Method and material

A literature search in Pubmed, using the following search word; spinal cord injuries (MeSH term), spinal cord injury, Traumatic spinal cord injury, prognosis (MeSH term), recovery of function (MeSH term), neurologic recovery, American spinal cord injury association impairment scale and ASIA impairment scale. This was performed to find relevant articles that could highlight the neurologic recovery in SCI according to objective, and get more in-depth knowledge about the neurologic recovery of SCI.

Inclusion criteria were as follows:

- studies using AIS as measure for neurologic recovery, with one AIS within the first month after injury and one after 12-24 months.
- only studies that included the information about how many that increase, decline or stays with baseline AIS.
- patients with traumatic spinal cord injury.
- published the last five years, 2014-2019.

Exclusion criteria were as follows:

- experimental studies with interventions currently is not a part of treatment/rehabilitation of SCI. Due to that this type of intervention may affect the neurologic recovery.
- studies with shorter follow-up time than 12 months or longer than 24 months.
- studies not using AIS as measure on neurologic recovery.

From the objective, inclusion and exclusion criteria and research of existing literature, the search words (see table 2 below) were chosen. MeSH terms were used to include already indexed articles from US national library of medicine. Search words searching in the abstract and title were chosen to include non-indexed articles. The used MeSh terms has the following definition (according to pubmed):

- Spinal cord injuries; “Penetrating and non-penetrating injuries to the spinal cord resulting from traumatic external forces (e.g., wounds, gunshot, whiplash injuries, etc.)” (32).
- Prognosis; “A prediction of the probable outcome of a disease based on an individual's condition and the usual course of the disease as seen in similar situations” (33).
- Recovery of function; “A partial or complete return to the normal or proper physiologic activity of an organ or part following disease or trauma” (34).

The search word neurologic recovery is chosen due to that this term is used in articles who try to measure or describe the change in neurologic status from injury to follow-up. The other search words; spinal cord injury, traumatic spinal cord injury, American spinal injury association impairment scale and ASIA impairment scale, are extracted according to objective.

Eirik Reierth, librarian at the University library of the Artic University of Tromsø, UiT, assisted in building the search correctly to include as many relevant articles as possible.

Search word used in the literature search				
"spinal cord injuries"[MeSH Terms]	AND	“prognosis"[MeSH Terms]	AND	"American spinal injury association impairment scale"[Title/Abstract])
OR		OR		OR
"spinal cord injury"[Title/Abstract]		"recovery of function"[MeSH Terms]		"ASIA impairment scale"[Title/Abstract]
OR		OR		
"traumatic spinal cord injury"[Title/Abstract]		"neurologic recovery"[Title/Abstract]		

Table 2 - Search words used in literature search

All eligible studies were collected, and a full-text analyzation was performed. Relevant information was collected and inserted in a scheme (table 3) to compare the results of the studies. The following information where recorded; article title, authors, design, country, population, objective, variables, follow-up time, results and conclusion. Another scheme (table 4) was used for analyzing the neurologic recovery measured with AIS. The following information were recorded; AIS A no development, AIS A increase, AIS B no development, AIS B increase, AIS B reduction, AIS C no development, AIS C increase, AIS C reduction, AIS D no development, AIS D increase, AIS D reduction and AIS E. The number of study participants recorded with baseline AIS and control AIS (12-24months) is mentioned in parenthesis for the actual AIS in the no development collum.

The search was completed on May the 15th 2019. To find the newest articles which analyzed this theme, articles the last five years was screened.

The numbers extracted from the articles describing AIS development were analyzed using windows excel to calculate the means for each group.

3 Results

The search resulted in 52 articles. These articles were assessed for eligibility through heading and abstract, according to the inclusion and exclusion criteria. This process reduced the number of articles to six articles. Full-text articles were collected, with access through the university library, and read for assessment of eligibility. Then four studies were excluded because of they did not specifying the AIS improvement. One study was identified in the process of acquiring knowledge about SCI in the reference list of a meta-study (Khorasanizadeh et.al (3)) and included in the study. This results in three eligible studies (35-37).

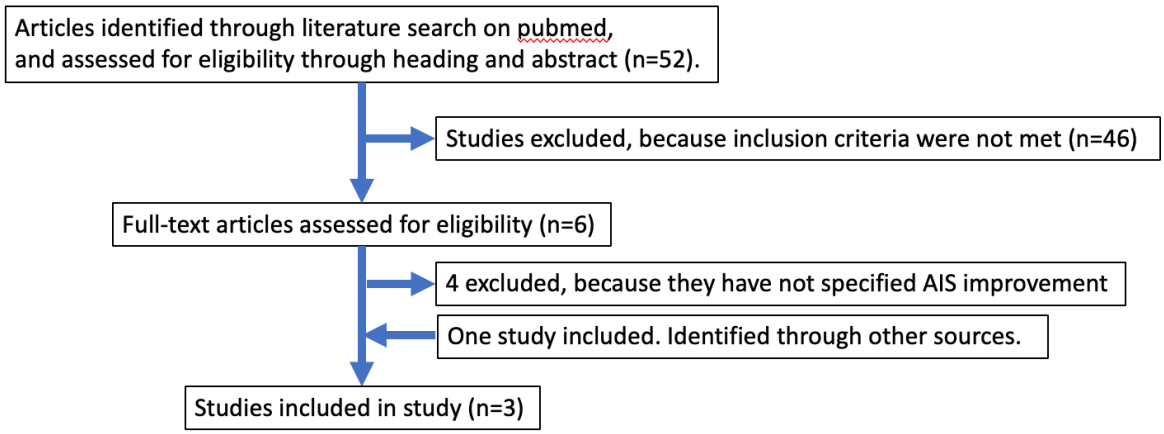

Figure 3 – flow diagram of process to identify the included articles

The comparison of the three studies show that there are significant differences between them, and this is shown in table 3. The most important differences are with regards to country, number of participants and design. There are one American, one Iranian and one Chinese study. The number of participants is raging from 35-711 participants. With regards to design, there are one study with a retrospective design, one randomized-controlled trial (RCT) and one cohort (prospective design). Only one of the included articles (35) measured neurological and functional outcome as main variables, and the others measure neurologic outcome as secondary variables (36, 37). One of the studies (36) focused on the effect of late and early surgical decompression, and one (37) used AO spine injury classification system to identify indication for early or late surgery .

Table 4 show the analysis of AIS grade. A high percentage, 84.5% and 86,6%, with AIS A (complete SCI) at baseline, did not change AIS grade at follow-up. For the incomplete grades the percentages for AIS B with increase in AIS grade from baseline to follow-up, is 58,8%, 36,4% and 100% respectively. For AIS C the percentages of AIS grade increase from baseline was 56,7%, 75% and 85,8%. For AIS D; 12,5%, 45,3% and 62,5%. The results of this study show that incomplete injuries have a better neurologic outcome (AIS B-D) than complete injuries (AIS A) 12-24-months postinjury.

Scheme for analyzing the articles									
Article title (year)	Authors	Design	Country	Population	Objective	Variables	Follow-up time	Results	Conclusion
Neurological and functional recovery after thoracic spinal cord injury (2016)	Lee L. A., Leiby B. E., Marino R. J.	Retrospective analysis of longitudinal database	USA	Injured between 2000 and 2011. At least 15 years old at the time of injury. Given a neurological exam within 1 week of injury. Sensory levels from Th1 – L2 on initial examination. 661 patients in total, but only 265 subjects had 1-year neurological data	To describe neurological and functional outcomes after traumatic paraplegia	AIS grade, Lower extremity motor scores (LEMS), sensory level (SL), FIM scores and walking status.	First neurological exam (done within one week) to 1-year postinjury	"At baseline 73% of subjects were AIS A, and among them, 15,5% converted to motor incomplete. The means SL increase for subjects with an AIS A grade was 0,33+-0,21; 86% remained within two levels of baseline. Subjects with low thoracic paraplegia (T10–12) demonstrated greater LEMS gain than high paraplegia (T2–9), and also had higher 1-year FIM scores, which had not been noted in earlier reports. Better FIM scores were also correlated with better AIS grades, younger age and increase in AIS grade. Ability to walk at 1 year was associated with low thoracic injury, higher initial LEMS, incomplete injury and increase in AIS grade".	"Little neurological recovery is seen in persons with complete thoracic SCI, especially with levels above T10. Persons who are older at the time of injury have poorer functional recovery than younger persons. Conversion to a better AIS grade is associated with improvement in self-care and mobility at 1 year".
Early versus late surgical decompression for traumatic/thoracolumbar (T1-L1) spinal cord injured (2014)	Rahimi-Movaghar V., Niakan A., Haghnegahdar A., Shahlaee A., Saadat S., Barzideh E.	RCT with one year follow up.	Iran	Injured from 2010, referred to trauma center in Shahid Rajaee hospital. Of 1480 patients 394 had TSCI. Of these thirty-five met the inclusion/exclusion criteria and where included in the study. 16 where randomly assigned to early, and 19 to late surgery.	"To assess the efficacy of surgical decompression <24 (early) versus 24-72 hours (late) in thoracic/thoracolumbar traumatic spinal cord injury"	Late and early surgical decompression, AIS, AMS, ASS, length of hospitalization, complications, postoperative vertebral height restoration/rebuilding and angle reduction and 12-month loss of height restoration/rebuilding and angle reduction were evaluated.	Neurologic exams were performed pre and postoperative, at one, 3, 6 and 12-months.	"Sixteen patients (46%) had complete TSCI. No AIS change was seen in 17 (52%) patients. Complete TSCI patients had no motor improvement. The AIS change in this group was solely due to increased sensory scores. For incomplete TSCI, the mean motor score improved from 77 (±22) to 92 (±12) in early, and from 68 (±22) to 82 (±16) in late surgery. One deep vein thrombosis was observed in each group. There were 2 wound infections, one CSF leak, one case of meningitis, and one decubitus ulcer in the late surgery group. Six screw revisions were required."	"Our primary results show overall AIS and motor score improvement in both groups. Motor improvement was only observed in incomplete TSCI. Two-grade improvements in AIS were seen in 3 early, and one late surgery patient."

Decompression for traumatic thoracic/thoracolumbar incomplete spinal cord injury: application of AO spine injury classification system to identify the timing of operation (2018)	Du J. P., Fan Y., Liu J. J.,Zhang J. N., Meng Y. B., Mu C. C., Hao D. J.	Prospective cohort	China	Patient assigned to western orthopedic trauma center in China, between April 2013 to November 2016, with traumatic thoracic/thoracolumbar (Th1-L1) incomplete SCI. 721 patient in total, where 711 completed the study. Patient where between 16-80 years. They had an initial AIS grade between B-D with a spinal cord compression or injury confirmed with CT or MR. Do not include patients with injury to two adjacent vertebra levels, penetrating cause of injury, comorbidities, NTSCI.	Application of AO spine injury classification system (AOSICS) to identify the timing of operation for different types of traumatic thoracic/thoracolumbar incomplete spinal cord injury	Sex, age, causes of injury, level of lesion, injury severity score, hospital LOS, complications and mortality.	Initial AIS grade and follow-up AIS after one-year postinjury	"Seven hundred twenty-one patients with thoracic/thoracolumbar incomplete SCI were included; 335 patients underwent early surgery, and 386 patients underwent delayed surgery. Statistical results included the following comparisons of the early versus late groups: AIS improvement of 1 grade or more (combined groups: P = 0.009, odds ratio [OR] = 1.487; A: P = 0.777, OR = 1.072; B: P = 0.029, OR = 1.701; C: P = 0.007, OR = 1.762), AIS improvement 2 grades or more (combined groups: P = 0.002, OR = 2.471; A: P = 0.189, OR = 3.939; B: P = 0.011, OR = 2.550; C: P = 0.035, OR = 3.964) and PCS (combined groups: P = 0.327; A: P = 0.776; B: P = 0.019; C: P = 0.562). LOS (combined groups: P < 0.0001; A, B and C: P < 0.0001). Complications (combined groups: P = 0.267; A: P = 0.830; B: P = 0.111; C: P = 0.757)".	"Patients with type-A injuries with incomplete SCI do not have to undergo aggressive early operations. Patients with type-B and type-C injuries should undergo an operation early to achieve better clinical results".

Table 3 – scheme of results and comparison between three eligible studies

Scheme for analyzing the development of AIS.												
Article title	AIS A no development (n)	AIS A increase	AIS B no development (n)	AIS B increase	AIS B decrease	AIS C no development (n)	AIS C Increase	AIS C decrease	AIS D no development (n)	AIS D Increase	AIS D decrease	AIS E (n)
Neurological and functional recovery after thoracic spinal cord injury	84,5% (194)	15,4%	20,6% (34)	58,8%	20,6%	4,8% (21)	85,8%	9,5%	87,5% (16)	12,5%	0%	Not included in study
Early versus late surgical decompression for traumatic/thoracolumbar (T1-L1) spinal cord injured	86,6 % (13 of 15)	13,3% (2 of 15)	0%	100% (6)	0%	25% (1 of 4)	75% (3 of 4)	0%	37,5% (3 of 8)	62,5% (5 of 8)	0%	Not included in study
Decompression for traumatic thoracic/thoracolumbar incomplete spinal cord injury: application of AO spine injury classification system to identify the timing of operation	Not included in study	Not included in study	63,5% (129 of 203)	36,4% (74 of 203)	0%	43,2% (90 of 208)	56,7% (118 of 208)	0%	54,6% (164 of 300)	45,3% (136 of 300)	0%	Not included in study
Mean	85,5	14,35	28,03	65,07	6,9	24,33	72,5	3,17	59,87	40,1	0	Not applicable

Table 4 – scheme for analyzing development of AIS. Percentages mentioned by AIS grouping. AIS A/B/C/D no development means same AIS grade at follow-up compared to AIS baseline. AIS A/B/C/D decrease/increase means decrease/increase in AIS grade at follow-up compared to baseline AIS

4 Discussion

The results of this study imply that SCI individuals with complete injuries have a low rate of neurological recovery. Incomplete SCI individuals have a better prognosis for an increase in AIS. This is equal to what the metanalysis of Khorasanizadeh et al.(3) found. Anyway, this thesis only consists of three studies published the last five years. This might imply that SCI neurological recovery is currently not a large field of research. This might be due to SCI is not a very frequent condition, as mentioned earlier an incidence at 10 to 80 per million per year and prevalence between 236 to 1298 per million. However, it is a very costly group of diagnoses on the economic level, both for the individual and the society, so good treatment might reduce expenses (2).

All three of the included studies does only included thoracic and lumbal segments, and not cervical segments. However, it is the thoracic segments which has the poorest neurologic recovery and this group have been included. According to the metanalysis of Khorasanizadeh et.al (3), the potential for neurologic recover is in this manner thoracic < cervical and thoracolumbar < lumbar (3). However, since cervical segments were not included in the analysis, these findings have to be interpreted with caution.

Khorasanizadeh et al. (3) discovered that AIS C has a greater rate of neurological recovery than AIS B, which has a greater rate than AIS D. AIS A has the lowest rate of recovery (3). The same result of highest increase in AIS C were found in the studies of Du et al. (37) and Lee et al. (35). In Rahimi-Movaghar et al. (36) they found that AIS B has the largest AIS increase group. However this study only consists of 35 participants, and all the six participants with AIS B at baseline increased in AIS grade at follow-up (36).

The effect of lower increase in AIS D is thought to be a result of a ceiling effect in AIS (28). A newly published study, by Halvorsen et al. (11), included 347 patients with AIS A to AIS D. Four patients ended up with AIS E (at hospital discharge) and these four had AIS D at baseline. This suggest that SCI has a small chance of getting total normal neurologic function back after injury.

In the meta-analysis of Khorasanizadeh et al. (3), they mention that the use of prognosis data can be used to tailor rehabilitation and shape realistic goals for the individual patient. The findings of neurological recovery, in this study and the meta-analysis of Khorasanizadeh et al. (3), might suggest that AIS A rehabilitation should mostly focus on improving function which is not impacted by injuries, and incomplete injuries can in a higher degree be focused on acquiring function below neurologic level of injury.

The rates of AIS conversion (change in AIS grade) were recorded by the meta-analysis of Khorasanizadeh et al. (3). They found that 19,3% (95% CI 16.2–22.6) of AIS A, 73.8% (95% CI 69.0–78.4) of AIS B, 87.3% (95% CI 77.9– 94.8) of AIS C and 46.5% (95% CI 38.2–54.9) have conversion in AIS D (3). The percentages show that there are many of SCI who get a better AIS throughout rehabilitation, and points at high occurrence of neurologic recovery. Anyhow, an increase in AIS only means better neurologic function, and is not focusing on every day function. A study from 2017 by Kaminski et al. (2) used Spinal cord independence measure (SCIM) as main outcome with one-year follow-up. SCIM is developed for SCI individuals, and provide a functional recovery outcome and measure mobility, management of natural functions and hygiene (2). Studies like this might emphasize the everyday function of SCI injured and is as well as important as neurologic function.

Previous studies have found that AIS (incomplete/incomplete) together with neurologic level of injury and the initial motor score on ISNCSCI are the best predictors for neurologic recovery (38). All these variables are included in ISNCSCI, which means the examination is important for predicting the prognosis of the newly injured SCI. Motor scores is also included in the calculation of AIS.

This thesis merely includes three studies, and this shows that it is few studies on SCI performed and few that has been analyzing the neurologic recovery of SCI the last five years. Anyway, these three studies are different in design and objective, but record similar results, that incomplete injuries have better neurologic recovery than complete. This might imply that regardless of how the recording of results is performed or design of study, the findings are reproduceable for SCI.

The three studies are from different countries and continents, one from China, USA and the last one from Iran. This means that the populations are quite different in case of culture, economy and health care system. The meta-analysis of Khorasanizadeh et al. (3) commented that there were few studies from Africa and Asia. The two studies of Du et al. (37) and Rahimi-Movaghar et al. (36) are important for the SCI field of research, and not only studies of SCI in western-countries.

A follow-up time longer than 6 months, as mentioned earlier, might be ideal according to Khorasanizadeh et al. (3) to record neurologic recovery, even though it has it challenges. From the three studies included in this thesis, Lee et al. (35) had initially 661 participants but only 265 had one-year data in the register that they extracted data from. Du et al. (37) had initially 721 participants but 711 completed (37). In the study of Rahimi-Movaghar et al. (36) all participants completed (36 participants in total). This show that one challenge of a long follow-up time is loss of follow-up data. Longer follow-up period also needs more resources than shorter follow-up. These two reasons might explain some of the findings of Khorasanizadeh et al. (3) that most of the studies examine neurologic recovery has an shorter follow-up than six months.

To compare the results of these thesis and the results from Khorasanizadeh et al. (3) table 5 were made. Table five shows that the results from this thesis is lower than the results of the meta-analysis with regards to increase in AIS grade from baseline to follow-up (3).

	This thesis	Meta-analysis of Khorasanizadeh et al.	Difference
Conversion in AIS A	14,35%	19,3%	4,95 percent points
Conversion in AIS B	65,07%	73,8%	8,73 percent points
Conversion in AIS C	72,5%	87,3%	14,80 percent points
Conversion in AIS C	40,1%	46,5%	6,40 percent points

Table 5 – Difference in AIS conversion percentages between this thesis and meta-analysis of Khorasanizadeh et al.

Limitations of this thesis is the short period used, and the few articles included that only include the segments Th1-L2. Anyhow, these three articles were included due to inclusion criteria and time period, and might emphasize the necessity of more studies on this area. Subsequently the results of this thesis could be more representable with more included studies. It would also be an advantage that studies study functional outcome as well to map the everyday function of SCI.

5 Conclusion

The results in thesis imply that traumatic spinal cord injured who acquire AIS A at initial examination, has a small chance off AIS improvement after 12-24 months. Incomplete injuries (AIS B-D) however, has a better rate of neurologic recovery. This suggest that AIS A rehabilitation should mostly focus on improve the function which is not impacted by injury. On the other hand, rehabilitation of incomplete injuries one should focus more of acquiring function since the chance of neurologic recovery is greater. For future research, it is important to perform studies analyzing neurologic recovery with long follow up, 12-24 months or even longer, to give accurate prognosis of neurologic recovery in SCI. It is also important to do future research on how to individualize the rehabilitation for the different AIS groups (complete-incomplete) in order to obtain a best possible result of rehabilitation.

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Studiedesign: Tverrsnittstudie

Grade - kvalitet Lav

Formål	Materiale og metode	Resultater	Diskusjon/kommentarer/sjekkliste
«Målet med denne studien var å kartleggje omfanget og vurdere behandlinga av cauda equina-syndro- met ved avdelinga vår». **Konklusjon** «Om lag 1 % av operasjonstrengande isjias-pasientar har eit cauda equina-syndrom. Fleirtalet har berre eit partielt syndrom, komplette syndrom er svært sjeldne. Sjølv med optimal behandling kan det oppstå per- manente nerveutfall». **Land** Norge **År data innsamling** 1981-2001	**Populasjon: «**isjaspasienter ved avdelingen fra 1981 til 2001. Toltalt antall var 551 isjaspasienter som var førstegangsopererte i tidsperioden pluss 65 isjiaspasienter som blei reopererte og 57 av desse for residiv i same skive og åtte for prolaps i ei naboskive». Totalt 616 pasienter **Utfall -** Alle inkluderte pas har fått isjasoperasjon. Flesteparten av pasientene ble fulgt opp i etterkant poliklinisk. **Statistiske metoder –** Populasjonen er delt opp i grupper og det er oppgitt prosentsatser av dette. Ut fra dette er det oppgitt en prevalens av cauda equina syndrom i populasjonen. Samt er det oppgitt gjennomsnitt.	**Hovedfunn:** Av 616 pasienter ble 130 lagt inn akutt med sterke isjas/ryggmerter, evt kombinert med nevrologiske utfall. Av denne gruppa var 21 innlagt med mistanke om cauda equina-syndrom. Etter videre undersøkelse fikk seks pas diagnosen cauda equina syndrom og ble operert akutt. Resterende ble operert på andre indikasjoner.	**Sjekkliste:** • **Er formålet klart formulert? Ja** • **Er befolkningen (populasjonen) som utvalget er tatt fra, klart definert? Ja** • **Var inklusjonskriteriene klart definert?* Ja.** • **Var responseraten høy nok?* Gjennomgikk journaler i systemet så samtlige er inkludert. 77% kom til kontroll, så 23% møtte ikke til kontroll og man har ikke langtidsresultat fra disse.** • **Bruker studien målemetoder som er pålitelige for det som skal måles? Ja men det burde brukes konfidensintervall for gjennomsnittene** • **Er datainnsamlingen standardisert? Nei** • **Er dataanalysen standardisert? Nei** • **Hva forteller resultatene? At i studiens begrensa populasjon så er det en prevalens på cauda equina syndrom som samsvarer med det andre studier finner.** • **Kan det overføres til praksis? Ja. Den sier da noe om hvor ofte isjaspasienter har cauda equina syndrom** • **Stoler du på resultatene? Ja, men studien er noe enkelt utført** • **Kan resultatene overføres til praksis? Ja** • **Annen litteratur som støtter resultatene? Ja** **Hva diskuterer forfatterne som:** • **Styrke - delvis** • **Svakhet – Ikke nevt i særlig grad**

Referanse: Halvorsen A,Pettersen A.L, Nilsen M, Krizak Halle K, Epidemiology of tramatic spinal cord injury in Norway in 2012-2016: a registry-based cross-sectional study, spinal cord (2019) 57:331-338			Studiedesign: Tverrsnittstudie Grade - kvalitet Lav
Formål	Materiale og metode	**Resultater**	**Diskusjon/kommentarer/sjekkliste**
To analyse the epidemiological and demographic characteristics of persons with traumatic spinal cord injury (TSCI) in Norway. **Konklusjon** Lav insidens av TSCI i Norge sammenligna med studier globalt. TSCI erverves som oftest om våren og sommeren, samt i helgene. **Land** Norge **År data innsamling** 2012-2016.	**Populasjon: Alle registrerte i Norscir i perioden fra 1.1.2012-31.12.2016 som ervervet en TSCI. Samtlige var da innlagt ved en av tre spinalenheter i Norge. Totalt 349 pas.** **Hovedutfall: insidens av TSCI i Norge, kjønnsfordeling, aldersfordeling, skade etiologi, utskrivelsessted, tetaraplegi/paraplegi, AIS skåre endring.** **Statistiske metoder: insidens, løpende variabler presentert med gjennomsnitt med SD og med median med intervall, kategoriske med antall og prosenter og forhold mellom kjønn.**	**Hovedfunn** **Insidens for hvert år fra 2012 til 2016. Varierte fra 11,4/million (2012) til 15,9/million (2014). Totalt 349 fikk TSCI ila perioden. Totalt var 76% menn og gjennomsnittsalderen var 47. Flest skada var det i aldergruppa 60-74 år. Forholdet mellom tetra- og paraplegi var 48/42%. Av tetraplegikerne hadde 63% høy cervical skade, dvs C1-C4. De som var AIS A ved innkomst, så fortsatte 77% å ha denne skåren ved utskrivning. De som hadde innkomplette skader hadde større andel økning i skåren. Fall var hovedårsaken til skade (47%). 41% av skadene skjedde i helgene. Gjennomsnittlig lengde på primæroppholdene var 120 dager. Flest, 68% ble utskrevet til sitt hjem.**	**Sjekkliste:** • **Er formålet klart formulert? Ja** • **Er befolkningen (populasjonen) som utvalget er tatt fra, klart definert? Ja** • **Var inklusjonskriteriene klart definert?* Ja.** • **Var responsraten høy nok?* ja, over 90%** • **Bruker studien målemetoder som er pålitelige for det som skal måles? JA** • **Er datainnsamlingen standardisert? Ja.** • **Hva forteller resultatene? Lav insidens av TSCI i Norge sammenligna med globale data.** • **Kan det overføres til praksis? Ja.** • **Stoler du på resultatene? Ja** • **Kan resultatene overføres til praksis? Ja** • **Annen litteratur som støtter resultatene? Ja** **Hva diskuterer forfatterne som:** **Styrke –** bruk av register data, funn samsvarer med internasjonal forskning. **Svakhet – «**90% of admitted patients consented to NorSCIR, causing a potential underestimation of the incidence. Patients with limited findings or quick recovery may be admitted to other departments or discharged home. It may be possible that elderly people with TSCI are less often transferred to a specialized SCI department, for example, given the limited possibility for rehabilitation due to comorbidities. Persons with TSCI who die in the acute phase are not included in this study. A previous study demonstrated that when individuals with TSCI who die at the scene of the accident are included, the incidence may be increased [34]. Unfortunately, the Norwegian SCI registry contains no information about alcohol consumption or drug use prior to injury given that this information is not included in the data set».

Referanse: Kirshblum S, Millis S, McKinley W, Tulsky D. Late neurologic recovery after traumatic spinal cord injury. Arch Phys Med Rehabil 2004;85:1811-7.			Studiedesign: longitudinell studie Grade - kvalitet: Lav
Formål	Materiale og metode	**Resultater**	**Diskusjon/kommentarer/sjekkliste**
Presentere MSCIS data på nevrologisk bedring etter ett år etter SCI. **Konklusjon** Man fant en liten grad av nevrologisk bedring (mellom 1 og 5år) etter en traumatisk SCI. Økning I AIS mellom ett og fem år hos complett skadde skjedde I 5,6% av tilfellene, men bare hos 2,1% var det en økning fra motorisk komplett til motorisk inkomplett. **Land** Norge **År data innsamling** 1988-1997	**Populasjon: Pasienter med tramatisk SCI som ble innskrevet til en MSCIS mellom 1988 og 1997 med 1 og 5-års kontrollopphold.** **Hoved utfall: AIS, MIS og NLI** **Statistiske metoder: Frekvens distribusjon og spearman p korrelasjons koeffisient, para t test, lin konkordans korrelasjons koeffisient,**	**Hovedfunn** Majoriterten av komplett skade forble komplett skadde etter 5 år (94,4%). 3,5% av komplett skadde økte til AIS grad b og 1,05% økte til C og det samme til D. Man fant en signifikant forandring i MIS. Det var ikke statistisk signifikant endring i motorisk nivå eller NLI. Derimot fikk 20% økning i motorisk og nevrologisk nivå. Pas med komplette og inkomplette skader hadde loik forbedring i motorisk nivå, men pas med inkomplett skade hadde økt sjanse for større forberinger i NLI og MIS.	**Sjekkliste:** • Formålet klart formulert? Ja • Er gruppene rekruttert fra samme populasjon/befolkningsgruppe? (seleksjons bias) Ja • Var gruppene sammenliknbare i forhold til viktige bakgrunnsfaktorer? (seleksjons bias)* uvisst om komplett skadde er en befolkningsgruppe ulikt sammensatt en de med inkomplett skade. • Var de eksponerte individene representative for en definert befolkningsgruppe/populasjon?* Ja • Ble eksposisjon og utfall målt likt og pålitelig (validert) i de to gruppene? (Classification bias) ** Ja • Ble mange nok personer i kohorten fulgt opp? (Attrition bias/follow-up-bias) Ja • Tror du på resultatene? Ja. men studien er gammel, og er gjort i USA, derfor kan det være noe forskjell norske tall og i nåtiden. • Kan resultatene overføres til den generelle befolkningen? Kan overføres til prognose til ryggmargskada • Annen litteratur som styrker/svekker resultatene? Ja • Hva betyr resultatene for endring av praksis? Gir en pekepinn på prognose. **Hva diskuterer forfatterne som:** • **Styrke** • **Svakhet - det har vært endringer i AIS klasifikasjonen i perioden. Intra og interrater reabilitet, pga forksjellige utfører undersøkelsene. Funksjonelle endringer ble ikke undersøkt.**

Referanse: Gedde M H, Lilleberg H S, Assmus J, Gilhus N E, Rekland T, Traumatic vs non-tramatic spinal cord injury: a comparison of primary rehabilitation outcomes and complications durin hospitalization			Studiedesign: Kohortestudie Grade - kvalitet: Middels
Formål	Materiale og metode	**Resultater**	**Diskusjon/kommentarer/sjekkliste**
Sammenligne resultat,, i form av AIS, lengde på opphold og komplikasjoner, for pasienter med TSCI og NTSCI etter primærrehabilitering. **Konklusjon** Pasienter med SCI har et rehabiliteringspotnsial uavhengig av om det er TSCI eller NTSCI. Komplikasjoner oppstår i like høy grad i begge grupper og forlenger lengden på oppholdet. Komplikasjonsmønsteret er forskjellig i de to gruppene. Spesifikke profylaktiske tiltak og optimal behandling vil forkorte og optimalisere primæroppholdet for pasientene. **Land** Norge **År data innsamling** 2004-2013	**Populasjon: 174 personer med SCI innlagt ved spinalenheten ved Haukeland sykehus. 102 TSCI og 72 med NTSCI. Inkluderer pasienter med forventa livslengde lengre enn lengda på primæroppholdet. Eksklusjonskriterier var død ila primæroppholdet eller mangel på samtykke. Dette gjadt fire pas.** Kohorter: NTSCI og TSCI. **Hovedutfall: Nevroligisk forbedring malt med økning I AIS skåre fra innkomst til utskrivning, oppholdslengd og hvor ofte og signifikans på komplikasjoner ble sammenligna** **Statistiske metoder: t-test, wilcoxon rank sum test, chi-squared test, logistisk regresjon, linær regresjon, multivariat logistisk regresjon, . P verdi satt til mindre enn 0,05.**	**Hovedfunn** Gjennomsnittsalderen var ikke signifikant forskjellig fra NTSCI og TSCI. Begge gr hadde større andel av menn, 58% og 72%. (p-0,069). Lengen på opphold var lengre for TCI enn NTSCI med 3,4 uker i gjennomsnitt (p-0007). Det var signifikant flere TSCI som hadde AIS A ved innkomst. Gjennomsnittlig fikk en fjerdedel av pas økning med mer eller lik en grads økning i AIS. 15% hadde ikke komplikasjoner. Andelen av med komplikasjoner var høyere blant NTSCI enn TSCI. TSCI hadde signifikant høyere andel med UVI enn NTSCI. NTSCI hadde en signifikant høyere andel med trykksår. Hovedfunnet var at etiologi er ikke en prediktor for forbedring i AIS skåre under primærrehabiliteringsoppholdet. Det er ingen forskjell i anatomisk nivå mellom TSCI ohg NTSCI	**Sjekkliste:** • Formålet klart formulert? Ja • Er gruppene rekruttert fra samme populasjon/befolkningsgruppe? (seleksjons bias) Ja • Var gruppene sammenliknbare i forhold til viktige bakgrunnsfaktorer? (seleksjons bias)* Viss man går utfra at TSCI og NTSCI rammer de ulike deler av populasjonen likt, så ja. Dette er ikke noe forskning på ennå som jeg veit. • Ble eksposisjon og utfall målt likt og pålitelig (validert) i de to gruppene? (Classification bias) ** Ja • Den som tolket journalene var ikke med i behandlingen av pas. • Var studien prospektiv? Nei retrospektiv. • Er det utført frafallsanalyser? (Eval. attrition bias) Nei, med det var to pga død under oppholdet og to som ikke samtykket. Liten gr. • Tror du på resultatene? Ja. • Kan resultatene overføres til den generelle befolkningen? Til den generelle SCI befolkningen, ja • Annen litteratur som styrker/svekker resultatene? Andre studier styrker funnene generellt sett. Noen funn er forskjellig fra andre studier. • Hva betyr resultatene for endring av praksis? Ja, at man ikke kan vurdere prognose utfra etiologi. **Hva diskuterer forfatterne som:** • **Styrke – inntaket på spinalenheten er offentlig finansiert, så sosioøkonomiske faktorer spiller liten rolle på populajonen** • **Svakhet – noen pas med NTSCI ble ikke tilbudt behandling pga kort forventa levetid. Progressive sjukdommer som gir NTSCI var eksludert (i inntaket ved avd). Retrospektive designet kan ha ført til underrapportering av komplikasjoner. Fornadringer i retningslinjer kan ha skjedd under studieperioden, som kan ha ledet til forskjellig behandling.**

Referanse: Rahimi-Movaghar V, Niakan A, Haghnegahdar A, Shahlaee A, Saadat S, Barzideh E. Early versus late surgical decompression for traumatic/thoracolumbar (T1-L1) spinal cord injured. Neurosciences (Riyadh). 2014;19(3):183-91.

Studiedesign: **RCT**

Grade - kvalitet Høy

Formål	Materiale og metode	Resultater	Diskusjon/kommentarer/sjekkliste
«To assess the efficacy of surgical decompression <24 (early) versus 24-72 hours (late) in thoracic/thoracolumbar traumatic spinal cord injury»	**Injured from 2010, referred to trauma center in Shahid Rajaee hospital. Of 1480 patients 394 had TSCI. Of these thirty-five met the inclusion/exclusion criteria and where included in the study. 16 where randomly assigned to early, and 19 to late surgery.** **Rekruttering deltakere: folk som ble skadet og henvist til et traume senter i Iran.** **Inklusjonskriterie:** «age of 18 years or older, TSCI between T1-L1, hemodynamic stability, evidence of spinal cord/conus medullaris compression and/or MRI signal change, and hospital admission before 24 hours of injury». **Eksklusjonskriterie:** «major and current psychiatric illness, significant concurrent traumatic brain injury, major concurrent medical disease, pre-injury major neurologic deficits or disease, ankylosing spondylitis, penetrating thoracolumbar injuries, pregnant females, life-threatening injuries preventing early cord decompression, criminals under indictment, or incarceration, substance abuse, an American Spinal Injury Association (ASIA) Impairment Scale (AIS) grade of E, no cord compression on MRI, spinal shock, any cognitive deficit, inability to provide informed consent, and an injury involving more than 2 adjacent vertebral levels». **Datagrunnlaget: 35 pasienter.** **Utfall (outcome) validering** **(for eks. diagnose): TSCI diagnosen var basert på sjukdomshistorie samt ASIA kriterie.** **Viktige konfunderende faktorer : metylpredisolon administrering.** **Statistiske metoder: students t-test, mann-whitney test, Fischer exact test, chi squared test. Signifikans nivå på <0,05.**	**"Sixteen patients (46%) had complete TSCI. No AIS change was seen in 17 (52%) patients. Complete TSCI patients had no motor improvement. The AIS change in this group was solely due to increased sensory scores. For incomplete TSCI, the mean motor score improved from 77 (±22) to 92 (±12) in early, and from 68 (±22) to 82 (±16) in late surgery. One deep vein thrombosis was observed in each group. There were 2 wound infections, one CSF leak, one case of meningitis, and one decubitus ulcer in the late surgery group. Six screw revisions were required."** **Hovedfunn** **Hvor stor er «intervensjons-effekten»?** **Incidence/RR/risk reduction/aRR** **CI** **Bifunn – andre viktige endepunkter**	**Sjekkliste:** • **Er formålet klart formulert? Ja** • **Hvem er inkludert/ekskludert? (seleksjon/generaliserbarhet) Inklusjonskriterier og eksklusjonskriterier er forenlige med at de bare ønsker å måle reine ryggmargskade uten comorbiditeter.** • **Var gruppene like ved starten? (seleksjon?, har randomiseringen fungert?) Ja** • **Randomiseringsprosedyre? Blocked sample randomization..** • **Ble deltakere/studiepersonell blindet mht gruppetilhørighet? Ja, klinikerne som utførte ASIA undrsøkelsen var det. Pasienter og kirurger var ikke det.** • **Ble gruppene behandlet likt utover «intervensjonen»? ja** • **Primære endepunktet – validert? (Classificatin bias?)** • **Ble deltakernne gjort rede for på slutten av studien? (attrition/follow-up bias)** • **Hva er resultatene? Presisjon? Er jo få deltagere men det er jo vanskelig å gjennomføre RCT på en stor populasjon.** • **Kan resultatene overføres til praksis? Som sagt liten populasjon, men i denne studien har man kontrollert inhentinga/intervensjonen kontra kohorte.** • **Ble alle utfallsmål vurdert? Ingen frafall.** • **Er fordelene verdt ulemper/kostnader?** • **Annen litteratur som styrker resultatene?** **Hva diskuterer forfatterne som:** **-styrke – «is that all surgical procedures were performed under supervision and decision of a single attending». «Also, separate randomization of complete and incomplete T1-L1 TSCI enables a comparison of outcome measures in these groups with long-term follow-up and a low dropout rate».** **-svakhet – «Neurological examination of our patients is prone to inter-observer variability as patient assessment and follow-up were not performed by a single examiner. A further limitation is the small number of cases preventing us from employing powerful statistical analyses».** **Har resultatene plausible forklaringer? Ja, de er forenlige med eksisterende litteratur.**
Konklusjon "Our primary results show overall AIS and motor score improvement in both groups. Motor improvement was only observed in incomplete TSCI. Two-grade improvements in AIS were seen in 3 early, and one late surgery patient."			
Land Iran			
År data innsamling 2010			

Referanse: Hagen E, Eide G, Rekand T, Gilhus N, Gronning M. A 50-year follow-up of the incidence of traumatic spinal cord injuries in Western Norway. Spinal cord. 2010;48(4):313-8.

Studiedesign: Historisk kohortestudie

Grade - kvalitet: middels

Formål	Materiale og metode	**Resultater**	**Diskusjon/kommentarer/sjekkliste**
"To assess the prevalence and temporal trends in the incidence of traumatic spinal cord injuries (TSCI), and demographic and clinical characteristics of an unselected, geographically defined cohort in the period 1952–2001". **Konklusjon** "The incidence of TSCI has increased during the past 50 years. Falls and MVA are potentially preventable causes. The increasing proportion of older patients with cervical lesions poses a challenge to the health system". **Land** Norge **År data innsamling** 1952-2001	**Populasjon: "…all inhabitants who sustained a TSCI in the period 1952–2001 in two Norwegian counties, Hordaland and Sogn og Fjordane". The patients were identified from hospital records.** **Hovedutfall:** - **Incidence** - **Prevalence** - **Mean age** - **Cause of injury** - **Age** - **sex** - **Incomplete/complete, and which segment of the spinal cord that where injured** - **relationship between cause of injury, age at injury, decade of injury and gender.** **Viktige konfunderende faktorer: ikke oppgitt** **Statistiske metoder: prosenter oppgitt for kategoriske variabler. For Løpende variabler er gjennomsnitt og SD oppgitt. For sammenligning av grupper brukte de X2test for proposjoner og gossets t-test og ANOVA for løpende variabler. Årlige rater er beregnet. Poisson regresjon ble benyttet for å bergene TSCI rater. Konfidensintervall (95%) er også benyttet.**	**Hovedfunn: "Of a total of 336 patients, 199 patients were alive on 1 January 2002. Giving a total prevalence of 36.5 per 100 000 inhabitants. The average annual incidence increased from 5.9 per million in the first decade to 21.2 per million in the last. Mean age at injury was 42.9 years and the male to female ratio 4.7:1. Fall was the most common cause of injury (45.5%), followed by motor vehicle accidents (MVA) (34.2%). The incidence of MVA-related injuries increased during the observation period, especially among men over 30 years. The lesion level was cervical in 52.4%, thoracic in 29.5% and lumbar/sacral in 18.2%. The lesion was clinically incomplete in 58.6% and complete in 41.4%. The incidence of fall-related injuries and the proportion of incomplete cervical lesions increased during the observation period, especially among men over 60 years".** **CI (wide/narrow) – 95%** This study found higher prevalence and incidence than other comparable studies completed in other Scandinavian countries. Anyway these studies has a different way of identifying its population.The study shows an trend of increasing numbers of eldery that acquire incomplete cervical TSCI fcaused by falling from ground level. "The incidence of TSCI has increased during the last 50 years. Falls and MVA are potentially preventable causes. The increasing proportion of older patients with cervical lesions poses a challenge to the health system."	**Sjekkliste:** • Formålet klart formulert? Ja • Er gruppene rekruttert fra samme populasjon/befolkningsgruppe? (seleksjons bias) Ja. Alle deltagere er rekrutert fra to fylker. • Var gruppene sammenliknbare i forhold til viktige bakgrunnsfaktorer? (seleksjons bias)* Det er uvisst, da det kan hende at enkelte undergrupper av TSCI er forskjellige fra andre. • Var de eksponerte individene representative for en definert befolkningsgruppe/populasjon?* Samtlige deltagere hadde TSCI • Var studien prospektiv? Nei. Retrospektiv. • Er det utført frafallsanalyser? (Eval. attrition bias) er ikke nevnt frafall. • Tror du på resultatene? Ja. Studien viser funn I sin gruppe som kan gi pekepinn på norske tall når det gjelder TSCI. Da ikke hele landet er inludert kan det være forskjeller mellom fylker med tanke på utdanningsnivå, yrkessammensetning og ellers demografisk fordeling. • Kan resultatene overføres til den generelle befolkningen? Se over • Annen litteratur som styrker/svekker resultatene? Andre skandinaviske studier viser lavere tall men er anderledes oppbygd I design og rekrutering I deltagere. Senere norske studier fra Norscir viser lavere tall, noe som kan tyde på at disse tallene er noe høye for den norske befolkningen som helhet. • Hva betyr resultatene for endring av praksis? Evt at det trengtes en opprustning av SCI behandlingen. **Hva diskuterer forfatterne som:** **Styrke – "**Patients with trauma have, however, had easy access to hospitals during the whole period. Therefore, we do not expect underreporting to have had a significant influence on our data. Our study is strengthened by the population-based case ascertainment and long observation period». **Svakhet – "**Some patients may have received a diagnostic code that did not suggest a TSCI. Some patients with minor neurological deficits may not have been initially diagnosed, and some patients never reached hospital because of a lethal injury». .

Referanse: Du JP, Fan Y, Liu JJ, Zhang JN, Meng YB, Mu CC, et al. Decompression for traumatic thoracic/thoracolumbar incomplete spinal cord injury: application of AO spine injury classification system to identify the timing of operation World Neurosurgery. 2018;116:e867-e73.

Studiedesign: prospectiv kohort.

Grade - kvalitet: middels

Formål	Materiale og metode	**Resultater**	**Diskusjon/kommentarer/sjekkliste**
Application of AO spine injury classification system (AOSICS) to identify the timing of operation for different types of traumatic thoracic/thoracolumbar incomplete spinal cord injury **Konklusjon** "Patients with type-A injuries with incomplete SCI do not have to undergo aggressive early operations. Patients with type-B and type-C injuries should undergo an operation early to achieve better clinical results". **Land** Kina **År data innsamling** 2013-2016	**Populasjon:** Patient assigned to western orthopedic trauma center in China, between April 2013 to November 2016, with traumatic thoracic/thoracolumbar (Th1-L1) incomplete SCI. 721 patient in total, where 711 completed the study. Patient where between 16-80 years. They had an initial AIS grade between B-D with a spinal cord compression or injury confirmed with CT or MR. Do not include patients with injury to two adjacent vertebra levels, penetrating cause of injury, comorbidities, NTSCI. **Hovedutfall: Endring I AIS. Sammenligner gruppe med sein operasjon med tidlig operasjon.** **Statistiske metoder: gjennomsnitt, standardavvik, students t test, chi-square test**	**Hovedfunn** "Seven hundred twenty-one patients with thoracic/thoracolumbar incomplete SCI were included; 335 patients underwent early surgery, and 386 patients underwent delayed surgery. Statistical results included the following comparisons of the early versus late groups: AIS improvement of 1 grade or more (combined groups: P = 0.009, odds ratio [OR] = 1.487; A: P = 0.777, OR = 1.072; B: P = 0.029, OR = 1.701; C: P = 0.007, OR = 1.762), AIS improvement 2 grades or more (combined groups: P = 0.002, OR = 2.471; A: P = 0.189, OR = 3.939; B: P = 0.011, OR = 2.550; C: P = 0.035, OR = 3.964) and PCS (combined groups: P = 0.327; A: P = 0.776; B: P = 0.019; C: P = 0.562). LOS (combined groups: P < 0.0001; A, B and C: P < 0.0001). Complications (combined groups: P = 0.267; A: P = 0.830; B: P = 0.111; C: P = 0.757)".	**Sjekkliste:** • Formålet klart formulert? Ja • Er gruppene rekruttert fra samme populasjon/befolkningsgruppe? (seleksjons bias) Ja, Kinesisk befolkning med TSCI • Var gruppene sammenliknbare i forhold til viktige bakgrunnsfaktorer? (seleksjons bias) ja. • Var de eksponerte individene representative for en definert befolkningsgruppe/populasjon? Nei, alle var i kinesisk populasjon • Ble eksposisjon og utfall målt likt og pålitelig (validert) i de to gruppene? (Classification bias) Ja. • Er den som vurderte resultatene (endepunkt- ene) blindet for gruppetilhørighet? ja • Var studien prospektiv? ja • Ble mange nok personer i kohorten fulgt opp? ja • Er det utført frafallsanalyser? Det er lite frafall, 721 kontra 711. • Var oppfølgingstiden lang nok til å påvise positive og/eller negative utfall? Ja. 12mnd oppfølging med SCI er nok fro å kartlegge nevrologisk forbedring. • Er det tatt hensyn til viktige konfunderende faktorer i design/ gjennomføring/analyser? • Tror du på resultatene? Ja, det er en en godt gjennomført studie. • Kan resultatene overføres til den generelle befolkningen? For TSCI, og man fant at AOSICS kan være med å prioritere pas for hastegrad til operasjon. • Annen litteratur som styrker/svekker resultatene? AIS er forenlig med hva andre studier har funnet. • Hva betyr resultatene for endring av praksis? Kan vise seg viktig for å prioritere hastegrad. **Hva diskuterer forfatterne som:** • **Styrke – mange deltagere. Samt tydlig retninglinje pga bruk av AOSCI.** • **Svakhet – er en kohorte som ikke kan derfor randomisere eller bruke dobbelt blinda metoder. Subgruppe analyser med signifikante forskjeller mellom sein og tidlig gr kan fortynne resultatet og derav påvirke dette. Operasjonene var utført av forskjellige kirurger.**

Referanse: Lee LA, Leiby BE, Marino RJ. Neurological and functional recovery after thoracic spinal cord injury. The journal of spinal cord medicine. 2016;39(1):67-76.			Studiedesign: historisk kohorte (retrospektiv registerstudie) Grade - kvalitet: Middels
Formål	Materiale og metode	**Resultater**	**Diskusjon/kommentarer/sjekkliste**
To describe neurological and functional outcomes after traumatic paraplegia **Konklusjon** "Little neurological recovery is seen in persons with complete thoracic SCI, especially with levels above T10. Persons who are older at the time of injury have poorer functional recovery than younger persons. Conversion to a better AIS grade is associated with improvement in self-care and mobility at 1 year". **Land** USA **År data innsamling** 2000-2011	**Populasjon:** Injured between 2000 and 2011. At least 15 years old at the time of injury. Given a neurological exam within 1 week of injury. Sensory levels from Th1 – L2 on initial examination. 661 patients in total, but only 265 subjects had 1-year neurological data **Hoved utfall: AIS etter ett år** Variabler: AIS grade, Lower extremity motor scores (LEMS), sensory level (SL), FIM scores and walking status. **Statistiske metoder: X^2 analysis, tukeys test, t-test, de lagde og en logistics mixed effects model**	"At baseline 73% of subjects were AIS A, and among them, 15,5% converted to motor incomplete. The means SL increase for subjects with an AIS A grade was 0,33+-0,21; 86% remained within two levels of baseline. Subjects with low thoracic paraplegia (T10–12) demonstrated greater LEMS gain than high paraplegia (T2–9), and also had higher 1-year FIM scores, which had not been noted in earlier reports. Better FIM scores were also correlated with better AIS grades, younger age and increase in AIS grade. Ability to walk at 1 year was associated with low thoracic injury, higher initial LEMS, incomplete injury and increase in AIS grade".	**Sjekkliste:** • Formålet klart formulert? Ja • Er gruppene rekruttert fra samme populasjon/befolkningsgruppe? (seleksjons bias) Ja, fra register om amerikanske SCI • Var gruppene sammenliknbare i forhold til viktige bakgrunnsfaktorer? Ja • Var de eksponerte individene representative for en definert befolkningsgruppe/populasjon? Ja • Ble eksposisjon og utfall målt likt og pålitelig (validert) i de to gruppene? Dette er en retrospektiv kohorte, så ikke aktuelt • Er den som vurderte resultatene (endepunkt- ene) blindet for gruppetilhørighet? Er en registerstudie. • Var studien prospektiv? Nei • Ble mange nok personer i kohorten fulgt opp? (Attrition bias/follow-up-bias) Ja, men var betydelige mange i registeret som ikke møtte inklusjonskriterier, 661 pas i registeret, så var det bare 265 som hadde dataene de så etter. • Er det utført frafallsanalyser? Ja, eller loss-of-follow up rate som er 60%. Og de fant ikke signifikante data mellom frafallsgruppe og inklusjonsgruppe. • Var oppfølgingstiden lang nok til å påvise positive og/eller negative utfall? Ja • Er det tatt hensyn til viktige konfunderende faktorer i design/ gjennomføring/analyser? Er andre som har innhenta dataene, så da har værtfall ikke forfatterne mulighet å påvirke dette. Derimot er det jo mange forskjellige klinikere som har innhenta data. • Tror du på resultatene? Ja. • Kan resultatene overføres til den generelle befolkningen? For de med TSCI ja. • Annen litteratur som styrker/svekker resultatene? Resultatene er forenlige med kjente data. • Hva betyr resultatene for endring av praksis? Gir et viktig bidrag til forskning pga at de har en lang oppfølgingstid. Noe som er viktig for forskninga på SCI. **Hva diskuterer forfatterne som:** • **Styrke – De har vurdert frafall og analysert om forskjeller mellom inklusjonsgruppe og gruppa uten adekvate data.** • **Svakhet – høy frafall og liten populasjon.**