Prospective Study

High Level of Childhood Trauma Predicts a Poor Response to Spinal Cord Stimulation in Chronic Neuropathic Pain

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Background: Spinal cord stimulation (SCS) relieves pain by delivering doses of electric current to the dorsal column of the spinal cord and has been found to be most effective in the treatment of neuropathic pain. Psychological distress is a significant risk factor for the development of chronic pain and has been found to affect the outcome of SCS. Childhood trauma is a risk factor for chronic pain, but has not previously been studied in SCS patients.

Objectives: The objective of this prospective registry-based study was to investigate the prevalence of 5 domains of childhood trauma (emotional neglect, emotional abuse, physical neglect, physical abuse, and sexual abuse) and their relationship with the outcome of spinal cord stimulation on patients suffering from treatment-resistant chronic pain.

Methods: SCS patients treated at Kuopio University Hospital between 1/1/2015 and 12/31/2016 were sent a survey in the mail, the Trauma and Distress Scale, assessing childhood trauma (n = 43). Neuropathic pain, disability, anxiety, and depression were measured in the patients pre-surgery and at 6 and 12 months post-surgery. The patients who provided their name on the questionnaire (n = 22) and had suffered from 3 or more domains of trauma were grouped as the high-trauma group (n = 13) and the rest as the low-trauma group (n = 9).

Results: The questionnaire was completed by 40 patients (93%). At least 1 domain of trauma was experienced by 35 (88%) patients, and at least 2 by 24 (60%). The low-trauma group displayed a statistically significant decrease in the mean PainDETECT score from 21.5 before SCS to 16.5 at 12 months post-surgery (Wilk's lambda = 0.297, F(2,9) = 10.6, P = 0.004), contrary to the high-trauma group (Wilk's lambda = 0.904, F(2,6) = 0.3, P = 0.739).

Limitations: Only 22 of the 40 patients provided their name on the questionnaire, which decreased the sample size on follow-up.

Conclusion: This was the first study to investigate childhood trauma in SCS patients. Patients who had experienced high amounts of childhood trauma did not experience any relief from neuropathic pain 12 months' post-SCS, contrary to the low-trauma group. Childhood trauma might be a factor worth screening in the preoperative evaluation and aftercare of SCS candidates.

Key words: Spinal cord stimulation, the Trauma and Distress Scale, chronic pain, childhood trauma, childhood abuse, childhood neglect, chronic back pain, back pain, psychological distress, neuropathic pain

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Chronic pain is defined as pain lasting over 3 months exceeding the normal healing time of tissue damage, as defined by the International Association for the Study of Pain (1).Chronic pain conditions are long-lasting and difficult to treat, while still being rather common. The prevalence of chronic pain is 19% in Europe, and its healthcare expenditures might exceed those associated with diabetes, heart disease, and cancer individually (2,3).

Spinal cord stimulation (SCS) is used for patients

suffering from chronic neuropathic pain and is commonly only performed after other forms of treatment have already been exhausted. SCS relieves pain by delivering doses of electric current to the dorsal column of the spinal cord. Currently, there are both paresthesia and paresthesia-free SCS techniques. The specific mechanism of action is unknown (4). SCS patients tend to report a high degree of psychological distress. Preoperative psychological screening has been found to be predictive of the treatment outcome, although there have also been conflicting research results (5,6).

Childhood psychological trauma has been found to influence the development of functional somatic syndromes, mental disorders, chronic pain, and other negative health outcomes in adulthood (7–9). Individuals who have suffered from childhood trauma tend to have an earlier onset of and report more chronic pain conditions (10–12). Childhood trauma appears to be associated with the onset of chronic pain, even after controlling for mental disorders and gender (12). Chronic pain patients or individuals self-reporting chronic pain also report more childhood trauma (13–16). HPA-axis dysregulation and allostatic load, alterations in inflammatory markers, and psychological schemas have been proposed as mechanisms by which psychological trauma might cause chronic pain (17–20).

This study was the first to assess childhood trauma in SCS patients. Our purpose was to investigate the prevalence of 5 distinct forms of childhood trauma (emotional neglect, physical neglect, emotional abuse, physical abuse, and sexual abuse) and their effect on the outcome of SCS in the relief of pain and disability using the Trauma and Distress Scale (TADS), a 43-item questionnaire that uses self-reports to retrospectively measure childhood trauma (21). Due to the multifaceted nature of chronic pain and its unresponsiveness to treatment, the childhood trauma of chronic pain patients needs to be further investigated to develop a more effective interdisciplinary approach to treating pain.

Methods

Patient selection for SCS

Kuopio University Hospital is a tertiary referral hospital. We performed an analysis of consecutive patients admitted to Kuopio University Hospital (KUH) between January 1, 2015 and December 31, 2016 using the prospectively acquired Kuopio Neuromodulation Database. The database is run by a dedicated nurse coordinator who interviews all new patients. The clinical data from the hospital periods and follow-up visits are coded in an extensive list of variables in the Kuopio Neuromodulation Database, which encompasses all patients who have permanent SCS. Follow-up visits to a dedicated nurse for outcome data collection took place 6 and 12 months after implantation. The clinical history, current symptoms, and previous operations were used to evaluate the candidates for SCS. The risks and rationale of the operation were explained to the patients. After a percutaneous lead or paddle-lead was implanted, patients underwent a week of trial stimulation. If adequate reduction in pain was achieved, a permanent pulse generator was implanted. Adequate pain reduction was measured with the PainDETECT questionnaire (22). SCS patients who received a permanent stimulator and agreed to participate in the study were sent a survey IN THE MAIL assessing childhood trauma.

Questionnaires

The Trauma and Distress Scale is a 43-item questionnaire that retrospectively measures childhood trauma. The frequency of trauma is estimated with a 5-point scale (0 = never, 4 = almost always). The questionnaire divides trauma into 5 domains: emotional neglect, physical neglect, emotional abuse, physical abuse, and sexual abuse. The severity scores for each individual question (0 = 0–1; 1 = 2–4) were dichotomized and then summed appropriately to form the 5 domains. Those who scored ≥2 in a domain were regarded as having experienced childhood trauma in that particular aspect, as described by Salokangas et al (21) using the same questionnaire. Patients who had experienced 3 or more domains of childhood trauma were grouped as the high-trauma group and the others as the low-trauma group. There were a total of 19 missing values among the 43 items of TADS. If the value of a missing response could affect the dichotomized scoring of a domain score, the domain score was regarded as missing data. The questionnaire was validated by Salokangas et al (21), with excellent internal consistency in every domain and good consistency compared to the interviewed TADS.

Anxiety and depression were measured with the Beck Anxiety Inventory (BAI) and Beck Depression Inventory (BDI), both of which are 21-item self-report questionnaires with a 4-point response scale (range 0–63) (23,24). A BAI score under 7 is considered to indicate a minimal level of anxiety, while 8–15 indicates mild anxiety, 16–25 moderate anxiety, and 26–64 severe anxiety (23) The following guidelines have been sug-

gested for the interpretation of BDI scores: 0–13 = no depression, 14–19 = mild depression, 20–29 = moderate depression, and 29–63 = severe depression (24).

Disability was measured with the Oswestry Disability Index (ODI), which consists of 10 items with 6 statements. Each statement has a value from 0 to 5, which are then summed together. The total score is presented as the percentage of the maximum score. A score of 21% to 40% is interpreted as moderate disability, 41% to 60% as severe disability, and 61% to 80% denotes a crippled individual. Scores under 20% are non-concerning (25). Pain intensity was measured with Numeric Pain Rating Scale (range 0–10) (26). The likelihood of neuropathic pain was measured with PainDETECT questionnaire (range 0–35). PainDETECT scores exceeding 19 suggest a high likelihood (>90%) of neuropathic pain (22).

Statistical Methods

The baseline measures of the high- and low-trauma group were compared using Fisher's exact test for nominal and the independent-samples t-test for scale variables. Variables used to measure the outcome of surgery were temporally compared using one-way repeated-measures ANOVA. The significance cut-off level was set at 5%. IBM SPSS Statistics V22 was used for the appropriate statistical tests.

Ethical Aspects

The study was approved by the Ethical Committee of the Kuopio University Hospital. The SCS registry has the permission of Ministry of Social Affairs and Health.

Results

Baseline Characteristics

The patient selection for the study is illustrated in Fig. 1. In total, 71 SCS patients were treated at Kuopio University Hospital during 2015 and 2016. We sent the TADS questionnaire to 43 patients who had received a permanent stimulator, and 40 of them completed and returned the questionnaire. At baseline, the mean BDI score was 13.0, which is between no depression and mild depression, and the mean BAI score of 10.7 indicated mild anxiety. The mean ODI score of 47.0 and PainDETECT score of 20.1 indicated severe disability and a high likelihood of neuropathic pain. The baseline characteristics are presented in detail in Table 1.

The Trauma and Distress Scale

A total of 40 patients completed the TADS questionnaire. Only the survey results of the 22 patients who provided their name on the questionnaire could be integrated with the follow-up data. The most common domain of trauma was emotional neglect (n = 30, 75%), followed by physical neglect (n = 25, 63%), emotional abuse (n = 14, 35%), physical abuse (n = 10, 25%), and sexual abuse (n = 4, 10%). Thirty-five (88%) reported having experienced at least one and 24 (60%) at least 2 kinds of childhood trauma. The most common combinations of 2 traumas were emotional neglect and physical neglect (n = 21, 53%), emotional neglect and emotional abuse (n = 13, 33%), emotional neglect and physical abuse (n = 9, 23%), and physical neglect and physical abuse (n = 8, 20%). The patients who had suffered from 3 or more domains of childhood trauma formed the high-trauma group (n = 9) and the rest formed the low-trauma group (n = 13). There was no significant difference between the groups at baseline (Table 1).

In one-way repeated-measures ANOVA, only the low-trauma group experienced a significant decrease in the PainDETECT score (P = 0.004), while both groups had a significant decrease in the NRS score. Detailed findings are presented in Table 2.

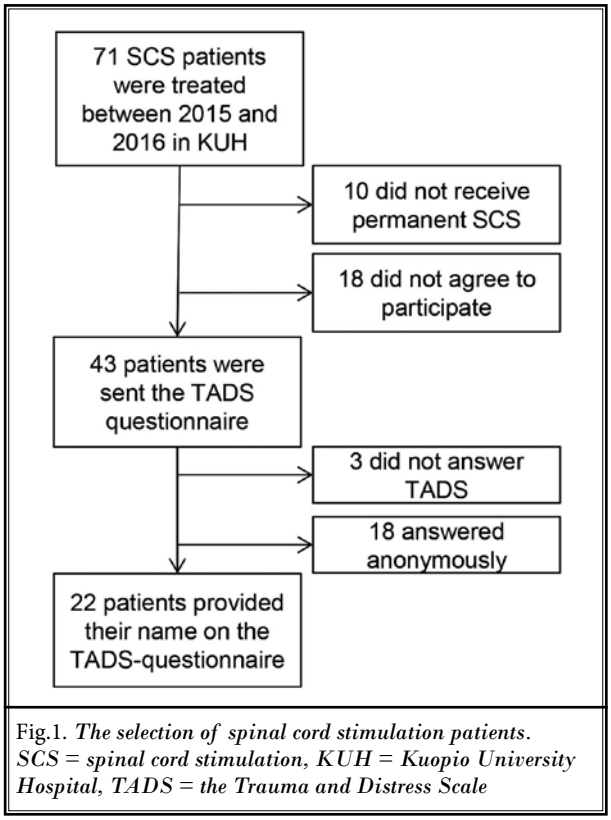

Fig.1. *The selection of spinal cord stimulation patients. SCS = spinal cord stimulation, KUH = Kuopio University Hospital, TADS = the Trauma and Distress Scale*

Table 1. *Baseline characteristics of the patients who received permanent SCS (n = 43) and completed the TADS questionnaire using their name (n = 22) divided into high- and low-trauma groups treated at Kuopio University Hospital during 2015 and 2016.*

Baseline characteristics	Permanent SCS (n = 43)	High-trauma group (n = 9)[a]	Low-trauma group (n = 13)[a]	*P*-value
Age (mean ± SD)	54.0 ± 16.2	59.7 ± 11.2	60.4 ± 16.1	0.909
Gender (male/female)	21/22	6/3	7/6	0.674
Number of back surgeries on those with FBSS (mean ± SD)	2.3 ± 1.8	2.9 ± 2.4	2.0 ± 0.8	0.334
Posterior lumbar desis (%)	13 (30)	5 (56)	3 (23)	0.187
PainDETECT (mean ± SD)	20.1 ± 6.7	16.2 ± 5.8	20.4 ± 7.1	0.161
Beck Anxiety Inventory (mean ± SD)	10.7 ± 7.2	11.2 ± 9.0	10.8 ± 6.2	0.895
Beck Depression Inventory (mean ± SD)	13.0 ± 8.5	16.0 ± 12.0	12.2 ± 6.1	0.395
Oswestry Disability Index (mean ± SD)	47.1 ± 16.8	47.1 ± 16.3	47.7 ± 20.5	0.942
Numeric Pain Rating Scale (mean ± SD)	7.1 ± 1.3	6.44 ± 1.0	7.55 ± 1.3	0.170
Failed Back Surgery Syndrome	33	8	8	
Pelvic floor pain	2	1	1	
Post-stroke pain	1	-	1	
Coccodynia	1	-	1	
CRPS	1	-	-	
Small-fiber neuropathy	1	-	-	
Thoracic pain	2	-	-	
Disease of the ulnar nerve	1	-	1	
Iatrogenic peripheral nerve damage	1	-	1	

The *P*-values were calculated by comparing the high-trauma and low-trauma groups using Fisher's exact test for nominal and the independent-samples t-test for scale variables. [a]The high-trauma group had experienced 3 or more domains of trauma and the low trauma group 2 or less. SCS = spinal cord stimulation, TADS = Trauma and Distress Scale, FBSS = failed back surgery syndrome.

We conducted pairwise comparisons using Bonferroni-adjusted significance tests to further specify the statistically significant findings in one-way repeated-measures ANOVA. The low-trauma group experienced a significant decrease in PainDETECT between pre-surgery and the 12-month post-surgical follow-up (P = 0.003), but not between pre-surgery and the 6-month post-surgical follow-up (P = 1.000). The high-trauma group did not display a significant decrease in the NRS score between any time points, contrary to the low-trauma group, which experienced an improvement in NRS between pre-surgery and the 12-month post-surgical follow-up (P = 0.007).

The high-trauma group experienced a significant improvement in disability between pre-surgery and 12 months post-surgery (P = 0.039), but not between 6 and 12 months post-surgery (P = 1.000). The high-trauma group also experienced a significant increase in the BDI score between pre-surgery and 6 months after (P = 0.035), but not between 6 and 12 months post-surgery (P = 1.000). In addition, we calculated the association between the BDI and BAI scores with the trauma group as a nominal variable using the eta value (η). Eta was 0.191 (η^2 = 0.036) between the trauma group and BDI score and 0.033 (η^2 = 0.001) between the trauma group and BAI. The association between the BDI score and trauma group can be interpreted as medium and that between the BAI score and trauma group as small, as proposed by Cohen (27).

Discussion

Results of the study compared with existing literature

The current study was based on a prospective registry that follows the disability, pain, anxiety, and depression of SCS patients. We used a retrospective postal survey to measure the childhood trauma of SCS patients. Our study revealed a high prevalence of childhood trauma in SCS patients: 88% of the patients reported having experienced at least 1 domain of childhood trauma, while a study (21) on the general

Finnish population using the same questionnaire found this prevalence to be 70%. The prevalence of sexual abuse was found to be 1.6% in the general population compared to 10% in the current study. Another study (28) on a Finnish population-based sample found that 34.4% of men and 30.3% of women reported at least a single event of abuse using the Childhood Trauma Questionnaire, which is also significantly lower than in the current study.

The patients who had experienced 3 or more domains of childhood trauma did not experience any significant relief in neuropathic pain during the follow-up, contrary to the low-trauma group. According to the PainDETECT scores, the patients in the low-trauma group on average shifted from the category with a high likelihood of neuropathic pain to that in which patients might have a slight neuropathic component to their pain, as described by Freynhagen et al (22). The discrepancy in the treatment outcome might be due to the already smaller neuropathic component in those with more childhood trauma (Table 2), since SCS tends to be more effective in treating neuropathic rather than nociceptive pain (29). Interestingly, those patients with more childhood trauma reported a similar relief in pain and disability post-surgery compared to those with less trauma, although the neuropathic component of their pain was much smaller, which might reflect the psychological aspects of chronic pain that SCS cannot treat. Patients with a history of trauma might tend to seek treatment with similar levels of pain, but with less actual physical trauma or nerve damage to which the origin of the pain could be attributed due to their increased sensitivity to pain (30). There was also a medium-sized association between depression and the trauma group, which might be a confounding factor that contributes to the findings, since current depression and anxiety in the patients may be associated with a poor SCS outcome (5).

Multiple previous studies (10-12,14) have found a dose–response relationship between childhood trauma and the development and the onset of chronic pain, which might explain why the patients in the current study reported such a high prevalence of childhood trauma. McLaughlin et al (10) found that patients with 3 or more violent events in childhood had 3 times higher odds of developing back and neck pain, even after adjusting for parental education, household income, and mental disorders, suggesting an inde-

Table 2. *The changes in the outcome variables at 6 and 12 months post-surgery between the low-trauma (n = 13) and the high-trauma group (n = 9).*

Outcome variables	Presurgery (mean ± SD)	6 months post-surgery (mean ± SD)	12 months post-surgery (mean ± SD)	Wilks' Lambda	F(df, dferror)	*P*
PainDETECT						
Low trauma	20.4 ± 7.1	14.3 ± 6.7	15.8 ± 8.6	0.297	F(2, 9) = 10.633	0.004
High trauma	16.2 ± 5.8	14.1 ± 5.1	15.6 ± 4.9	0.904	F(1, 7) = 0.318	0.739
Numeric Pain Rating Scale						
Low trauma	7.55 ± 1.3	6.0 ± 2.3	5.6 ± 1.7	0.363	F(2, 9) = 7.788	0.010
High trauma	6.44 ± 1.0	5.0 ± 2.1	5.1 ± 1.7	0.367	F(2, 6) = 5.175	0.049
Oswestry Disability index						
Low trauma	47.7 ± 20.5	40.9 ± 15.8	41.7 ± 24.1	0.563	F(2, 8) = 3.107	0.100
High trauma	47.1 ± 16.3	37.8 ± 21.8	41.0 ± 17.6	0.113	F(2, 5) = 19.667	0.004
Beck Anxiety Inventory						
Low trauma	10.8 ± 6.2	11.7 ± 10.3	13.6 ± 10.2	0.835	F(2, 9) = 0.888	0.445
High trauma	11.2 ± 9.0	11.9 ± 8.3	11.6 ± 7.2	0.947	F(2, 6) = 0.167	0.850
Beck Depression Inventory						
Low trauma	12.2 ± 6.1	12.4 ± 15.8	13.5 ± 9.1	0.815	F(2, 7) = 0.210	0.815
High trauma	16.0 ± 12.0	18.8 ± 12.8	18.1 ± 16.0	0.303	F(2, 6) = 6.912	0.028

The statistical test used was one-way repeated-measures ANOVA. The high-trauma group had experienced 3 or more domains of trauma and the low trauma group 2 or less.

pendent relationship between chronic pain and early psychological trauma. Similar findings were presented by Scott et al (12) in a cross-sectional community survey of adults in 10 countries, and by Stickley et al (14) in a population-based cross-sectional survey in Japan. Both studies revealed an increase in the risk of chronic neck and back pain in people who reported 3 or more childhood adversities. These studies support the idea that the allostatic load, recorded as the cumulative occurrence of childhood trauma, appears to increase the risk of chronic pain (12,14). The early psychological trauma of individuals might leave such a strong detrimental imprint on the developing brain that its effects can be seen decades later (31) In addition, childhood trauma has previously been associated with a spectrum of health risk behaviors in adulthood, including physical inactivity and obesity, which are major factors for the development of chronic pain (32,33). Childhood trauma also poses a risk for further abuse in adulthood, which contributes to the present mental health status of the patients (34).

Multi-disciplinary pain treatment was superior at treating pain compared with single-discipline treatment according to a meta-analysis of 65 studies (35). The results of SCS might be optimized when it is simultaneously performed with psychiatric treatment modalities. Psychological factors such as anxiety and depression and their effect on the treatment outcome of SCS have previously been investigated in SCS patients, unlike childhood trauma (5). Our findings on the prevalence of childhood trauma suggest that it might a factor worth considering in the preoperative evaluation and aftercare of SCS patients. We suggest that the childhood trauma of SCS patients should be screened using a questionnaire that includes all 5 core domains of childhood trauma. Patients who report childhood trauma in multiple domains should undergo preoperative psychological evaluation. The postoperative follow-up should also include an option for psychiatric counseling or care, preferably in a multidisciplinary pain center.

Limitations

The current prospective registry-based study relied on self-reports of exposure to childhood trauma. Retrospective self-reports might increase the risk of response bias and the incomplete recall of events (36). There might be a difference in recall between those who do and do not suffer from chronic pain (37). Moreover, TADS might be a more sensitive measure of childhood trauma, or the Finnish population might have a tendency to report milder trauma (21). Although we had a high response rate for the TADS questionnaire, only 22 of the 40 patients provided their name on the questionnaire, which prevented us from controlling for covariates such as anxiety and depression. However, there was no significant difference between the 2 groups in most baseline variables, which suggests that the results could describe the whole group.

Strengths of the Study

The study design was based on a prospective registry. The patient characteristics were well described with various different indicators that measure neuropathic pain, anxiety, depression, and disability. In addition, when assessing prevalence, we had a very high response rate, with only 3 out of the 43 participants failing to complete the TADS questionnaire. Furthermore, in many countries, a third party requires preoperative psychological screening for SCS, which might result in response bias (38,39). The patients in our study did not have such conflicts of interest, and they had an option to respond anonymously.

Conclusion

The current study was the first to assess childhood trauma and its effect on the treatment outcome of SCS patients. The chronic pain patients had a high prevalence of childhood trauma, and those who had experienced especially high amounts of childhood trauma did not experience a significant relief in neuropathic pain during 12 months of follow-up. The findings suggest that childhood trauma might be a factor worth screening in the preoperative psychological evaluation and aftercare of SCS patients.

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Author contributions: Mr. Määttä had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Mr. Määttä conducted literature search and wrote the first draft of the manuscript. Dr. Huttunen and Dr. Fraunberg designed the study protocol, supervised its implementation and reviewed the final manuscript. Dr. Martikainen, Dr. Pakarinen, Dr Nissen and Dr. Viinamäki reviewed the manuscript and provided significant intellectual contribution to the analysis of the data. Ms. Ikäheimo significantly contributed to the acquisition of data and review of the manuscript.

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