

Factors affecting central sensitization inventory score before surgery for distal radius fractures

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Abstract. Volar locking plate fixation enables early postoperative return to daily activities. However, from the patient's perspective, undergoing surgery can pose substantial challenges. In particular, the perioperative period is considered a time of high psychological stress. The central sensitization inventory (CSI) score is an assessment tool for psychosocial factors in pain. In the present study, the utility of CSI scores for assessing the psychosocial factors influencing patients' status before surgery for distal radius fracture (DRF) were evaluated. This study included 22 patients who underwent volar locking plate fixation of DRF. Before surgery, data on sex, side of injury, fracture type, age, interval (in days) from injury to evaluation, numerical rating scale (NRS), Quick Disabilities of the Arm, Shoulder and Hand (Q-DASH) score and CSI score were collected. We analyzed the relationship between each evaluation item and CSI score. There were no significant associations between CSI score and sex ($P=0.389$), side of injury ($P=0.774$), fracture type ($P=0.063$), interval from injury to evaluation ($P=0.529$, $r=-0.142$) and Q-DASH score ($P=0.385$, $r=0.195$). On the other hand, significant associations between CSI score and age ($P=0.049$, $r=0.424$) and NRS ($P=0.003$, $r=0.607$) were found. CSI scores were significantly associated with age and NRS before volar locking plate fixation for DRF. Mental stress management and nociceptive pain relief for elderly patients may be useful in preoperative patient care.

Introduction

As individuals age, physical impairments may have a deleterious effect on the musculoskeletal system (1). Distal

radius fractures (DRF) are a commonly encountered type of traumatic injury in daily practice. The incidence of osteoporosis-associated DRF has been reported to increase from approximately the age of 70 years (2). DRF associated with osteoporosis are frequently identified as the earliest manifestation of fragility fractures, which precede other osteoporotic fractures (3). The number of patients with DRF is expected to continue to rise due to the increasing age of the global population (2). The World Health Organization has recognized osteoporotic fractures and associated morbidity as important health issues globally (4).

Volar locking plate fixation enables early postoperative return to daily activities. It has increasingly been indicated not only for elderly patients but also for adolescents (5). However, from the patient's perspective, undergoing surgery can pose substantial challenges, such as psychological stressors associated with the illness itself, anesthesia, surgical outcomes and postoperative recovery (6). In particular, the perioperative period is considered a time of high psychological stress (6). Furthermore, preoperative patients with orthopedic diseases are concerned about their postoperative physical condition and anxious about postoperative restrictions on physical movement (7).

The central sensitization inventory (CSI) score is a patient-reported outcome used to identify symptoms associated with a central sensitization syndrome (8). It was recently reported that the CSI score can be used as an assessment tool for psychosocial factors in pain assessment (9). In the present study, the use of the CSI score to assess the psychosocial factors of patients' status before surgery for DRF was investigated. Furthermore, factors influencing the CSI score before surgery for DRF were investigated.

Patients and methods

Ethical approval. This study was approved by the Research Ethics Committee of the Faculty of Medicine, Juntendo University (Tokyo, Japan; approval no. E22-0447; date of approval: November 11, 2024). This committee is registered with the Ministry of Health, Labour and Welfare's Research Ethics Review Committee Reporting System in accordance with Japanese ethical guidelines (Institutional Review Board no. 21000123). This study was retrospective and was approved

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by the Research Ethics Committee of the Faculty of Medicine, Juntendo University (Tokyo, Japan) to be conducted using an opt-out approach rather than written informed consent. In accordance with the ethical guidelines, the requirement for written informed consent was waived due to the retrospective design of the study. Instead, information about the study and the opportunity to opt out were provided on the hospital website. Furthermore, an opt-out approach was implemented to ensure that patients had the opportunity to decline participation. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Study design and patient selection. Of the 37 patients who underwent volar locking plate fixation for DRF at our hospital between January and September 2024, 22 patients with available preoperative CSI scores were included in this study, while 15 patients without CSI score were excluded. During the study period, completion of the CSI score was voluntary and not mandatory in routine clinical practice. Therefore, patients without available preoperative CSI score were excluded from the analysis.

Study objective and variables. The aim of this study was to analyze the clinical factors associated with preoperative CSI scores in patients DRF. The study variables included sex; side of injury; fracture type; age; the interval (in days) from injury to the preoperative assessment at which the questionnaires were completed; numerical rating scale (NRS); quick disabilities of the arm, shoulder and hand (Q-DASH) score; and CSI score.

Outcome measures. The CSI score is a self-reported questionnaire consisting of 25 items, each scored from 0 to 4, yielding a total score ranging from 0 to 100, with higher scores indicating greater central sensitization (10). The NRS was used to assess pain intensity, ranging from 0 (no pain) to 10 (worst imaginable pain) (11). The Q-DASH score was used to evaluate upper extremity disability; it consists of 11 items scored on a 5-point Likert scale and is transformed to a score ranging from 0 to 100, with higher scores indicating greater disability (12).

Variable definitions. To quantify qualitative data, sex was coded as 0 for male and 1 for female; side of injury as 0 for the dominant hand and 1 for the non-dominant hand; and fracture type as 0 for extra-articular or partial intra-articular fractures and 1 for complete intra-articular fractures. Fractures were classified according to the AO classification: Extra-articular fractures were classified as type A, partial intraarticular fractures as type B and complete intra-articular fractures as type C. Age, interval from injury to evaluation (in days), NRS and Q-DASH scores were treated as continuous variables, and their association with the CSI score was statistically analyzed.

Statistical analysis. Categorical variables (sex, side of injury and fracture type) were analyzed by Mann-Whitney U analysis and continuous variables (age, interval from injury to evaluation in days, NRS and Q-DASH score) were analyzed using bivariate analysis with Pearson's correlation coefficient. Furthermore, variables that demonstrated

significant associations in the univariate analysis were included in a multiple linear regression analysis to identify independent predictors. Model goodness-of-fit in the multiple linear regression analysis was evaluated using the overall F-test and the coefficient of determination (R^2). A post-hoc power analysis was performed for the multiple linear regression model using the observed effect size, sample size and number of predictors.

Results

Patient characteristics. In this study, 7 patients were male and 15 female; 12 had injuries on the dominant side and 10 on the non-dominant side; 8 patients had extra-articular or partial intra-articular fractures and 14 had complete intra-articular fractures; the mean age was 60.6 ± 12.3 years; the interval (in days) from injury to evaluation was 4.7 ± 2.6 days; the NRS score was 6.1 ± 2.8 ; and the CSI score was 19.2 ± 12.4 (Table I).

Univariate and correlation analyses. Univariate analysis of the relationship between CSI score and each of the evaluation items showed no significant relationships between CSI score and sex ($P=0.389$), side of injury ($P=0.774$) or fracture type (extra-articular fracture, partial intra-articular fracture or complete intra-articular fracture) ($P=0.063$), and neither was there a correlation with the interval (in days) from injury to evaluation ($P=0.529$, $r=-0.142$) or Q-DASH score ($P=0.385$, $r=0.195$). On the other hand, there were significant correlations between the CSI score and age ($P=0.04$, $r=0.424$) and NRS ($P=0.003$, $r=0.607$) (Table I).

Multiple linear regression analysis. Age and NRS showed significant associations with CSI score in the univariate analyses; therefore, multiple linear regression analysis was performed to further examine these relationships. The overall regression model was statistically significant ($F=11.02$, $P=0.0007$), explaining 53.7% of the variance in CSI scores ($R^2=0.537$, adjusted $R^2=0.488$) (Table II). In the multivariable model, both age ($B=0.424$, $P=0.0165$) and NRS ($B=2.721$, $P=0.0011$) were independently associated with the CSI score (Table II). Specifically, each 1-year increase in age was associated with a 0.424-point increase in the CSI score, and each 1-point increase in NRS was associated with a 2.721-point increase in the CSI score.

Discussion

The present study investigated factors associated with the CSI scores before volar locking plate fixation for DRF. Factors investigated included patient features (sex, side of injury and age), fracture-related variables (fracture type and interval from injury to evaluation in days) and patient-reported outcomes (NRS and Q-DASH scores). It was found that the CSI score was significantly associated with age and NRS.

It has been reported that postoperative pain is more intense in female fracture patients than in male fracture patients (13). This suggests that sex may influence pain perception following trauma and it was included as a variable in the analysis. However, no significant association between the CSI score and sex was found. Iitsuka *et al.* (14) investigated differences in postoperative functional recovery between dominant and

Table I. Relationship between CSI score and each of the evaluation items.

Evaluation items	Results	Correlation with CSI score	P-value and correlation coefficient
Sex (0, male; 1, female)	0:7; 1:15	(-)	P=0.389
Side of injury (0, dominant side; 1, non-dominant side)	0:12; 1:10	(-)	P=0.774
Fracture type (0, extra-articular or partial intra-articular fracture; 1, complete intra-articular fracture)	0:8; 1:14	(-)	P=0.063
Age, years	60.6±12.3	(+)	P=0.049 r=0.424
Interval from injury to evaluation, days	4.7±2.6	(-)	P=0.529 r=-0.142
NRS	6.14±2.8	(+)	P=0.003 r=0.607
Q-DASH score	55.6±25.1	(-)	P=0.385 r=0.195
CSI score	19.2±12.4	/	/

NRS, numerical rating scale; Q-DASH, quick disabilities of the arm, shoulder and hand; CSI, central sensitization inventory.

Table II. Multivariable linear regression analysis of factors associated with the central sensitization inventory score.

Variable	B	SE	b	95% CI	P-value
Age, years	0.424	0.161	0.421	0.086-0.762	0.0165
NRS	2.721	0.711	0.615	1.238-4.209	0.0011

Model fit indices: F=11.02, P=0.0007; R²=0.537; adjusted R²=0.488. NRS, numerical rating scale; B, unstandardized coefficient; SE, standard error; b, standardized coefficient; CI, confidence interval.

non-dominant side injuries in patients who underwent volar locking plate fixation for DRF. They reported that patients with dominant-side injuries showed significantly greater postoperative improvement in hand joint range of motion and grip strength than those with non-dominant-side injuries (14). Therefore, it was hypothesized that the side of injury (dominant or non-dominant side) influences pain after fracture treatment and preoperative CSI score. However, no significant relationship was found between the side of injury and CSI score. DRF involving the articular surface have been reported to be associated with poorer functional outcomes compared with extra-articular fractures (15). Furthermore, at 6 months postoperatively, patients with complete intra-articular fractures (AO classification type C) have been shown to experience significantly greater pain than those with partial intra-articular fractures (AO classification type B) (16). Based on these findings, it was hypothesized that the fracture type influences preoperative CSI scores. On the other hand, as the cohort of the present study included only three type A fractures, five type B fractures and 14 type C fractures, types A and B were combined into a single group and compared with type C for statistical analysis. As a result, it was found that the type of fracture (extra-articular or intra-articular fractures) was not related to the preoperative CSI score. Wilson *et al* (17) reported that pain was inversely correlated with the interval from injury

to initial consultation and initial response for DRF. Therefore, it was hypothesized that the interval (in days) from injury to evaluation influences preoperative CSI scores; however, no significant association was found. Patient-reported outcomes that assess pain and directly reflect quality of life have gained attention as important measures in evaluating wrist function. Kawamura *et al* (18) reported that the visual analogue scale and grip strength were associated with Q-DASH scores after volar locking plate fixation for DRF. The Q-DASH score is a widely used patient-reported outcome measure for the upper extremities and has been employed in previous studies that evaluated the outcomes of DRF (19). However, in the present study, no significant relationship was found between the Q-DASH and CSI scores.

In the present study, it was found that age and NRS had a significant association with the CSI score. Furthermore, the NRS had a greater impact on the CSI scores than age. Older age decreases the ability of patients to cope with emotional stress and control their emotions in response to stressful events such as anxiety and depression (20). In the present study, patients' CSI scores were investigated in response to being informed of a DRF diagnosis and the subsequent recommendation for surgical treatment. It was found that the CSI score was significantly associated with age and was higher with increasing age. Pain is classified into three categories: Nociceptive pain,

neuropathic pain and psychosocial pain (21). The results of the present study that the NRS, a measure of nociceptive pain, was related to the CSI score supports those of a previous study (22). The present findings suggest that nociceptive pain intensity is positively associated with central sensitization in the preoperative state before DRF surgery, highlighting the importance of pain assessment prior to surgery.

In the present study, the mean CSI score before volar locking plate fixation for DRF was 19.2 ± 12.4 , and 9.1% (2 patients) of the cohort had a CSI score of 40 or higher. A CSI score of 40 or higher has been proposed as a clinically relevant cutoff indicating the presence of central sensitization-related symptoms (10). Previous reports have shown that the mean CSI score was 16.1 ± 11.1 in patients with chronic low back pain, with 4.4% scoring 40 or higher (22). In addition, the mean CSI score in patients with hip osteoarthritis was 19.5 ± 11.3 , with 5.0% scoring 40 or higher (23). Compared with these reports, the CSI scores of patients before volar locking plate fixation for DRF are not lower than those reported for other musculoskeletal disorders. Furthermore, CSI is used not only as a diagnostic indicator for central sensitization syndrome but also as an indicator of psychosocial factors, such as anxiety and depression (9). Therefore, in the present study, CSI scores were regarded as an indicator of psychosocial factors, and it was evaluated how CSI scores are associated with activities of daily living impairment in patients before volar locking plate fixation for DRF.

This study has several limitations. First, the sample size in this study was relatively small ($n=22$). Post-hoc power analysis demonstrated that the statistical power for the correlation between the NRS and CSI score was sufficient (power=0.882), whereas the power for the association between age and CSI score was moderate (power=0.522). In addition, the multivariable linear regression model showed high statistical power (power=0.99). Although the primary associations observed in this study appear to be statistically robust, the finding regarding age should be interpreted with caution due to its moderate power. Further studies with larger sample sizes are warranted to validate this association. Second, Multivariate analysis was performed; however, due to the small sample size ($n=22$), the number of covariates that could be included in the model was limited. Inclusion of additional variables in such a small cohort may increase the risk of model overfitting and unstable estimates, as described by Riley *et al* (24). Therefore, potential confounding factors such as psychological comorbidities (e.g., anxiety and depression), osteoporosis and psychosocial background were not included in the final model (25-27). Thus, a certain degree of residual confounding may remain. Previous studies have demonstrated that these factors may influence pain perception and central sensitization (25,26). Accordingly, an independent association between CSI and clinical outcomes cannot be definitively established. Future studies with larger sample sizes and multivariate models are warranted to confirm these findings. Third, this

study evaluated only the preoperative clinical status. Therefore, the impact of preoperative CSI scores on postoperative pain and functional recovery remains elusive. Longitudinal studies with follow-up assessments are required to determine the predictive value of CSI. Finally, because the completion of the CSI score was voluntary, data were missing in a subset of eligible patients, which may have introduced selection bias.

In conclusion, CSI scores were significantly associated with age and NRS before volar locking plate fixation for DRF. Mental stress management and nociceptive pain relief for elderly patients may be useful in preoperative patient care.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

SI mainly wrote the manuscript, and performed acquisition, analysis and interpretation of data. KN and MI were involved in the conception and design of this study. NI, TS, KK, SK and TI participated in the acquisition analysis and interpretation of data. SI and KN confirm the authenticity of all the raw data. All authors have read and approved the final version of the manuscript.

Ethics approval and consent to participate

The study was approved by the Ethics Committee for Medical Research of Juntendo University (Tokyo, Japan; approval no. E22-0447; date of approval: November 11, 2024).

Patient consent for publication

Informed consent was obtained for participation and publication by opt-out on a website. Patients who declined to provide consent were excluded.

Competing interests

The authors declare that they have no competing interests.

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