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Patient coping and expectations about recovery predict the development of chronic post-surgical pain after traumatic tibial fracture repair

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Abstract

Background: The association of patient expectations about recovery with the development of chronic post-surgical pain (CPSP) is uncertain.

Methods: Three hundred and fifty-nine patients enrolled in the SPRINT trial completed the Somatic Preoccupation and Coping (SPOC) questionnaire six weeks after a traumatic tibial fracture repair. The SPOC questionnaire measures patients' somatic complaints, coping, and optimism for recovery. Using adjusted models, we explored the association of SPOC scores with ≥ mild CPSP and ≥ moderate pain interference with activity at one yr after surgery.

Results: Of 267 tibial fracture patients with data available for analysis, 147 (55.1%) reported CPSP at one yr. The incidence of CPSP was 37.6% among those with low (≤40) SPOC scores, 54.1% among those with intermediate (41–80) scores, and 81.7% among those with high (>80) scores. Addition of SPOC scores to an adjusted regression model to predict CPSP improved the *c*-statistic from 0.61 (95% CI 0.55–0.68) to 0.70 (95% CI 0.64–0.76, P=0.005 for the difference) and found the greatest risk was associated with high SPOC scores (OR 6.56, 95% CI 2.90–14.81). Similarly, an adjusted regression model to predict pain interference with function at one yr (*c*-statistic 0.77, 95% CI 0.71–0.83) found the greatest risk for those with high SPOC scores (OR 10.10, 95% CI 4.26–23.96).

Conclusions: Patient's coping and expectations of recovery, as measured by the SPOC questionnaire, is an independent predictor of CPSP and pain interference one yr after traumatic tibial fracture. Future studies should explore whether these beliefs can be modified, and if doing so improves prognosis.

Clinical trial registration: NCT 00038129

Key words: chronic pain; postoperative pain; tibial fractures

In North America, chronic non-cancer pain affects ~30% of the population, with similar rates in Europe and Australia.[1–5] Surgery and trauma are frequently cited as triggering events responsible for the development of chronic pain. A survey of 5130 patients attending 10 outpatient clinics located throughout North Britain found that 41% attributed their pain to a traumatic event or surgery.[6] Rates of chronic post-surgical pain (CPSP) range from 0.1 to 65% with higher rates associated with cardiac, breast, and orthopaedic surgeries.[7–9]

Surgical repair of long bone fractures constitute the majority of emergent surgical procedures at trauma centres, of which traumatic tibial fractures are the most common.[10] A systematic

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Editor's key points

- Chronic post-surgical pain (CPSP) can result in significant long term morbidity and disability.
- Early identification of those at risk of developing CPSP could allow targeted treatment.
- The Somatic Preoccupation and Coping (SPOC) Questionnaire was used six weeks after traumatic tibial fractures.
- High SPOC scores at six weeks, were associated with significant pain interference at one yr.
- Further studies are needed of the SPOC in early identification of CPSP and directing treatment.

review of 20 observational studies of traumatic tibial fracture repairs found a CPSP mean incidence of 47.4% (range: 10–86%) at an average of 23.9 months after surgery.[11]

Although several risk factors for CPSP have been identified, many, such as younger age and female gender, are non-modifiable and thus not amendable to direct intervention.[8 12 13] However, there are emerging data that suggest patients' beliefs and expectations may be associated with clinical outcomes, including pain.[14 15] Positive expectations for recovery after an episode of acute low back pain is associated with improved recovery and reduced disability.[16] The relationship between psychological factors, behaviors, and cognitive processes with the sensation of pain is well documented. Stress, distress, anxiety, depression, catastrophizing, fear-avoidance behaviors, and poor coping strategies appear to have a significant relationship with both acute and chronic pain.[17] Evidence suggests that these psychological factors can cause alterations along the spinal and supraspinal pain pathways which influence the perception and experience of pain.[18]

The SPOC is a 27-item self-administered questionnaire that was developed in traumatic tibial fracture patients and found to predict functional outcomes at one yr after surgery.[19] The SPOC questionnaire assesses several psychological, cognitive, and behavioral factors that cluster into four domains: somatic complaints, energy, coping, and optimism. The SPOC assesses these factors with regards the patient's postoperative recovery—higher scores on the SPOC represent worse coping, increased somatic complaints, lower energy and pessimism regarding recovery. While this instrument has been shown to predict functional outcomes, many of the sub-domains assessed (i.e. poor coping, attitudes, distress, self-perception, optimism) are known to be associated with pain.[17 20] Strengths of the SPOC instrument over other questionnaires is that it is multi-dimensional, whereas other tools focus on a single factor such as anxiety, catastrophizing, or general distress. In a separate sample of lower limb trauma patients, the SPOC questionnaire has demonstrated strong psychometric properties including test-retest reliability (intraclass correlation coefficients for the total SPOC and all subscales ranged from 0.72 to 0.91) internal consistency (Cronbach's α=0.94), and construct validity.[21]

The purpose of this investigation was to determine whether patients' coping abilities and expectations regarding recovery after traumatic tibial fractures, as operationalized by the SPOC questionnaire, are associated with the development of CPSP.

Methods

Our investigation utilized data from the Study to Prospectively evaluate Reamed Intramedullary Nails in Tibial fractures (SPRINT) trial.[22] A multicentre, randomized controlled trial that assessed the efficacy of reamed or unreamed intramedullary nailing, for patients ≥18 yr old with an open or closed tibial fracture. Exclusion criteria included neurovascular deficits, pathologic fractures, excessive surgical delay (>12 h from time of injury for open fractures, >3 weeks from time of injury for closed fracture), and associated fractures in the foot, ankle, or knee. From July 2000 to September 2005, 1339 patients were enrolled into the SPRINT trial from 29 clinical sites in Canada, the USA, and the Netherlands. The last follow-up visit occurred in September 2006, with final outcomes adjudicated by January 2007. Each institution involved obtained an ethics review board approval before starting, which was registered at Clinicaltrial.gov (Identifier: NCT00038129). A detailed protocol of the SPRINT trial has been published elsewhere.[10]

During the conduct of the trial, centres with high recruitment rates were approached to administer the SPOC questionnaire, to enrolled tibial fracture patients at six weeks after surgical fixation, regardless of group assignment. The SPOC instrument produces a single score on a scale of 0–162, with higher scores representing greater somatic preoccupation, worse coping, and pessimism about recovery. The development and initial validation of the SPOC questionnaire among patients undergoing surgical fixation for tibial fracture has been published elsewhere,[19] as has a re-validation study in a separate population of lower limb trauma patients.[21]

The SPRINT trial administered the short form-36 (SF-36), a generic health status and quality of life instrument, at hospital discharge, two weeks, six weeks, and three, six, nine and 12-months post-surgery. The SF-36 has been validated in surgical and non-surgical populations and demonstrates good validity, reliability, and internal consistency.[23–25] Questions seven and eight of the SF-36 capture information regarding the degree of bodily pain and interference of pain with daily activities during the last four weeks before survey completion.

Pain must be present for ≥2 months after surgery to meet the International Association for the Study of Pain's (IASP's) definition of CPSP[26]; however, we believe that patients are more likely to be concerned about pain that persists for longer periods of time. Accordingly, our primary outcome was the presence of pain at one yr after surgery. Secondary outcomes were the severity of pain and interference of pain on normal work (including both work outside the home and housework).

Missing or incomplete data for responses to the SF-36 at one yr were imputed using the last value carried forward from the six month follow-up date, as we found 90% concordance between patient-reported pain at six months and one yr among patients with complete data at both time points. We did not impute missing one yr data from the three month follow-up as there was only 64% concordance in pain data. Accordingly, patients that did not provide SF-36 data at the six month or one yr follow-up visit were excluded from analysis. The second IASP criteria for CPSP is that other causes for the pain have been excluded, in particular pain from a condition preceding the surgery. To increase confidence that this criteria was met, we excluded any patients who reported taking two or more pain medications (e.g. acetaminophen, anti-inflammatory, opioids, anti-convulsants) before surgery.

Statistical analysis

We generated frequencies for all collected data. We reported the mean and standard deviation (SD) of continuous variables, and the number of occurrences with proportions represented as percentages for categorical variables. The presence of CPSP was determined by responses to question seven of the SF-36 at one yr, which asks about bodily pain and provides six response options: none; very mild; mild; moderate; severe; or very severe. We dichotomized responses to this question—none and very mild pain *vs* other response options—and selected this threshold as we found that 27.1% of the 48 patients with mild pain at one yr reported ≥ moderate pain interference compared with only 3.8% (3 of 80) of patients with very mild pain (Supplementary Appendix). Responses to question eight of the SF-36 regarding the interference of pain on normal work included five response options: none; a little bit; moderately; quite a bit; and extremely. We dichotomized responses as none and a little bit *vs* other response options, as we believe pain that at least moderately interferes with normal work would be important to patients.

We categorized patients into three groups based upon their six week post-surgery SPOC scores. We used the interquartile range (IQR) to create tertiles as the Shapiro–Wilk test indicated the data was not normally distributed (P<0.001). We calculated risk differences for chronic pain and pain interference at one yr in the intermediate and high SPOC score groups, in reference to the low score group, expressed as odds ratios (ORs) with 95% confidence intervals (CI). We used the Kruskal–Wallis (KW) test to explore for differences in the severity of pain and degree of interference across the three categories of SPOC scores. If the KW test was significant, we used the Wilcoxon ranked-sum test to explore for differences in the intermediate and high score groups in reference to the low score group.

We constructed multivariable logistic regression models to explore the association between SPOC questionnaire scores at six weeks after surgery, and the presence of chronic pain or interference of pain with daily activities at one yr. We selected five additional variables that we judged might be associated with CPSP, and predicted the direction of anticipated effects: female gender, younger age, open fractures, the presence of multi-trauma, and positive smoking status—all associated with worse outcomes. We assessed collinearity between each variable included in our regression models with the variance inflation factor (VIF), and if the VIF >5 we removed the variable the smaller coefficient (smaller association).[27] We constructed our regression models with and without SPOC scores and calculated the concordance statistic (*c*-statistic) and associated 95% CI for each model to quantify the change in discrimination with the addition of SPOC scores. A *c*-statistic of 0.5 indicates that the model is no better than chance at predicting the outcome, 0.7–0.8 is considered reasonable prediction, and ≥0.8 is considered strong prediction.[28] SPOC scores were added to the model as a categorical variable (low, intermediate, and high scores). We assessed the goodness-of-fit of our logistic regression models with the Hosmer–Lemeshow test.[28] We explored over-fitting of our regression models by calculating optimism of the model using boot-strapping methods of 400 cycles—optimism is a measure of over-fitting in a model and should be as small as possible.[29]

All statistical analyses were performed using R Statistical Package (R Foundation for Statistical Computing, Vienna, Austria). All tests were two-sided and P<0.05 was considered statistically significant.

Results

Of 1339 patients enrolled in the SPRINT trial, 359 patients were approached to complete the SPOC questionnaire; 316 patients provided complete SPOC data at six weeks post-surgery. Of these patients, 224 had complete SF-36 data at one yr. We imputed outcome data for an additional 43 patients from their six month follow-up visit. The remaining 49 patients only provided SF-36 data at three months or less and were not included in our analyses. Baseline characteristics of patients are provided in Table 1. The mean age of patients was 38.7 yr old (range 78) and most were male (74.9%). The majority of patients presented with a closed tibial fracture, most often resulting from a motor-vehicle accident, fall, or motor-cycle accident.

A total of 147 patients (55.1%) reported mild to very severe pain at one yr after surgery, and 94 (35.2%) reported pain that interfered, moderately to extremely, with their daily activities (Table 2). Low SPOC scores were defined as ≤40, intermediate scores from 41 to 80, and high scores as >80. The risk and severity of chronic pain or pain that interfered with activities at one yr after surgery increased with higher SPOC scores (Table 2). Compared with those in the low score group, patients reporting an intermediate SPOC score at six weeks after surgery were twice as likely to report pain (OR 1.95; 95% CI 1.11–3.44, P=0.02) and three times more likely to report pain that interfered with activities (OR 3.43, 95% CI 1.68–7.01, P<0.001) at one yr. Patients reporting a high SPOC score six weeks after tibial fixation were seven times as likely to report CPSP (OR 7.38, 95% CI 3.36–16.22, P<0.001) and 10 times more likely to report pain that interfered with activity (OR 10.51, 95% CI 4.70–23.51, P<0.001) at one yr.

Compared with those with low SPOC scores, those with high (P<0.001) and intermediate scores (P=0.007) had more severe pain intensity (Table 3). Similarly, those with high (P<0.001) and intermediate (P<0.001) SPOC scores reported more pain interference than the low-score group (Table 4).

When limited to adjustment variables, our multivariable logistic regression model to predict the persistent pain (no SPOC scores) produced a *c*-statistic of 0.61 (95% CI 0.55–0.68), with an optimism of 0.072. When SPOC scores were added to the model with the low (≤40 scores) group used as the reference, the model indicated a significant association with the development of CPSP with those in the intermediate (OR 1.84, 95% CI 1.02–3.31) and high score group (OR 6.56, 95% CI 2.90–14.81) (Table 5). The *c*-statistic of the model improved to 0.70 (95% CI 0.64–0.76, P=0.005 for the difference) and optimism decreased to 0.052.

Table 1 Patient characteristics of SPOC sample and SPRINT population. MVA, motor vehicle accident; SD, standard deviation; SPOC, Somatic Preoccupation and Coping. *Some multitrauma patients presented with bilateral tibial fractures

Variable	Total SPRINT population (*n*=1319)	SPOC sample (*n*=267)
Age, mean in years (Range)	39.2 (78.6)	38.7 (78)
Sex, no. (%)		
Male	979 (74.2)	200 (74.9)
Female	340 (25.8)	67 (25.1)
Smoking history, no. (%)	446 (34.0)	87 (32.6)
Fracture type, no. (%)		
Open	435 (32.7)*	98 (36.7)
Closed	892 (67.6)	169 (63.3)
Isolated fracture, no. (%)	888 (67.3)	154 (57.7)
Mechanism of injury (*n*, %)		
Crush injury	68 (5.2)	11 (4.1)
Direct trauma (blunt)	91 (6.9)	22 (8.2)
Direct trauma (penetrating)	21 (1.6)	3 (1.1)
Fall	374 (28.4)	63 (23.6)
Motorcycle accident	147 (11.2)	39 (14.6)
MVA (driver/passenger)	277 (21.0)	60 (22.5)
MVA (pedestrian)	274 (20.8)	59 (22.1)
Twist	65 (4.9)	6 (2.2)
SPOC score (mean, SD)		57.2 (28.6)

Table 2 Patient-reported chronic pain and pain that interferes with normal work at one yr, stratified by SPOC scores acquired six weeks after surgery (*n*=267)

SPOC score category	None to very mild pain	Mild to severe pain	Risk (95% CI)	None to a little pain interference	Moderate to extreme pain interference	Risk (95% CI)
Low (≤40)	53	32	37.6 (27.3–47.9)	73	12	14.1 (6.7–21.5)
Intermediate (>40, ≤80)	56	66	54.1 (45.3–62.9)	78	44	36.1 (27.6–44.6)
High (>80)	11	49	81.7 (71.9–91.5)	22	38	63.3 (51.1–75.5)

Table 3 Distribution of pain severity at one yr stratified by SPOC scores acquired six weeks after surgery (*n*=267)

SPOC category	None to very mild (%)	Mild (%)	Moderate (%)	Severe (%)	Very severe (%)
Low (≤40)	53 (62.4)	16 (18.8)	15 (17.1)	1 (1.2)	0 (0.0)
Intermediate (40>, ≤80)	56 (45.9)	24 (19.7)	33 (27.0)	8 (6.6)	1 (0.8)
High (>80)	11 (18.3)	8 (13.3)	25 (41.7)	12 (20.0)	4 (6.7)
Total	120 (44.9)	48 (20.0)	73 (27.3)	21 (7.9)	5 (1.9)

Table 4 Distribution of pain interference at one yr stratified by SPOC scores acquired six weeks after surgery (*n*=267)

SPOC category	Not at all to a little bit (%)	Moderately (%)	Quite a bit (%)	Extremely (%)
Low (≤40)	73 (85.9)	11 (12.9)	1 (1.2)	0 (0.0)
Intermediate (40>, ≤80)	78 (63.9)	25 (20.5)	13 (10.7)	6 (4.9)
High (>80)	22 (36.7)	15 (25.0)	13 (21.7)	10 (16.7)
Total	173 (64.8)	51 (19.1)	27 (10.1)	16 (6.0)

Table 5 Variables associated with chronic pain at one yr (*n*=267). Age in decades

Variable	Adjusted model without SPOC scores Odds ratio (95% CI)	Adjusted model with SPOC scores Odds ratio (95% CI)
Sex	1.02 (0.56–1.83)	1.01 (0.54–1.88)
Age	1.09 (0.93–1.27)	1.13 (0.96–1.34)
Open	1.11 (0.66–1.88)	1.00 (0.58–1.73)
Multi-trauma	1.54 (0.92–2.56)	1.30 (0.76–2.24)
Smoker	2.41 (1.38–4.20)	2.10 (1.17–3.77)
SPOC		
Low		Reference
Intermediate		1.84 (1.02–3.31)
High		6.56 (2.90–14.81)

Table 6 Variables associated with pain interference at one yr (*n*=267). Age in decades

Variable	Adjusted model without SPOC scores Odds ratio (95% CI)	Adjusted model with SPOC scores Odds ratio (95% CI)
Sex	0.75 (0.39–1.43)	0.69 (0.34–1.37)
Age	1.11 (0.93–1.32)	1.20 (0.99–1.45)
Open	2.28 (1.32–3.95)	2.24 (1.24–4.03)
Multi-trauma	1.34 (0.78–2.30)	0.99 (0.55–1.79)
Smoker	2.38 (1.60–4.99)	2.54 (1.39–4.67)
SPOC		
Low		Reference
Intermediate		3.15 (1.49–6.69)
High		10.10 (4.26–23.96)

Positive smoking status was also found to be a significant predictor of CPSP with an OR of 2.10 (95% CI 1.17–3.77).

When limited to adjustment variables, our model to predict interference of pain on normal work produced a *c*-statistic of 0.68 (95% CI 0.61–0.74), and an optimism of 0.050. When SPOC scores were added to the model, the intermediate (OR 3.15, 95% CI 1.49–6.69) and high SPOC score groups (OR 10.10, 95% CI 4.26–23.96) were significant predictors (Table 6), the *c*-statistic improved to 0.77 (95% CI 0.71–0.83, P=0.003 for the difference) and optimism reduced to 0.042. Open fracture (OR 2.24, 95% CI 1.24–4.03) and positive smoking status (2.54, 95% CI 1.39–4.67) were also associated with an increased risk of pain interference at one yr. The Hosmer–Lemeshow test was non-significant for all regression models.

Discussion

Our study found that patient coping abilities, beliefs, and expectations about recovery, as operationalized by the SPOC instrument, are a strong predictor of CPSP, pain severity, and interference of pain one yr after traumatic tibial fracture repair.

Strengths of this study include use of a validated instrument to assess patient coping and recovery expectations, and adjustment of our regression models for patient and injury characteristics.

There are several limitations to our study. First, this analysis was performed in the same sample population used to develop and validate the SPOC instrument, which may inflate the strength of association because of nonindependence (i.e. the predictive model has greater optimism). While external validation on a separate tibial fracture patient sample is needed, internal validation testing using the boot-strapping methods demonstrated low optimism. Second, our inability to directly exclude pre-existing pain may have overestimated the incidence of persistent pain. Third, we were unable to control for other potential prognostics factors (i.e. preoperative catastrophizing, depression) in our adjusted analyses. Finally, although there was good concordance (90%) between six month and one yr pain and pain interference scores, ~16% of patients included in our analysis had these data imputed using their six month scores.

Findings from our study add to a growing body of evidence regarding the influence of patient expectations on clinical health outcomes. A systematic review found 45 studies assessing the relationship of a patient's expectation for recovery in a variety of clinical conditions ranging from myocardial infarctions to alcoholism.[14] Of the studies rated as moderate to high-quality, 94% indicated an association between positive expectations and improved outcomes; 73% of these studies indicated a moderate to high effect size. While the majority of studies did not control for other prognostic factors, the studies with statistical adjustment found similar results, suggesting an independent effect of patient expectations.

There is evidence that the experience of chronic pain arises from the interplay between biomedical, cognitive, affective, and behavioral factors.[30] However, the effect of patients' beliefs and expectations on chronic pain is an under-investigated area. A recent systematic review on measures of patient expectations on recovery found only four studies in the perioperative setting, none of which examined the relationship with CPSP.[15] Our study provides evidence that poor coping and low patient expectations may be associated with the development of chronic pain after surgery.

In contrast to patient characteristics, injury severity, and other prognostic factors that are otherwise unmodifiable, patient beliefs and expectations are potentially malleable and thus allow for an opportunity to reduce the risk of chronic pain. If expectations about recovery are related to the development of chronic pain, interventions aimed at improving patients' coping abilities and outlook in the perioperative period could improve prognosis. Self-instruction, which is the process of identifying negative cognitions and replacing them with positive ones, appears to improve pain thresholds in catastrophizing males.[31]

Our investigation found that smoking is a strong predictor of chronic pain and interference of pain at one yr after traumatic tibial fracture. Epidemiological data also demonstrates a link between smoking and the development of chronic pain.[32] This relationship is complex and is likely an interaction of biological, psychological, and social factors.[33] Additionally, in our study, open fractures were at higher risk of developing pain interference. This association is likely a reflection of the increased severity of injury and complicated recovery of those with open fractures over closed fractures.[34]

Results of our study suggest an influence of negative beliefs and poor coping in the pathogenesis of CPSP among patients undergoing surgical repair for tibial fracture and further supports a biopsychosocial model as a framework to understand the development of chronic pain. Future investigations are needed to evaluate the relationship of SPOC scores and chronic pain in other surgical populations and whether patient beliefs and expectations can predict the development of other psychological constructs, such as depression or anxiety. Randomized controlled trials are also needed to determine whether patient beliefs and expectations can be modified and whether doing so results in improved prognosis.

Author's contributions

Study design/planning: J.S.K., P.J.D., J.W.B.
Study conduct: J.S.K., P.J.D., J.W.B.
Data analysis: J.S.K., Y.L., J.W.B.
Writing paper: J.S.K., P.J.D., Y.L., J.W.B.
Revising paper: all authors

Supplementary material

Supplementary material is available at *British Journal of Anaesthesia* online.

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Declaration of interest

There were no conflicts of interest in the conduct, analysis, and publishing of this manuscript among study authors.

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