



## Original research

# Pain perception and coping strategies influence early outcomes following knee surgery in athletes

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## ABSTRACT

**Objectives:** To determine whether pain perceptions and coping strategies are predictive of the following outcomes after knee surgery in athletes: (1) return to similar level of sport, (2) improvement in symptoms, and (3) improvement in kinesiophobia.

**Design:** Prospective cohort study.

**Methods:** 101 athletes (52 men, 49 women; mean age 32.7 years) at mean 12.1 months follow-up were included. Independent relationships between patient outcomes and pre-operative measures were determined: short form McGill Pain questionnaire (SF-MPQ), Pain Catastrophizing Scale (PCS), Pain Coping Measure (PCM), and the brief COPE subscales of acceptance, denial, positive reframing, and use of instrumental support. Adjustment was performed for length of follow-up, symptom duration, surgical history, age, activity level, and surgical procedure.

**Results:** Rate of return to similar level of sport was 73%; severe pain catastrophizers (PCS >36 points) had increased odds of not returning to similar level of sport (OR 11.3 CI 1.51, 236;  $p=0.02$ ) whereas COPE-use of instrumental support was protective (per point increase: 0.72 CI 0.54, 0.94;  $p=0.02$ ). Problem-focused coping positively correlated with improvement in IKDC-S scores (beta 0.032 SE 0.010;  $p=0.001$ ). Improvement in kinesiophobia after surgery was less likely with higher pre-operative perceived pain frequency (OR 0.23 CI 0.06, 0.71;  $p=0.009$ ) and higher COPE-denial scores (OR 0.43 CI 0.21, 0.88;  $p=0.02$ ).

**Conclusions:** Among athletes undergoing knee surgery, severe pain catastrophizing is negatively associated with return to similar level of sport. Instrumental support and problem-focused coping strategies are associated with improved outcomes. High preoperative pain scores are negatively associated with improvement in kinesiophobia after rehabilitation.

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## Practical implications

- Physicians should be aware that severe pain catastrophizing is negatively associated with return to similar level of sport among athletes who have undergone knee surgery.
- Instrumental support and problem-focused coping strategies are associated with improved outcomes.
- Injured high-level athletes struggling with rehabilitation and return to sport will often work with our sports psychologists on cognitive-behavioral therapy techniques and other strategies to address these issues.

- The current study findings suggest that increased use of instrumental coping strategies should be a focus of cognitive behavioral therapy in the injured athlete.
- High preoperative pain scores are negatively associated with improvement in kinesiophobia after rehabilitation.

## 1. Introduction

Knee injuries in athletes are common,<sup>1</sup> and there is significant variation in subjective outcomes following sports-related knee surgery.<sup>2</sup> Physical factors known to affect recovery and patient-reported outcomes include baseline activity level and injury severity. Psychological factors also play a role in postsurgical outcomes and affect how athletes perceive pain, as well as their willingness to return to prior activity levels and participate in rehabilitation.<sup>3</sup> Factors such as kinesiophobia, pain catastro-

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phizing, ratings of pain severity, and coping have previously been associated with outcomes in orthopedic surgery patients.<sup>4–6</sup>

Pain is highly subjective, and there are individual differences in psychological distress due to pain or the anticipation of pain. “Kinesiophobia” is a fear of movement due to possible re-injury or recurrent pain,<sup>7</sup> and it can play a major role in an athlete’s decision not to return to sport, particularly after procedures such as anterior cruciate ligament (ACL) reconstruction.<sup>8–10</sup> Some athletes may display “pain catastrophizing,” a tendency to exaggerate the pain and ruminate on the pain experience.<sup>11</sup> This tendency is predictive of both perceived pain intensity and disability,<sup>12</sup> and when demonstrated prior to rehabilitation, is associated with worse knee symptom scores after rehabilitation.<sup>13</sup> Both kinesiophobia and pain catastrophizing can influence an athlete’s perception of pain symptom severity.<sup>14</sup> However, the relationship between patient-reported pain severity or pain catastrophizing and return to sport following sports-related knee surgery has not been described.

The strategies patients use in responding and cope with pain and pain-related distress can affect post-surgery outcomes.<sup>15</sup> In general, strategies of coping with pain have been viewed as both advantageous (i.e., adaptive and active) as well as disadvantageous (i.e., maladaptive and avoidant). Among hip arthroscopy patients, use of maladaptive coping strategies (e.g., venting, self-blame, and behavioral disengagement) was associated with lower rates of return to sport, while patients who reported use of more adaptive coping strategies (e.g., acceptance, planning, reframing, and active coping) had higher rates of return to pre-injury sport.<sup>16</sup> Further, use of avoidant coping, characterized by mental avoidance of the problematic situation, and a reliance on wishful thinking, has been associated with increased pre- and postoperative pain severity among patients undergoing arthroscopic knee surgery.<sup>5</sup> Similarly, among total knee replacement patients, use of avoidant coping predicted less relief from knee pain and decreased improvements in knee function six weeks following surgery.<sup>17</sup>

This study assessed the relationship of pre-operative patient-reported pain catastrophizing, pain severity, and coping to short-term outcomes following knee surgery in athletes. Our primary aim was to determine the degree to which pain severity or pain catastrophizing are predictive of: (1) return to similar level of sport, (2) improvement in knee symptoms, and (3) improvement in kinesiophobia after knee surgery. Our secondary aim was to determine whether coping strategies moderate the effect of pain severity or catastrophizing on outcomes. We hypothesized that greater perceived pain severity and pain catastrophizing will be associated with worse outcomes and that greater use of instrumental support and problem focused coping strategies will be associated with improved outcomes.

## 2. Methods

This study received approval from our local Institutional Review Board. Athletes (101 total, 52 men and 49 women) with an average age of 32.7 years (SD 13.5, range 14–69) undergoing knee surgery were prospectively enrolled in the research study at a single sports medicine practice at a university medical center (Table 1). Athletes were defined as patients who reported regular pre-injury participation in a recreational physical activity or higher level of play. The mean length of follow-up was 12.1 months (SD 7.5 months, maximum 4 years). The most common primary sports were basketball (15%), followed by soccer (13%), and track & field or running (13%). Pre-injury Tegner activity scores were a mean of 6.6 (SD 1.6). The most common surgical procedures included arthroscopy with partial meniscectomy and/or chondroplasty (41%), ACL reconstruction (35%) and isolated meniscus repair (9%) (Table 2).

**Table 1**  
Demographics, activity level, and baseline psychological variables.

Variable	Summary statistic
Age	Mean 32.7 years SD 13.5 range 14–69
Sex	52 male (51%), 49 female (49%)
Level of competition	Professional-(1%) Semi-professional-(2%) Recreational-(68%) Middle school/high school-(14%) Collegiate-intramural-(3%) Collegiate-varsity-(6%) Club-(6%)
Pre-injury Tegner score	Mean 6.6 SD 1.6
Post-injury Tegner score	Mean 2.7 SD 1.8
IKDC-subjective score	Mean 46.0 SD 11.6 range 20.7–77.0
Symptom duration >6 months	39% yes, 61% no
Prior knee surgery	43% yes, 57% no
Kinesiophobia (TSK-11) score	Mean 24.7 SD 5.9 range 11–44
SF-MPQ pain score	Mean 27.6 SD 7.4 range 15–60
VAS pain score	Mean 3.3 SD 2.7 range 0–10
SF-MPQ pain frequency score	Mean 2.1 SD 0.7 range 1–3
SF-MPQ pain intensity score	Mean 3.3 SD 1.1 range 1–6
PCS-catastrophizing total score	Mean 23.9 SD 9.6 range 13–63
PCS-rumination subscore	Mean 8.2 SD 3.6 range 4–20
PCS-magnification subscore	Mean 5.7 SD 2.4 range 3–15
PCS-helplessness subscore	Mean 9.8 SD 4.5 range 6–29
Problem-based coping score (PCM-9)	Mean 13.7 SD 3.3 range 6–21
Emotion-based coping score (PCM-9)	Mean 14.7 SD 5.1 range 4–28
Brief COPE acceptance score	Mean 6.2 SD 1.4 range 3–8
Brief COPE denial score	Mean 2.7 SD 1.3 range 2–8
Brief COPE positive reframing score	Mean 5.8 SD 1.6 range 2–8
Brief COPE use of instrumental support score	Mean 5.6 SD 1.9 range 2–8

A pre-operative electronic survey was completed prior to surgery. The survey included self-report questions regarding duration of symptoms, preferred sporting activities, pre-injury and current (pre-operative) Tegner activity scores,<sup>18</sup> knee surgery history, and the International Knee Documentation Committee subjective knee symptoms questionnaire (IKDC-S).<sup>19</sup> The IKDC-S demonstrated very good internal consistency in this sample (Cronbach’s alpha = 0.91). The pre-operative survey also included the following questionnaires regarding pain perceptions and coping strategies:

- The Tampa Scale for Kinesiophobia 11 item questionnaire (TSK-11) consists of a series of questions related to anticipated pain with movement or the consequence of movement in the context of an ongoing injury.<sup>20</sup> The 11-item version was originally constructed in a population of low back pain patients.<sup>20</sup> Higher TSK-11 scores have been seen in likely functional non-copers after ACL injury.<sup>21</sup> The TSK-11 demonstrated adequate internal consistency in this study (Cronbach’s alpha = 0.78).
- The short-form McGill pain questionnaire (SF-MPQ) is designed to measure several aspects of self-reported pain.<sup>22</sup> It consists of a list of 15 descriptors of pain such as “sharp,” “shooting,” or “throbbing,” and the respondents rate the degree to which they experience each pain descriptor from 0 (none) to 3 (severe); the scores are summed for a total ranging from 0 to 45. The questionnaire also included a visual analog scale (VAS) for pain (scored 0 for no pain to 10 for maximum pain) as well as two additional questions regarding pain intensity (1 is least intense, 6 is most intense) and pain frequency (1 is intermittent, 3 is constant). The SF-MPQ demonstrated good internal consistency in this sample (Cronbach’s alpha = 0.87).
- The Pain Coping Measure (PCM) is a 7-item questionnaire designed to measure the degree to which respondents utilize emotion-based or problem-based pain coping strategies on a daily basis. It is an adaptation of a generalized daily coping measure by Stone and Neale<sup>23</sup> for measurement of daily cop-

**Table 2**  
Surgical indication, rehabilitation requirement, and postoperative outcomes.

Indication for surgery	ACL reconstruction (35%) Partial meniscectomy and/or chondroplasty (27%) Microfracture (13%) Isolated meniscus repair (9%) Cartilage restoration procedure (6%) Anterior stabilization procedure (4%) Other ligament repair (2%) Biologic knee reconstruction (ACL and meniscus transplant) (1%) Complete synovectomy (1%) Extensor mechanism repair (1%) Debridement cyclops lesion (1%) 50% Intensive, 21% moderate, 29% limited
Rehabilitation requirement	
Postoperative outcomes:	
Final IKDC-S score	Mean 59.8 SD 14.3 range 17–85
% Improvement in IKDC-S scores	Mean 28% SD 16%
Final Tegner activity score	Mean 4.9 SD 2.2 range 0–10
Return to similar level of sport <sup>a</sup>	72% yes, 28% no
Tampa scale for kinesiophobia	Mean 20.9 SD 5.6 range 11–32
Change in kinesiophobia (from pre-operative assessment to follow up)	Mean –3.5 SD 6.8 range –21 to 10
Improvement in kinesiophobia at follow-up	73% improved, 27% same or worsened

<sup>a</sup> Defined as return within 2 points of prior Tegner score.

ing with pain.<sup>24,25</sup> Emotion-based coping strategies include items related to venting emotions, redefinition, seeking spiritual comfort, or seeking emotional sport (minimum score 4, maximum 28); problem-based coping strategies included pain reduction attempts, relaxation, and distraction (minimum score 3, maximum 21). Internal consistency for the PCM in this study was good (Cronbach's alpha 0.85).

- The Pain Catastrophizing Scale (PCS) is a 13 item scale designed to measure the degree of distress the respondent experiences due to pain.<sup>11</sup> The respondent is asked to rate statements such as “It (the pain) is awful and I feel that it overwhelms me” and “I keep thinking about how much it hurts.” The scale provides a total pain catastrophizing score ranging from 13 (no catastrophizing) to 65. Subscales can be calculated for the degree of helplessness due to pain (minimum 6, maximum 30), rumination about pain (minimum 4, maximum 20), and magnification of pain (minimum 3, maximum 15). Internal consistency for the PCS in this study was very good (Cronbach's alpha = 0.93). In the current study, PCS scores >36 was used to define ‘severe catastrophizers’ and corresponds to scores above the 85th percentile in a large sample of patients with chronic musculoskeletal injury.<sup>26</sup>
- The Brief COPE survey is a 28-item measure asking respondents to indicate how frequently they utilize various strategies when coping with stress or adversity, using a 4-point scale (1 = do not do this at all to 4 = do this a lot).<sup>27</sup> For this study 4 subscales were selected that we hypothesized to be of relevance to recovery from knee surgery in an athletic population: acceptance, denial, positive reframing, and use of instrumental support. Total scores for each subscale range from 2 to 8, with higher scores representing more frequent utilization of this particular coping strategy. Internal consistency for the Brief COPE in this study was good (Cronbach's alpha = 0.83)

Patients completed an electronic postoperative survey at mean 12.1 months follow-up. The follow-up survey included questions regarding return to sport, Tegner activity scores, IKDC-S scores, and TSK-11 scores.

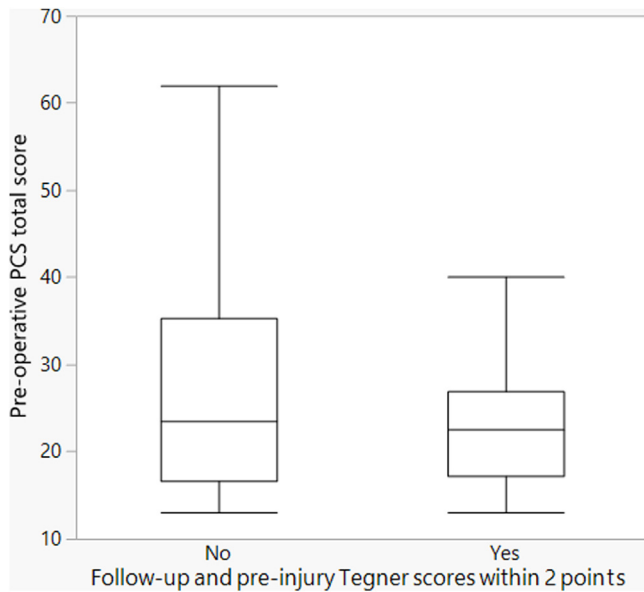
Return to a similar level of sport was defined as a postoperative Tegner score within 2 points of the pre-injury Tegner score based on prior survey data from our group (unpublished work). To account for a potential ceiling effect in symptom scores for patients who present with only mild-moderate symptoms, symptom improvement was calculated as a percent possible improvement in IKDC scores by the following formula:  $100 \times (\text{final IKDC} - \text{initial$

IKDC)/(100 – initial IKDC). Finally, as there is no established minimum clinically important difference in kinesiophobia scores, a decrease in kinesiophobia was defined as a decrease in TSK-11 scores of 1 or more points from initial evaluation to final follow-up.

Statistical analyses were completed with a standard statistical software package (STATA 13.1 College Station, TX). Descriptive statistics were first generated for the entire sample. All continuous data were normally distributed for the overall population. Pearson correlations were conducted SF-MPQ and PCS scores with pre-operative as well as postoperative continuous variables. Comparison of PCS scores between patients who did and did not return to similar level of activity was performed by Wilcoxon rank sum due to skewed PCS scores among non-returners; risk of failure to return to similar level of activity due to severe pain catastrophizing was determined by Likelihood ratio Chi-square test. To determine the independent association of PCS and SF-MPQ scores with outcomes, a series of multivariate regression models were then for the following outcomes: (1) return to a similar level of sport (yes/no; logistic regression), (2) knee symptom improvement (percent improvement); linear regression), and (3) improvement in kinesiophobia ( $\geq 1$  point improvement in TSK-11 scores, logistic regression). The models were created with a backwards selection method with exit criteria of Likelihood ratio Chi-square alpha  $\geq 0.05$ . At least one measure each of pain, coping, and catastrophizing were included in each model regardless of p-value. The moderating effect of coping on pain perception was assessed with the change-in-estimate method, which utilizes the change in effect sizes of pain and/or catastrophizing as predictors of a given outcome when coping is included in the model; a change in estimate criterion of >15% is a commonly used definition for a significant confounding (i.e. moderating) effect.<sup>28,29</sup> Additional confounders including age, gender, pre-injury activity levels, prior surgery, planned procedure, pre-operative kinesiophobia, and length of follow-up were also assessed with the change-in-estimate method and included if the change-in-estimate exceeded 15%.<sup>28,29</sup>

### 3. Results

In the bivariate analysis, pre-operative McGill (SF-MPQ) pain scores were negatively correlated with IKDC scores (Pearson  $r = -0.32$ ,  $p = 0.007$ ) (Supplemental Table 1). The median pain catastrophizing score for patients who returned to a similar activity level after surgery (median PCS score 22.5) did not differ from catastrophizing scores among those who did not (median score 23.5)



**Fig. 1.** Box plot of pain catastrophizing scores (PCS total score) based on return to prior activity levels (defined as pre-injury and follow-up Tegner activity scores within 2 points). Though both groups have similar median PCS scores (23.5 for 'no', 22.5 for 'yes';  $p=0.71$  Wilcoxon rank-sum), severe catastrophizers (PCS score  $>36$ ) were significantly more likely not to return to a similar activity level after surgery (unadjusted OR 14.75 CI 1.68, 129;  $p=0.002$ ).

( $p=0.71$  Wilcoxon rank-sum) (Fig. 1), but severe catastrophizers (which we have defined in this population as a PCS score  $>36$ ) were significantly more likely to fail to return to a similar activity level after surgery (unadjusted OR 14.75 CI 1.68, 129;  $p=0.002$ ).

The rate of return to similar level of activity after surgery was 73%. Severe pain catastrophizers (PCS score  $>36$  points) were significantly less likely to return to similar pre-injury activity levels (OR 11.3 CI 1.51, 236;  $p=0.02$ ) (Supplemental Table 2). Patients with greater perceived pain frequency had higher odds of failing to return to similar activity levels (per point increase, OR 2.08 CI 1.03, 4.40;  $=0.04$ ), but higher COPE-use of instrumental support was protective (per point increase, OR 0.72 CI 0.54, 0.94;  $p=0.02$ ). The type of surgical procedure performed was not a significant predictor of return to similar activity levels ( $p>0.05$ ). Coping (instrumental support) was not a significant confounder of the effect of pain perceptions on return similar activity levels (12% decrease in effect size for pain, 4% decrease for catastrophizing if excluded from the predictive model).

Older patients (beta 0.006 SE 0.003;  $p=0.02$ ), more active patients, (beta 0.088 SE 0.023,  $p=0.001$ ), and patients with greater problem-focused coping (beta 0.032,  $p=0.001$ ) experienced a higher percent possible improvement in IKDC-S scores (Supplemental Table 3). McGill (SF-MPQ) total pain scores and pain catastrophizing scores were not associated with symptom relief ( $p=0.60$  and  $p=0.56$ , respectively). The type of surgical procedure performed was not an independent predictor of degree of improvement in IKDC-S scores ( $p>0.05$ ).

There was a mean 3.5 points improvement in kinesiophobia from pre-operative assessment to final follow-up, with 73% improving 1 or more points (Table 2). Patients with high pre-operative kinesiophobia scores were more likely to have reduced kinesiophobia after surgery (per point increase, OR 1.38 CI 1.14, 1.77;  $p<0.001$ ) (Supplemental Table 4). Higher pre-operative pain frequency scores (per point increase, OR 0.23, CI 0.06, 0.71;  $p=0.009$ ) as well as cartilage or isolated meniscus repair (OR 0.14, CI 0.03, 0.60;  $p=0.007$ ) decreased odds of improved kinesiophobia after surgery. Higher COPE-denial scores decreased

odds of improvement in kinesiophobia (OR 0.43, CI 0.21, 0.88;  $p=0.02$ ). Pre-operative pain catastrophizing was not associated with improvement in kinesiophobia ( $p=0.83$ ). Denial as a coping strategy confounded the effect of pain perceptions on improvement in kinesiophobia, with a 22% decrease in effect size for SF-MPQ pain frequency score when denial was removed from the predictive model.

#### 4. Discussion

The central goals of sports-related knee surgery and rehabilitation are to restore knee function as well as athletes' confidence in the ability to perform activities without re-injury. The current study demonstrates a significant relationship between pre-operative pain perceptions and multiple subjective outcomes after sports-related knee surgery including IKDC-S scores, return to prior level of sport, and reduced kinesiophobia after completing rehabilitation. Many of these relationships are present irrespective of the planned surgical procedure. Specific coping strategies appear to moderate the effect of pain perceptions on postoperative outcomes, with some coping strategies being protective and others being harmful. Recognition of pain perception and coping styles early on in treatment may help sports medicine providers identify patients at risk for an unsatisfactory subjective outcome.

Regardless of the surgical procedure, return to sport occurred at low rates among athletes in this study with excessive pain catastrophizing or higher pre-operative pain scores. We believe there may be a perceived pain/catastrophizing threshold above which the injured athlete is significantly impaired in his/her ability to adequately perform postoperative rehabilitation and tolerate the not-infrequent discomfort associated with progressive return to activities after significant knee injury. Use of instrumental support as a coping mechanism had a protective effect in this study. Cognitive behavioral therapy can be used to enhance use of this coping mechanism and has previously been shown to be an effective method at addressing performance issues with rehabilitation and return to sport<sup>30</sup>; in patients with chronic pain or pain related disability, cognitive behavioral therapy can be used to provide effective coping strategies and more effectively return to work.<sup>31</sup> At our institution, injured high-level athletes struggling with rehabilitation and return to sport will often work with our sports psychologists on cognitive-behavioral therapy techniques and other strategies to address these issues; the current study findings suggest that increased use of instrumental coping strategies should be a focus of cognitive behavioral therapy in the injured athlete.

Success in reducing kinesiophobia may depend on several factors such as the planned surgical procedure, baseline kinesiophobia, and information provided by surgeons. Denial as a coping strategy as well as more severe subjective pre-operative pain scores appear to lead to persistent or even increased kinesiophobia. These factors may hinder athletes from regaining confidence in their knee as they progress through rehabilitation. In contrast, athletes with high preoperative kinesiophobia actually experienced the most consistent decrease in kinesiophobia after rehabilitation, suggesting the rehabilitation process is particularly beneficial to this group from a psychological perspective. Following meniscus and cartilage restoration procedures, athletes were more likely to have persistent or increased kinesiophobia. As a result of being warned that limited options exist for treating failed meniscus repairs or cartilage restoration, athletes may have a heightened fear of re-injury.

High-level athletes had the greatest degree of improvement in subjective knee function after rehabilitation in this study, regardless of surgical procedure. In higher-level athletes, greater motivation to return to activities may result in greater effort in

rehabilitation and correspondingly better subjective knee function upon rehabilitation completion. Baseline pain severity and pain catastrophizing were not associated with degree of improvement in IKDC scores, suggesting that patients with high baseline perceived pain levels (and catastrophizers) can still experience a relative improvement in subjective knee function with surgery.

The study had several limitations. Several analyses were performed, and multiple comparisons can increase the risk of type 1 statistical error (detection of a spurious significant result). Another limitation of the current study is the inability to assess whether pain perceptions and coping affect outcomes after knee rehabilitation regardless of surgical or non-surgical treatment; many knee injuries can be treated non-operatively with physical therapy, and it is possible that many of the psychological traits described in the current study may also influence the effectiveness of physical therapy without surgery. Counseling by the surgeon may influence kinesiophobia or return to sport decisions after certain procedures, though this needs to be further delineated in an appropriately designed study. Though surgical procedure and level of required rehabilitation were accounted for in the multivariate analysis, some procedures occurred in small numbers; in these cases, a significant relationship may exist between certain uncommon procedures and outcomes that was not appreciated in the current analysis.

Among athletes undergoing knee surgery, severe pain catastrophizing is negatively associated with return to similar level of sport. Instrumental support and problem-focused coping strategies are associated with improved outcomes. Denial increases the risk of persistent kinesiophobia. High pre-operative pain scores are negatively associated with improvement in kinesiophobia after rehabilitation.

## Disclosures

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## Appendix A. Supplementary data

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