

# Osteoarthritis and Cartilage



## The importance of perceived helplessness and emotional health in understanding the relationship among pain, function, and satisfaction following revision knee replacement surgery



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### ARTICLE INFO

#### Article history:

Received 28 September 2012

Accepted 9 April 2013

#### Keywords:

Revision knee replacement

Satisfaction

Pain

Function

Psychological factors

Mediation

### SUMMARY

**Objective:** Little is known about the relationships among pain, function, psychological variables like perceived helplessness and emotional health, and patient satisfaction in people with revision knee replacement surgery. We hypothesized that pain and function would have a direct association with satisfaction as well as an indirect association through patient perceptions of helplessness and emotional health.

**Design:** This longitudinal study included 145 participants undergoing revision knee replacement surgery. Demographic data and expectation of benefit from surgery were recorded prior to surgery. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the Arthritis Helplessness Scale (AHS) and the Mental Component Scale (MCS) of the SF-36 (emotional health) were collected prior to and 2 years post-surgery. Satisfaction was recorded 2 years post-surgery. Regression analyses were conducted to test for mediation effects of helplessness and MCS.

**Results:** Participants were on average 69 years old and 54% were women. Participants were satisfied with the results of the surgery (mean  $\pm$  standard deviation (SD) = 70.42  $\pm$  31.46). Less pain and functional disability were associated with increased patient satisfaction and, the effect of pain or function was also mediated through helplessness whereby more pain and disability were associated with perceptions of helplessness and helplessness was associated with lower satisfaction. MCS did not mediate the relationship of pain and function with satisfaction.

**Conclusion:** Helplessness plays an important role in understanding patient satisfaction. Interventions aimed at improving patient outcome should target not only pain and function but also should address strategies to support people in managing following knee revision surgery to maximize satisfaction with outcome.

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## Introduction

Patient-reported outcomes are well accepted as measures of benefit and it has been argued that the ultimate goal of orthopedic surgery is patient satisfaction<sup>1–5</sup>. Clinicians, clinical programs, administrators, and policy makers use satisfaction as a measure of success of treatment and care, and to make decisions about care delivery and reimbursement<sup>6,7</sup>. The Ministry of Health and Long-term Care in Ontario, Canada is implementing a health-based funding model where reimbursement will be linked to quality indicators. Additionally, while not yet implemented, funders such as the National Health System in the United Kingdom have indicated their intention to link reimbursement to patient outcomes<sup>8</sup>.

While there has been significant focus on primary hip and knee replacement outcomes in the literature, our understanding of the outcomes of revision total knee replacement (TKR) is more limited, particularly in understanding factors that are associated with outcome. This is concerning for a number of reasons: data indicate that while 80–90% of people with primary knee replacement are satisfied with the results of surgery, fewer people with revision TKR are satisfied (69–88%), despite similar improvements in pain and function; increasing volumes of primary joint replacements are being performed in the developed world; and, there is limited longevity of primary joint replacement with ultimate need for revision surgery<sup>1,3,4,9–13</sup>. In 2007, 550,161 TKRs were performed in the United States (US) representing 100% increase over 1997<sup>14</sup>. In 2008–2009, 47,429 knee replacements were performed across Canada (excluding Quebec), representing a 139% 10-year increase in TKR<sup>15</sup>. Approximately 6.2% of all knee replacements were revisions in 2009/10 in Canada<sup>16</sup>. Given this increase in primary TKR, the number of revision TKRs is expected to rise. This increased volume as well as the increased technical demand and longer operating time for revision surgery will impact the resources of the health system<sup>17</sup>. Consequently, it is critical that we understand patient outcome after revision TKR.

Pre-operative pain and function, obesity and the number of comorbidities, are reported predictors of pain and function outcomes following revision TKR<sup>18–21</sup>. However, there has been little evaluation of psychological variables in revision TKR, other than reporting pre- and post-surgery scores of measures such as the Mental Component Score (MCS) of the Shortform (SF)-36<sup>12,22</sup>. Additionally, Singh *et al.* reported no significant relationship between pain or function and the personality trait of optimism/pessimism<sup>23</sup>. In people with primary TKR, depression, anxiety, and helplessness in managing one's arthritis were associated with increased pain and reduced function, and decreased satisfaction. Depressive symptoms and anxiety were associated with pain and function 5 years after Total Knee Arthroplasty (TKA)<sup>24</sup>. Scott *et al.* found the Mental and Physical Component Scores of the SF-12 and pain to be independent predictors of satisfaction<sup>25</sup>. Having positive expectations of a good outcome, decreased pain and improved function are consistently related to satisfaction<sup>1,2</sup>. There is also evidence that feelings of helplessness affect pain and function. Helplessness refers to a belief that nothing can be done to resolve a problem, characterized by emotional, motivational, and cognitive deficits<sup>26</sup>. It is a belief that one's outcomes are independent of one's actions<sup>27</sup>. In a study looking at brain imaging of patients with osteoarthritis (OA), helplessness was found to play an important role in the perception of pain. A painful stimuli elicited considerable cognitive and emotional activity in the brain compared to control subjects<sup>28</sup>. Additionally, the literature shows that helplessness impacts pain in people with arthritis and greater helplessness predicted lower WOMAC change scores at 1 year after primary joint replacement surgery<sup>29–32</sup>.

Given this literature and that people experienced failure of their primary joint replacement, we were interested in evaluating if psychological variables like perceived helplessness and emotional health would explain the relationships between pain or function and satisfaction in people with revision TKR. We hypothesized that the relationship of pain and function with satisfaction occurred through a mediated model whereby pain and function affect helplessness and emotional health, which in turn affect satisfaction (Fig. 1). If mediation occurs, the following relationships would exist: (1) pain and function would be associated with satisfaction whereby less pain and higher function are associated with more satisfaction; (2) pain and function would be associated with helplessness and emotional health such that less pain and higher function are associated with less helplessness and improved emotional health; and, (3) statistically controlling for helplessness and emotional health should reduce the magnitude of the relationship between pain and function with satisfaction. That is, pain and function either become non-significant (i.e., a fully mediated model) or their effect is reduced (i.e., a partially mediated model). If a mediated relationship is present, interventions that address perceived helplessness and or emotional health may improve patients' perception of their outcome.

## Methods

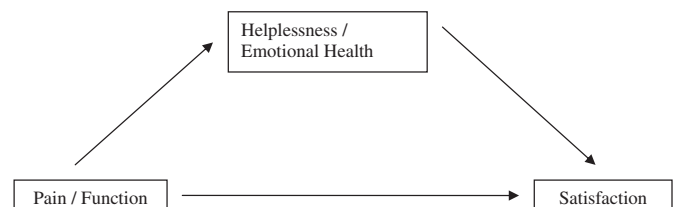
This research was part of a longitudinal study evaluating patient-reported outcomes of people with revision TKR<sup>33</sup>. The longitudinal study recruited patients from five academic Canadian centers (Halifax, London, Toronto, Vancouver, and Winnipeg) between 2002 and 2005 and followed them over 2 years. The cohort included people who underwent revision knee replacement for aseptic failure of a primary knee replacement initially for OA. Exclusion criteria included revision for infection, periprosthetic fracture, patellar revision only, or polyethylene liner exchanged only. Fluency in English was required for questionnaire completion. Participants, identified through the participating surgeon's rosters, who consented to participate completed questionnaires within 2 weeks prior to surgery at the pre-surgery admission clinic and by mail at 2 years post-surgery. The study was approved by the research ethics board at each of the participating institutions and all participants provided informed, written consent.

### Data collection

All data were collected via questionnaire.

### Outcome

**Satisfaction at 2 years following surgery:** Patients reported their satisfaction using a reliable and valid four-item scale that evaluates patient satisfaction with relief of pain, improvement in activities of daily living, improvement in recreational activities, and overall



**Fig. 1.** Mediation model. It shows the hypothesized relationship of pain (or function) directly associated with satisfaction and the indirect relationship through helplessness (i.e., partially mediated through helplessness).

satisfaction following joint replacement. Each item has a four-point response ranging from very satisfied to very dissatisfied. The scores were summed and converted to a scale ranging from 0 to 100 with higher scores representing greater satisfaction<sup>34</sup>.

#### Independent variables

**Pain and function:** The independent variables of interest were pain and function as measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC, Likert version 3.0). The WOMAC is a valid and reliable measure of symptoms and function for persons with OA of the hip and/or knee<sup>35–37</sup>. The pain subscale includes five items and the function subscale includes 17 activities reported on a 0–4 scale. The scores were converted to a scale ranging from 0 to 100 with higher scores depicting no pain or functional limitation.

#### Potential mediators

The **Arthritis Helplessness Scale (AHS)** is a five-item questionnaire measuring the individual's perception of their helplessness in managing their arthritis (e.g., 'My condition is controlling my life'; 'I would feel helpless if I couldn't rely on other people for help with my condition'). Items are scored on a five-point scale with scores ranging from 1 = strongly disagree to 5 = strongly agree, with one reverse-coded item. Aggregate scores were converted to a scale ranging from 0 to 100 with high scores indicating lesser helplessness in managing arthritis<sup>38–40</sup>.

**Emotional health** was measured by the Mental Component Summary Score (MCS) of the 36-item Short-Form Health Survey (SF-36). The SF-36 includes 36 questions, summarized into eight scales: physical function, role functioning or limitations due to physical problems, bodily pain, general health perception, vitality or energy level, social functioning, role functioning or limitations due to personal or emotional problems and mental health<sup>41</sup>. An algorithm is used to calculate the MCS; scores range from 0 to 100 with higher scores indicating better emotional health.

#### Covariates

In addition to completing demographic information (age, sex, marital status, and education), participants rated the expected benefit of their knee replacement surgery prior to surgery. The responses ranged from 1 = not at all beneficial to 5 = extremely beneficial. Due to the low frequency for some response options, expectation of benefit from surgery was dichotomized as extremely beneficial vs other.

#### Statistical analysis

Descriptive statistics were calculated for all variables including means, standard deviations (SDs) and proportions as appropriate to the data. Paired *t*-tests were used to evaluate change in each of WOMAC pain and function over time. The mediation effect of helplessness and emotional health at 2 years follow-up were tested separately for each of pain and function in relation to satisfaction using regression analysis and according to the steps outlined by Baron and Kenny<sup>42</sup>. In the first step, pain or function was entered into the regression equation as an independent variable and satisfaction as the dependent variable. In the second step pain or function was entered into the model with helplessness or emotional health as the dependent variable. In the final step, pain or function, helplessness or emotional health were entered into the regression as independent variables and satisfaction as the dependent variable. A mediation effect is demonstrated when the

magnitude of the coefficients for pain or function decreases from step one to step three. The Sobel test was also performed to test whether the indirect effect of pain and function on satisfaction via the mediator, helplessness or emotional health, was significantly different from zero.

All the models controlled for age as a continuous variable, sex and pre-surgery expectation of benefit (grouped as extremely beneficial vs other), and the pain and function models also controlled for the baseline (pre-surgery) pain or function score respectively as prior research, mainly in primary TKR, has shown that these variables are associated with satisfaction<sup>1,5,43,44</sup>.

Finally, as a sensitivity analysis, we evaluated whether pre-operative helplessness and emotional health mediated the relationship of pain and function with satisfaction at 2 years post-surgery. If no mediation effect was found using pre-operative AHS and MCS scores, demonstration of mediation at 2 years would support potential modification of the pain, function and satisfaction relationship through an intervention that addressed these psychological factors (i.e., helplessness or emotional health would not be 'fixed' concepts but rather potentially modifiable).

Regression diagnostics including normality of residuals, Cook's *D* and variance inflation, were checked to ensure underlying model assumptions were met. Statistical significance was accepted at a  $P < 0.05$  level. Data analyses were carried out using SAS version 9.2 software (SAS Institute Inc., Cary, NC, USA).

Sample size for this study was based on considering whether the available sample from the original study would allow sufficient power given the number of independent variables to be modeled such that we were not over-fitting the model. Given our final models included a maximum of six variables, 145 participants were sufficiently large<sup>45,46</sup>.

## Results

Of the 184 patients recruited to the cohort, 145 (79%) were included in the current study (four died, two withdrew, six were lost to follow-up and 27 had insufficient data for analysis). No statistically significant differences or clinically meaningful differences were observed between analyzable ( $n = 145$ ) and non-analyzable ( $n = 39$ ) participants in the study with respect to age, sex, pre-surgery WOMAC pain and function, MCS, and AHS scores (data not shown). The participants ( $n = 145$ ) were on average 69 years old (range 32–89 years) at the time of surgery and 54% ( $n = 78$ ) were women. As anticipated, participants experienced significant pain and disability pre-operatively. About 73% ( $n = 106$ ) used an ambulatory aid prior to surgery and 55% ( $n = 80$ ) expected their revision surgery to be extremely beneficial (Table I). Pain and function improved significantly from pre-surgery to 2 year follow-up with pain scores improved from a mean of 46.5–71.3

**Table I**  
Participant characteristics

$n = 145$	Pre-surgery
Age in years, mean $\pm$ SD	69.3 $\pm$ 9.8
Sex, $n$ (%)	
Female	78 (54%)
Male	67 (46%)
Married or with partner, $n$ (%)	92 (65%)
Having help around the house, $n$ (%)	100 (69%)
Education higher than high school, $n$ (%)	78 (54%)
Living alone, $n$ (%)	38 (26%)
Use walking aid, $n$ (%)	106 (73%)
Expect surgery to be extremely beneficial, $n$ (%)	80 (55%)

**Table II**  
Outcomes at pre- and 2 years post-surgery

	Pre-surgery, mean $\pm$ SD	Post-surgery, mean $\pm$ SD
SF-36 MCS score (100 = no emotional health problems)	51.90 $\pm$ 11.5	54.63 $\pm$ 9.7**
WOMAC (100 = no pain/functional disability)		
Pain score	46.5 $\pm$ 19.8	71.3 $\pm$ 24.4*
Function score	45.5 $\pm$ 20.0	65.8 $\pm$ 22.3*
AHS (100 = no helplessness)	41.4 $\pm$ 16.6	50.7 $\pm$ 19.3*
Satisfaction scale (100 = completely satisfied)		70.4 $\pm$ 31.5

\* $P < 0.0001$ ; \*\* $P = 0.01$ .

( $P < 0.0001$ ) and functional ability scores improved from a mean of 45.5–65.8 ( $P < 0.0001$ ). Improvement also occurred in emotional health with the MCS increasing from 51.9 to 54.6 ( $P = 0.01$ ). Participants also perceived less feelings of helplessness in dealing with their disease at 2 years post-surgery compared to prior to surgery, mean 41.4 and 50.7 ( $P < 0.0001$ ) respectively. The mean ( $\pm$ SD) satisfaction score at 2 years post-surgery was 70.4  $\pm$  31.5 (minimum and maximum score: 16, 100; quartiles: 75% = 100; 50% = 83.3; 25% = 50) (Table II).

Table III shows the results of the three equations testing the mediation effect<sup>42</sup> of perceived helplessness. We found that perceived helplessness partially mediated the relationship between pain or function at 2 years and satisfaction. While those with less pain were more satisfied with their outcome, there was also an indirect relationship in that those with less pain also had less feelings of helplessness in managing their arthritis which led to improved satisfaction with outcome as hypothesized (Fig. 1). Similarly for function, those with better self-reported function were more satisfied but better function also was associated with less feelings of helplessness which in turn was associated with higher satisfaction. While the pre-surgery and post-surgery AHS were moderately correlated (Spearman's  $\rho = 0.41$ ), sensitivity analyses demonstrated that the pre-surgery AHS did not mediate either the pain or function relationship with satisfaction (data not shown).

Emotional health as measured by the MCS did not mediate the effect of pain or function with satisfaction. As shown in Table IV, regression of the MCS on satisfaction did not result in a decrease in the magnitude of the regression coefficient for either pain or function compared to pain/function alone regressed on satisfaction. Rather there was a significant direct effect of emotional health with satisfaction in that higher MCS scores were associated with satisfaction, although the additional explanatory value of adding the MCS to the model was only 2%.

**Table III**  
Models demonstrating the partial mediation of the relationship of WOMAC pain and function with satisfaction by helplessness at 2 years post-surgery

Eq.	DV	IV	Unstd. regression coefficient	Std. error	95% CI	P-value	R <sup>2</sup>	Sobel test z-value
1	Satisfaction	Pain	1.0	0.1	0.9–1.2	<0.0001	0.60	
2	AHS	Pain	0.6	0.1	0.5–0.7	<0.0001	0.59	
3	Satisfaction	AHS	0.7	0.1	0.4–0.9	<0.0001		
		Pain	0.7	0.1	0.4–0.9	<0.0001	0.67	4.6*
1	Satisfaction	Function	1.1	0.1	0.9–1.3	<0.0001	0.57	
2	AHS	Function	0.6	0.1	0.5–0.7	<0.0001	0.60	
3	Satisfaction	AHS	0.7	0.1	0.4–1.0	<0.0001		
		Function	0.5	0.1	0.4–0.9	<0.0001	0.64	4.7*

Eq. = equation; DV = dependent variable; IV = independent variable; Unstd. regression coefficient = unstandardized regression coefficient; Std. error = standard error; 95% CI = 95% confidence interval; \* $P$ -value < 0.0001. All the above models are adjusted for age, sex, expectation of benefit and baseline pain or function.

## Discussion

This study contributes to the limited body of knowledge related to satisfaction with outcome of revision knee replacement surgery. It particularly highlights the relationship of psychological variables, perceived helplessness and emotional health, with pain and function and satisfaction. We found that although there was a direct relationship of pain and function at 2 years with satisfaction, there was also an indirect relationship through perceived helplessness in managing arthritis. While less pain was associated with higher satisfaction, less pain also resulted in less feelings of helplessness and hence, better satisfaction. Similarly, satisfaction was higher in those with higher function but, in part, this was because higher function was associated with less helplessness, and hence higher satisfaction. Given our findings that pre-operative AHS scores did not mediate the pain/function and satisfaction relationships but 2 year AHS scores were mediators, perceived arthritis helplessness does not seem to be fixed and may be a target for treatment in the context of people's recovery from revision TKR. Interdisciplinary management including interventions such as cognitive behavioral approaches in the context of surgical and arthritis self-management may reduce perceived helplessness and improve patient outcome following revision TKR<sup>26,47</sup>. Helplessness as a modifiable factor is further supported by a study in which Zutra *et al.* found that controlled release of oxycodone in patients with OA with persistent moderate to severe pain not only lead to clinically significant reductions in pain but also less feelings of helplessness<sup>48</sup>.

Somewhat to our surprise, while emotional health, as measured by the MCS, did not mediate the relationship with pain or function with satisfaction, it also added minimal additional explanatory value in understanding satisfaction. These findings are in contrast to data from primary TKR where Scott reported that emotional health as measured by the MCS was significantly associated with satisfaction such that those with better emotional health reported better satisfaction. We are not sure of the reason for this although we note that the post-surgery MCS scores were on average 54 points with a SD of 9.7 which is slightly above the Canadian normative value for the MCS of 51.7 (SD = 9.1)<sup>49</sup>, indicating that few people had scores below the population mean. The pre-surgery scores were similar to the population mean (51.9, SD = 11.5). Kasmire *et al.*<sup>22</sup> reported a statistically significant pre-post change of 10 points, while Hartley *et al.*<sup>12</sup> reported a change of 0.1 points. The variability of these results indicates that further research is required to understand emotional health as measured by the MCS in people undergoing revision TKR.

Although not in people with revision TKR, still other studies in people with arthritis have shown that psychological variables such as helplessness, depression and stress are important in understanding differences in how people respond to their disease and

**Table IV**

Models evaluating the mediation of the relationships of WOMAC pain and function with satisfaction by emotional health at 2 years post-surgery

Eq.	DV	IV	Unstd. regression coefficient	Std. error	95% CI	P-value	R <sup>2</sup>	Sobel test z-value
1	Satisfaction	Pain	1.0	0.1	0.9–1.2	<0.0001	0.60	
2	MCS	Pain	0.1	0.04	0.0–0.2	0.002	0.19	
3	Satisfaction	MCS	0.7	0.2	0.3–1.1	0.001		
		Pain	0.9	0.1	0.8–1.1	<0.0001	0.62	2.3*
1	Satisfaction	Function	1.1	0.1	0.9–1.3	<0.0001	0.57	
2	MCS	Function	0.2	0.04	0.1–0.2	<0.0001	0.20	
3	Satisfaction	MCS	0.6	0.2	0.2–1.1	0.006		
		Function	1.0	0.1	0.8–1.2	<0.0001	0.59	2.3**

Eq. = equation; DV = dependent variable; IV = independent variable; Unstd. regression coefficient = unstandardized regression coefficient; Std. error = standard error; 95% CI = 95% confidence interval; MCS = SF-36 Mental Component Score; \*P-value < 0.0001; \*\*P-value = 0.02. All the above models are adjusted for age, sex, expectation of benefit and baseline pain or function.

treatment<sup>50</sup>. In a study of knee OA patients, Creamer *et al.* found pain severity, obesity and helplessness were the most important determinants of disability with 60% of the variance in the model accounted for by these variables<sup>51</sup>. A recent study found greater helplessness independently predicted less functional improvement 1 year following primary TKR<sup>32</sup>. In the current study, we found helplessness not only associated with but partially mediating the relationship between pain and function with satisfaction.

While it is difficult to place our findings related to satisfaction following revision TKR in the context of the literature as most of the work related to psychological factors and outcomes has been done in patients with OA or primary hip or knee replacement, there are some informative data. We found the level of satisfaction experienced by the participants of this study was similar to that of patients in other studies. Our mean ( $\pm$ SD) satisfaction score was 70.42 ( $\pm$ 31.5) which is comparable to the findings of Meek *et al.*, in their study with patients who underwent revision TKR for infection (71.7  $\pm$  33.1)<sup>52</sup>. Similarly, Greidanus *et al.* compared satisfaction outcomes of patients undergoing primary and revision TKA and reported a mean satisfaction score of 72.9 ( $\pm$ 36.3) for revision TKA patients<sup>13</sup>. The mean ( $\pm$ SD) pre- and post-surgery MCS score in the present study are 51.90 ( $\pm$ 11.5) and 54.63 ( $\pm$ 9.7) respectively. The Canadian normative value for the MCS is 51.7 ( $\pm$ 9.1), comparable to our sample, suggesting similar emotional health<sup>49</sup>. Similar scores were reported for primary knee replacement patients with severe knee OA by Heck *et al.* The means were 52.5 (standard error = 0.7) and 54.4 (standard error = 0.6) for pre- and post-surgery respectively, and showed patients with lower MCS scores (i.e., poorer emotional health) were less likely to report improvements in physical function<sup>53</sup>.

While studies have looked at how pain and function are related to satisfaction or how psychological variables are related to pain and function<sup>1,2,54</sup>, this is the first study to our knowledge that has looked at the mechanism of how pain and function are related to satisfaction especially among patients having revision knee replacement surgery. While the psychological variables such as helplessness have been linked to outcomes of joint replacement surgery, depression and poor mental health have been linked to dis-satisfaction<sup>25,32</sup>. The literature shows a link between alleviation of pain and positive emotional health in people with arthritis<sup>55–57</sup>. The present study found higher MCS scores or better emotional health associated with greater satisfaction (although the explanatory value was limited in multi-variable modeling). The corollary to this finding can be found in the work by Gandhi *et al.* where they found poor mental health predicted less satisfaction<sup>58</sup>. Further research is needed to generalize these and our findings.

A strength of our work is that our analyses adjusted for a number of covariates or potential confounders that have been shown to be related to satisfaction with outcome following joint

replacement. Participants undergoing revision TKR in this study reported significant improvement in pain and physical function at 2 years post-surgery and the magnitude was similar to that typically reported in the literature. Additionally, the proportion who reported they were satisfied with their outcome was also within the range reported in the literature. The sample was recruited from multiple tertiary care institutions in Canada and given that revision knee replacement is usually performed in specialty centers, our sample likely represents the patients undergoing revision TKR for aseptic loosening in our country. However, a limitation of this study is that our sample did not include those who had revision knee replacement for infection or who had only polyethylene liner exchange. Hence, our results cannot be generalized to people having revision for these indications. Additionally, our sample was limited to those who had English competency such that they could consent and complete the questionnaires. While we did not specifically collect data on race or ethnicity, we anticipate that this language requirement limits the generalizability of our results. Finally, we were able to capture descriptive data only for those who consented to participate such that we do not know if or how our sample differed from those who were eligible but declined to participate.

## Conclusion

In summary, the majority of people undergoing revision knee replacement surgery were satisfied with the results of surgery. Patient satisfaction is not only important from a patient's or surgeon's perspective, it is also gaining importance from an economic perspective. The National Health Services (NHS) in the United Kingdom is linking reimbursement to patient satisfaction, indicating that up to 10% of hospital income will be dependent on patient experience and satisfaction<sup>7</sup>. So, not only is it important to understand factors associated with patient satisfaction, it becomes imperative to comprehend the mechanisms involved. In conclusion, pain and function are associated with patient satisfaction after revision knee replacement surgery. However, this study demonstrated that there is also an indirect relationship between pain and function and satisfaction, the mechanism of which is through perceived helplessness which may be modifiable through intervention.

## Authors' contributions

Conception and design: Davis, Gross, Gignac, Schemitsch, Mahomed.

Analysis and interpretation of the data: Davis, Gignac, Venkataramanan.

Drafting of the article: Davis, Gignac, Venkataramanan.

Critical revision of the article for important intellectual content: Venkataramanan, Gignac, Dunbar, Garbuz, Gollish, Gross, Hedden, MacDonald, Mahomed, Schemitsch, Davis.

Final approval of the article: Venkataramanan, Gignac, Dunbar, Garbuz, Gollish, Gross, Hedden, MacDonald, Mahomed, Schemitsch, Davis.

Provision of study materials or patients: Dunbar, Garbuz, Gollish, Gross, Hedden, MacDonald, Mahomed, Schemitsch.

Statistical expertise: Davis, Gignac, Venkataramanan.

Obtaining of funding: Davis.

Administrative, technical, or logistic support: Venkataramanan.

Collection and assembly of data: Venkataramanan, Davis, Dunbar, Garbuz, Gollish, Gross, Hedden, MacDonald, Mahomed, Schemitsch.

### Role of the funding source

This study was funded by an unrestricted operating grant from the Canadian Institutes of Health Research, grant number 49616. The funder had no role related to the conduct of the study or interpretation of the results.

### Conflict of interest

None of the authors had competing interests in relation to the work.

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