Preoperative Pain Neuroscience Education for Lumbar Radiculopathy

A Multicenter Randomized Controlled Trial With 1-Year Follow-up

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Study Design. Multicenter, randomized, controlled trial on preoperative pain neuroscience education (NE) for lumbar radiculopathy.

Objective. To determine if the addition of NE to usual preoperative education would result in superior outcomes with regard to pain, function, surgical experience, and health care utilization post-surgery.

Summary of Background Data. One in 4 patients after lumbar surgery (LS) for radiculopathy experience persistent pain and disability, which is nonresponsive to perioperative treatments. NE focusing on the neurophysiology of pain has been shown to decrease pain and disability in populations with chronic low back pain.

Methods. Eligible patients scheduled for LS for radiculopathy were randomized to receive either preoperative usual care (UC) or a combination of UC plus 1 session of NE delivered by a physical therapist (verbal one-on-one format) and a NE booklet. Sixty-seven patients completed the following outcomes prior to LS (baseline), and 1, 3, 6, and 12 months after LS: low back pain (numeric rating scale), leg pain (numeric rating scale), function (Oswestry Disability Index), various beliefs and experiences related to LS (10-item survey with Likert scale responses), and postoperative utilization of health care (utilization of health care questionnaire).

Results. At 1-year follow-up, there were no statistical differences between the experimental and control groups with regard to primary outcome measure of low back pain ($P = 0.183$), leg pain ($P = 0.075$), and function ($P = 0.365$). In a majority of the categories regarding surgical experience, the NE group scored significantly better: better prepared for LS ($P = 0.001$); preoperative session preparing them for LS ($P < 0.001$) and LS meeting their expectations ($P = 0.021$). Health care utilization post-LS also favored the NE group ($P = 0.007$) resulting in 45% less health care expenditure compared with the control group in the 1-year follow-up period.

Conclusion. NE resulted in significant behavior change. Despite a similar pain and functional trajectory during the 1-year trial, patients with LS who received NE viewed their surgical experience more favorably and used less health care facility in the form of medical tests and treatments.

Key words: preoperative, postoperative, neuroscience, lumbar surgery, radiculopathy, education, outcomes, health care costs.

Level of Evidence: 2

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Lumbar radiculopathy is often cited as an indication for lumbar surgery (LS), especially with failed conservative care and worsening symptoms.1-3 Lumbar discectomy for radiculopathy has shown a success rate of between 60% and 90%.4-7 Although this is quite good, it suggests that 10% to 40% of postsurgical patients may have had a poor outcome, with resulting pain, loss of movement, and dysfunction. Postoperative rehabilitation (consisting mainly of exercise) is often prescribed to help decrease disability and facilitate return to regular activities.4-10 To date, however, postoperative rehabilitation has shown little long-term benefit for patients after LS,11,12 which suggests that some patients may experience long-term pain and disability after LS for radiculopathy.

Preoperative education has long been proposed and used as a strategy to decrease postoperative pain and disability,13,14 and has been used in various orthopedic surgical procedures.15-18 However, 3 recent systematic reviews of preoperative education for orthopedic surgery have shown no postoperative benefit with regard to pain and disability.15,16,19 A number of studies have been conducted on the outcome of preoperative education specifically for patients after LS and all have shown little or no benefit.11,20-22 One possible explanation for this might be the apparent lack of “pain-specific” education.19,23,24

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This is underscored by the fact that McDonald et al23 were able to demonstrate that a preoperative educational program that specifically addressed pain prior to joint replacement resulted in immediate decrease in postoperative pain. In addition, Louw et al24 interviewed patients after LS regarding their perioperative education and found that patients wanted more education regarding their pain and the impact that the surgery would have on it. Ronnberg et al21 showed that patients undergoing disc surgery are generally satisfied with the care given to them preoperatively, but not with the content of the information regarding the impending LS.

Education has long been used to help alleviate the disability associated with low back pain (LBP).25–28 In the orthopedic domain, there are a number of studies on the effect of education on pain and disability, with outcomes ranging from “excellent”29 to “poor.”30,31 Most educational programs in orthopedics use biomedical models of anatomy and biomechanics to address pain,25,32–34 which not only has shown limited efficacy,25,32,33 but may even increase patient fears and anxieties, thereby negatively impacting their outcomes.32,36,37 Recent research has evaluated the use of neuroscience education (NE) in decreasing pain and disability among patients with LBP. NE deemphasizes the traditional anatomical tissue- and Cartesian-based models of pain,33,38 and aims to reduce the fear associated with LBP by providing more information about pain and the neurophysiology of a pain experience. Various high-quality randomized controlled trials and our own recent systematic review have shown that NE has a positive effect on pain, disability, pain catastrophization, and physical movement for patients with chronic LBP, extending to 1-year outcomes.34,38,42

The objective of this study was to test the premise that postoperative outcomes after LS for radiculopathy could be enhanced by the provision of preoperative pain-specific education. We used a novel preoperative NE program for LS24 to determine if its addition to usual care would result in superior outcomes in terms of postoperative pain, disability, surgical experience, and health care utilization.

MATERIALS AND METHODS

Patients were recruited from 7 clinical sites in the United States. The choice of these sites was based on the availability of physical therapists trained to deliver the preoperative NE program and access to a spine surgeon who was willing to participate in the study. Once determined that LS was indicated, each patient consulted with the surgeon’s assistant to set the date and receive administrative and procedural information about their surgery. At this time, patients were informed and invited to participate in this study examining the effects of 2 preoperative education programs.

Concealed randomization was performed, using computer-generated numbers. Patients were given an envelope, which randomly assigned them to either the control group (usual care group [UCG]) or the experimental group (usual care + NE [EG]). The envelopes contained identical information, except that patients in the EG were asked to schedule a 1-time educational session with a physical therapist to deliver their preoperative NE session. Patients were asked to ensure the session be completed in the week before LS, which is within the parameters of what is known about optimal timing for the delivery of preoperative education.13 Patients in the EG were advised that this was the surgeon’s usual practice and that they needed to call the physical therapy clinic to schedule their appointment. The envelopes contained no distinctive markings and the physician’s assistants were blinded to the fact regarding which patients were assigned to the UCG and EG.

All intake forms were completed by the patients with no input from the therapists, physician, physician staff, or researchers, placed in a prepaid sealed envelope and mailed to an independent research assistant for data entry. All entered data were checked for accuracy by the primary investigator prior to data analysis. Data were collected a further 4 times at 1, 3, 6, and 12 months after surgery. Data packets were sent out by an independent research assistant and returned to the same assistant. None of the postoperative data packets were viewed or handled by the surgeons, their staff, therapists who provided NE, or the investigators. Patients who did not return their assigned postoperative packets in the allotted time frames were sent reminders via mail (postcard), e-mail, or phone calls. Patients were offered a gift card worth US$20 at each interval for completion of the packets (preoperatively, 1, 3, 6, and 12 mo). The protocol for this study was reviewed and approved by Stellenbosch University Board of Institutional Review/Ethics.

Study Population

Patients with lumbar radiculopathy, who were scheduled for LS, were invited to participate. Inclusion criteria were: (1) scheduled for LS for radiculopathy; (2) willingness to comply with the predetermined follow-ups; and (3) willingness to complete postoperative questionnaires at designated time intervals. Exclusion criteria were: (1) age lesser than 18 years or more than 65 years; (2) not being proficient in reading or comprehending the English language; (3) scheduled for LS involving instrumentation (e.g., spinal fusion, arthroplasty); (4) participation in a formal back school or multidisciplinary pain management program; (5) undergoing LS for a condition other than lumbar radiculopathy; (6) presence of chronic pain-related conditions (e.g., fibromyalgia, chronic fatigue syndrome); or (7) symptoms of cord compression. We chose to exclude patients older than 65 years to ensure some degree of homogeneity in our sample in terms of symptoms being predominant leg pain with or without neurological deficit. Patients older than 65 years tend to have more stenotic conditions and predominantly neurological signs and symptoms rather than just leg pain.

Sample size was calculated on the basis of the primary outcome measures for pain and function, and was estimated from preliminary data (12 EG subjects and 3 UCG subjects). For both outcome measures, the sample size was based on an interaction effect for a 2 (experimental condition: EG and UCG) × 5 (time: preoperative, 1-mo postoperative, 3-mo postoperative, 6-mo postoperative, and 12-mo postoperative) mixed factorial analysis of variance using 70% power and a
df of 2. Using an interaction effect index of 0.160 (calculated from the preliminary data), the estimated sample size needed to see an interaction would be 56 to 99.

Ninety-two patients were screened for eligibility and after exclusions, 67 agreed to participate and were enrolled in the study. Thirty-two were randomly assigned to the EG and 35 to the UCG, respectively. One patient in each group did not undergo surgery; leaving 65 patients for follow-up post-LS. Figure 1 depicts a CONSORT study diagram.43

**Trial Interventions Usual Care Protocol**

Patients in the control group (UCG) received what constitutes “usual care” regarding preoperative education from their respective surgeons and staff. To ensure all surgeons involved in this study provided relatively similar usual care, each surgeon (n = 7) was asked to complete the Spine Surgery Education Questionnaire (SSEQ) to determine if their treatment followed the usual care established in SSEQ study.44 Two investigators independently reviewed the surgeons’ responses to the SSEQ to ensure their preoperative education was in line with the findings of the SSEQ. All participating surgeons used usual care per the SSEQ.

**Experimental Protocol**

The development and content of the preoperative NE has been published elsewhere.24,45 The sensitivity of the nervous system metaphorically described as an alarm system45 accompanied with drawings of action potentials34,45 was used to describe peripheral sensitization,34,39,40 central sensitization,34,40,45 and plasticity of the nervous system.40,45 Material covered in the NE included all of the following: (1) the decision to have LS; (2) the nervous system's physiology and pathways; (3) peripheral nerve sensitization; (4) surgical experiences and environmental issues effects on nerve sensitivity; (5) calming the nervous system; (6) recovery after LS; (7) scientific evidence for the NE booklet content; and (8) an opportunity to reflect and write questions to ask the surgeon prior to surgery.

Patients in the EG received usual care in addition to the preoperative NE program. NE was provided by participating physical therapists in a one-on-one verbal format, with the use of pictures, examples, metaphors, and drawings as needed. This was done in a conversational and personal approach rather than a lecture format. To ensure a standardized NE program, a systematic checklist was developed. The educational sessions averaged 30 minutes. Patients were additionally provided with a preoperative NE booklet summarizing the educational content of the preoperative NE session, including pictures, examples, and metaphors.46 Patients were asked to read the NE booklet at least once before and once after their surgery.

**Outcome Measures**

The primary outcomes of interest were back/leg pain and function. Secondary outcome measures were thoughts/beliefs about the surgery and health care utilization. Time frames for collection of outcome measures were chosen on the basis of previous postoperative LS studies.11,47

**Pain**

Low back and leg pain were measured using the numeric pain rating scale (NPRS), as has been used in various randomized controlled trials for NE and spinal pain.41,42,48 The minimal detectable change for the NPRS is reported to be 2.1.49

**Function**

Perceived disability was measured using the Oswestry Disability Index (ODI) that has good evidence for its reliability and validity as a measure of functional limitations related to LBP.50–52 A change of 5 points (10%) has been proposed as the minimal detectable change.53

**Postoperative Thoughts/Beliefs**

After their surgery, patients were asked to indicate by means of a numeric scale (1–10) their level of agreement (1 indicating minimal and 10 indicating maximal agreement) with statements about their spinal surgery/education experience. The following statements were based on previous studies evaluating patient satisfaction with LS.20,54,55

1. “I am glad I underwent surgery for my leg pain.”
2. “I was fully prepared (physically, emotionally, and psychologically) for the surgery.”
3. “The preoperative education I received prepared me well for the surgery.”
4. “Knowing what I know now, I would do this again given the same choices.”
5. “The surgery met my expectations.”

**Health Care Utilization Post-LS**

Patients were asked to indicate if they had any, and how many, of the following medical tests specifically related to their postoperative care: radiography, magnetic resonance imaging, computerized tomography, bone scanning, nerve conduction test, myelogram, and/or other medical tests. In addition, patients were asked to report if they received any postsurgical treatment from their spine surgeon, family doctor, physical therapist, other specialist physicians, chiropractor, massage therapist, acupuncturist, psychologist, psychiatrist, and/or other health care professionals. In both cases (medical tests and health care providers), patients were asked to indicate how many times they had the tests or treatments. Examples were provided to aid patients. Data were gathered to determine the total number of visits for each medical test and visits per health care provider. For each test and health care provider visit, a financial cost was calculated on the basis of the average cost for such tests and visits in the United States (www.cms.gov).

**Statistical Analysis**

To ascertain the differences between treatment and control, 2 (group: EG and UCG) × 5 (time: preoperative, 1 mo, 3 mo, 6 mo, and 1 yr) analysis of variances on 3 different outcome measures (LBP, leg pain, ODI) were conducted using a per protocol analysis (PPA) (i.e., all those who actually completed the study per group assignment) and an intent-to-treat
randomized trial

analysis wherein missing value imputation was conducted using the last observation carried forward method for those patients who dropped out of the study. The results of the PPA were the main focus of the study and were reported in detail; the intent-to-treat analyses were reported in detail only if the results differed from the PPA. If interactions were observed, then main effects using a Bonferroni correction were used. If no interaction was observed, then main effects were analyzed. If violations of sphericity were observed, then the Greenhouse-Geisser or Huynh-Feldt corrections were used.

To compare differences between the groups on postoperative thoughts/beliefs, 4 different 2 (group: EG and UCG) × 4 (time: 1 mo, 3 mo, 6 mo, and 1 yr) analysis of variances were conducted, both PPA and intent-to-treat, on the following thoughts/beliefs: glad, feeling prepared, preoperative care went well, do again, and met expectations. Interactions were broken done as previously outlined.

Total medical costs were compared between the groups by using t tests. Nonparametric analyses were used if there were violations of assumptions. All analyses were conducted using SPSS version 20.0 (SPSS, Chicago, IL). The significance threshold was set at α = 0.05. The following were analyzed as candidates to enter the analyses as covariates: age, sex, education, income, and duration of symptoms. None of them met the threshold for inclusion in the analysis as covariates (i.e., correlation coefficients greater than 0.70).

**RESULTS**

Of the 65 patients who underwent LS, 4 patients were lost to follow-up, 3 from the EG and 1 from the UCG (Figure 1). Table 1 provides demographic and baseline data on the 65 patients enrolled in the study. Results are based on data from 61 patients who competed the study (28 in EG and 33 in UCG).

**LBP, Leg Pain, and Function**

There were no significant interactions for NPRS (LBP), NPRS (leg pain), and ODI, $P > 0.167$. None of the main effects for group were significant ($P > 0.075$). All of the main effects for time were significant ($P < 0.002$). In general, most of the improvement (i.e., LBP and leg pain) occurred from the baseline to the 1-month postsurgery ($P < 0.046$) and then seemed to plateau thereafter ($P > 0.503$) (Figures 2–4).

**Postoperative Thoughts/Beliefs**

There were no interactions for the postoperative opinions (“glad underwent surgery,” “fully prepared for surgery,” “preoperative education prepared well,” “would do again,” and “met expectations”), $P > 0.331$. The main effects of time were significant only for “glad had surgery” ($P = 0.005$). There were no differences for the other postoperative opinions over time, $P > 0.072$. The main effect of group was significant for 3 thoughts/beliefs suggesting that the EG had a more favorable postoperative opinion than the UCG: “fully prepared for surgery” and “met expectations”).
surgery” ($P = 0.010$), “preoperative education prepared well” ($P = 0.001$), and “met expectations” ($P = 0.042$) (Figure 5). There were no main effects of group for “glad underwent surgery” ($P = 0.200$) and “would do again” ($P = 0.226$).

Health Care Utilization After LS
Overall costs of medical treatment were lower for the EG (mean = $2678.57$, standard deviation = $3135.30$) than they were for the UCG (mean = $4833.48$, standard deviation = $3256.00$), Mann-Whitney $U = 345.00$, $Z = -2.700$, $P = 0.007$ (Figure 6). Subjects in the UCG used radiographs (47 vs. 17 radiographs, $P = 0.015$) and physical therapy (394 vs. 113 visits, $P < .001$) more than the EG. None of the other subgroup expenses were significantly different, $P > 0.082$.

TABLE 1. Baseline (Preoperative) Characteristics of the Patients ($n = 67$) Enrolled in the Study

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>EG (n = 32)</th>
<th>CG (n = 35)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean) (yr)</td>
<td>49.59</td>
<td>49.65</td>
<td>0.591</td>
</tr>
<tr>
<td>Sex, no. (%)</td>
<td>17 (53)</td>
<td>19 (54)</td>
<td>0.924</td>
</tr>
<tr>
<td>Duration of symptoms (d)</td>
<td>91.41</td>
<td>92.29</td>
<td>0.971</td>
</tr>
<tr>
<td>Low back pain (NPRS 0–10) (mean)</td>
<td>4.57</td>
<td>5.12</td>
<td>0.406</td>
</tr>
<tr>
<td>Leg pain (NPRS 0–10) (mean)</td>
<td>5.25</td>
<td>6.06</td>
<td>0.273</td>
</tr>
<tr>
<td>Pain catastrophization scale (0–52)</td>
<td>24.54</td>
<td>27.24</td>
<td>0.271</td>
</tr>
<tr>
<td>Fear avoidance—Work subscale (0–42)</td>
<td>17.79</td>
<td>17.08</td>
<td>0.568</td>
</tr>
<tr>
<td>Fear avoidance—Physical Activity subscale (0–24)</td>
<td>17.54</td>
<td>17.70</td>
<td>0.826</td>
</tr>
<tr>
<td>Oswestry Disability Index (0–100)</td>
<td>44.21</td>
<td>46.67</td>
<td>0.393</td>
</tr>
</tbody>
</table>

EG indicates experimental group; CG, control group; NPRS, numeric pain rating scale.

Figure 3. Mean NPRS scores for leg pain for the EG ($n = 28$) and control group (UCG) ($n = 33$) presurgery and at each follow-up time interval. There was no significant difference between groups at any time point. EG indicates experimental group; NPRS, numeric pain rating scale; UCG, usual care group.

Figure 4. Mean ODI scores for the EG ($n = 28$) and control group (UCG) ($n = 33$) presurgery and at each follow-up time interval. There was no significant difference between groups at any time point. EG indicates experimental group; UCG, usual care group; ODI, Oswestry Disability Index.
DISCUSSION
The addition of a preoperative pain-specific NE program to usual care did not result in superior outcomes in postoperative low back or leg pain and disability for patients undergoing LS for radiculopathy. Although 1-month postoperative measurements did show a trend favoring the NE, the differences failed to reach statistical significance at any time point. However, despite similar pain and dysfunction for both groups at 12

**Figure 5.** Twelve-month postoperative thoughts/beliefs (outcomes) about LS experience (0 = strongly disagree; 10 = strongly agree). Mean scores compared by t tests. LS indicates lumbar surgery.

**Figure 6.** Comparison of total health care utilization (in US$) between the EG (n = 28) and control group (UCG) (n = 33) at 12 months post-lumbar surgery. Imaging = radiographs, magnetic resonance imaging, computed axial tomography, and myelography; diagnostic tests = blood tests and nerve conduction tests; MD visits = surgeon, family physician, or other physician. UCG indicates usual care group; EG, experimental group.

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months, patients in the NE group viewed their surgical experience more favorably and used fewer medical tests and treatments for their pain and dysfunction, resulting in significant health care savings.

Many patients with lumbar radiculopathy experience persistent postoperative pain and disability, and our results concur with outcomes from similar studies. Research suggests that patients who undergo LS for radiculopathy should expect to continue to experience LBP at an average of 2.5 to 3 of 10 on the NPRS for 6 to 12 months postsurgery. Similarly, patients after LS also report persistent disability. One year after surgery, patients in both arms of this study reported an average ODI score of 24%, indicating moderate disability, which concurs with the 12-month outcomes of the recent FASTER study by McGregor.

We hypothesized that the issues of persistent pain and disability after LS would be ameliorated by the addition of the NE program. In the NE session, patients were informed that persistent pain might be experienced after LS, but it would more likely be due to a hypervigilant nervous system and increased sensitivity, rather than persistent tissue pathology. The NE was limited to a single 30-minute session within a week of scheduled surgery, and it is possible that providing the NE during a longer period of time and reinforcing it during postoperative management may have led to a different result. Reconceptualization of pain is the main focus of NE, and it is possible that the degree of reconceptualization (the degree to which patients viewed their pain in a different light) was not enough to affect primary outcome measures. It may well have been enough to help explain why patients in the NE group saw their surgery as a more positive experience, culminating in a decreased need to seek help, as evidenced by decreased health care utilization.

Our results demonstrated that despite similar pain and disability 1 year after LS, the NE group spent 45% less on medical tests and treatments. This is in contrast to the cost-analysis reported by Morris et al. of their multicenter randomized controlled trial evaluating the outcomes after rehabilitation only, an educational booklet, rehabilitation plus booklet, or usual care only for patients undergoing LS. They found no significant differences in costs or outcomes associated with either intervention. The differences in findings between the 2 studies may be explained by timing and/or content of the education. Morris et al. provided the education as a booklet for patients to read after surgery (with or without rehabilitation), whereas our study provided the education in a 30-minute verbal, one-on-one format prior to the surgery. It is possible that patients in the EG group in our trial thought that they were better prepared before their surgery and, therefore, required less postoperative medical tests and treatment. The content of the education was also quite different between the 2 studies. The booklet used by Morris et al. had a primary focus on anatomy, biomechanics, and pathoanatomy (biomedical model) whereas, the education provided in our trial attempted to de-emphasize these aspects and focus more on pain neurobiology and pain neurophysiology. If patients in the NE group in our trial did indeed view their pain and disability as being less about persistent tissue pathology and more about persistent nerve sensitivity, it may account for the observed decrease in health care utilization after their surgery.

Patients who received NE reported a significantly different view of their surgical experience at 12 months postsurgery. Both groups reported similar LBP, leg pain, and disability at 12 months, yet the NE group viewed their results more positively. NE aims to help patients develop a greater understanding of pain and to shift patients from seeing pain, especially persistent pain, as being correlated to nociception. At 6 months and 12 months, the known healing phases of tissues would suggest that patients would be fully healed from a tissue perspective, yet patients in this trial and several other similar studies still experience LBP and even leg pain. The biomedical (tissue-based) explanation of persistent pain might well foster a belief that “something is still wrong,” whereas the NE approach would explain such pain as a nervous system that has remained sensitive to protect. Pain is therefore normal and expected after surgery, and such a reconceptualization of pain is a cornerstone of NE.

LIMITATIONS
This study contains some limitations. First, the results obtained pertain specifically to decompressive LS for radiculopathy and thus limit extrapolation to other LS interventions. Second, the NE was delivered in a single bolus format and the absence of reinforcement of the pain-specific education may have limited its effects. Future studies should examine a more pragmatic approach to education delivery with a preoperative session followed by several postoperative sessions to review and retain the information. Third, because there are no differences over time for back pain, leg pain, and function, it is possible that this trial may have been underpowered. However, a closer look at the effect sizes between the 2 educational programs for back pain, leg pain, and function suggests that the effect sizes were small and unlikely to be clinically meaningful even if they were significant. Finally, although we did track patients to determine if they received postoperative rehabilitation (physical therapy), this was not controlled.

CONCLUSION
The addition of NE to usual care after LS for lumbar radiculopathy did not result in significant differences in pain and disability, and indeed, some residual pain and disability after surgery is normal and expected. Patients who received NE did report a more favorable view of their surgical experience and also used fewer postoperative health care resources. Educating patients about the normal responses to LS in a neuroscience framework may result in significant behavior changes after surgery, and decrease the ongoing health care utilization of a large percentage of patients with LS.
Key Points

- Preoperative education programs for patients undergoing LS for radiculopathy have not demonstrated any significant effect on postoperative pain and disability.
- Recent literature provides support for education focusing on the neurophysiological processing of pain as a means to help patients reconsensitize their pain, leading to increased function, range of motion, and decreased pain.
- Sixty-seven patients scheduled for surgery for lumbar radiculopathy were randomly assigned to usual preoperative care or a combination of usual care plus 1 session of individualized NE delivered by a physical therapist.
- Baseline measures included ratings of low back and leg pain, ODI, various beliefs and experiences related to surgery, and postoperative utilization of health care.
- At 1-year follow-up, there were no statistical differences between the groups for pain ratings or function; however, patients in the NE group thought that they were better prepared for surgery; their surgery had met their expectations; and used 45% less health care services.

References

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