Surgical Intervention is Associated with Improvement in Health-Related Quality of Life Outcomes in Patients with Symptomatic Sacral Tarlov Cysts: Results from a Prospective Longitudinal Cohort Study

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OBJECTIVE: **The treatment of symptomatic Tarlov cysts remains a controversial topic within neurosurgery. We describe our experience with patients who underwent surgical intervention for sacral Tarlov cysts at a single institution. General and disease-specific outcome measures were used to assess health-related quality of life.**

METHODS: **Patients who underwent surgical treatment for one or more sacral Tarlov cysts between 2018 and 2021 were included. The Tarlov Cyst Quality of Life (TCQoL), a validated disease-specific measure, was the primary outcome of the study. Secondary outcomes included general outcome measures: 36-Item Short Form Survey, the Oswestry Disability Index, and Visual Analog Scale. Patients were followed at 3, 6, and 12 months postoperatively. Repeated measures analyses were used to assess change from preoperative to 12 months postoperative.**

RESULTS: **Data were obtained from 144 patients who underwent surgery for sacral Tarlov cysts, average age 52.3 ± 11.3 years, 90.3% female. Patients reported significant mean improvement on the TCQoL over time (preoperative 3.2 ± 0.1; 3-month postoperative 2.1 ± 0.1; 6-month 1.9 ± 0.1; 12-month 1.9 ± 0.1; $P < 0.001$). Patient age and duration of symptoms were not associated with outcome. A total of 82.3% of patients reported improvement on TCQoL. There was not a significant difference in the proportion of patients reporting improvement on TCQoL by cyst size (small 90.9% vs. large 77.9%; $P = 0.066$).**

CONCLUSIONS: **Our longitudinal series demonstrated patient-reported improvement following surgery for symptomatic sacral Tarlov cysts using a validated disease-specific health-related quality of life scale through 12 months after surgery. Patient age and preoperative duration of symptoms were not correlated with outcome.**

INTRODUCTION

Despite their potential to cause debilitating symptoms, Tarlov cysts have received little attention from the medical community. The topic has been largely ignored in the research literature for decades following Tarlov's landmark paper in 1938,[1] averaging approximately a single publication annually between the years 1950 and 2000. This shifted in the 21st century with dozens of case reports and series with small samples published.[2-6]

Within the last 5 years, meta-analyses have emerged and have reported outcomes such as recurrence and complications.[4-7] Sharma et al. published a meta-analysis of 38 studies comparing surgery (333 patients) versus percutaneous treatment (417 patients) for Tarlov cysts.[8] This team found no significant difference in symptom recurrence rate for patients treated surgically (21%) versus percutaneously (20%). Cyst recurrence was significantly higher in the cohort treated percutaneously (20% vs. 8%); however, several complications were significantly higher in the

Key words
- Health-related quality of life
- Perineural cyst
- Sacral spine
- Short Form-36
- Tarlov cyst
- Tarlov Cyst Quality of Life Outcome Scale

Abbreviations and Acronyms
HRQoL: Health-related quality of life
IRB: Institutional Review Board
MRI: magnetic resonance imaging
ODI: Oswestry Disability Index
SD: Standard deviation
SF-36: Short Form 36
SRM: Standardized Response Mean
TCQoL: Tarlov Cyst Quality of Life
VAS: Visual Analog Scale

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surgery group for cerebrospinal fluid leak (9% vs. 3%) and transient sciatica (17% vs. 8%).

More recently, in a 2024 meta-analysis of surgically treated Tarlov cysts including 16 studies with 283 patients reported "complete or substantial resolution of symptoms" in 81% of patients at 1 year following surgery.[9] This team also sited what they referred to as "mounting evidence support of surgical intervention".[2,7,10-19] Finally, Alberto Paredes Mogica et al. in 2024 conducted a systematic review of 31 papers that included a variety of treatment types such as conservative, percutaneous, surgical, and neuromodulation. Although this team cited failed conservative therapy in 9 of 12 studies, they suggested that conservative therapy, such as physiotherapy and/or medications, should be the initial approach followed by an extensive risk and benefit of subsequent treatments including surgery.[20] This team also noted that the lack of standardization among Tarlov cyst research made it difficult to interpret and noted that only 25.8% of the studies they reviewed used a visual analog scale to document pain.

This lack of standardization across Tarlov studies has made it more difficult for clinicians to understand the efficacy of treatments. Researchers have begun to standardize research and to adopt validated measures that can be used across a variety of demographics and disease states. Health-related quality of life (HRQoL) is a patient reported outcome that encompasses mental, physical, and social aspects of patient well-being and is thought to be of primary importance in guiding therapeutic choices.[21] Health specific HRQoL studies have emerged in many medical specialties over time, including in neurosurgery.[22-26] Recent studies conducted have documented significant improvements in HRQoL for patients surgically treated for Tarlov cysts[4,27,28]; Huang et al. studied 35 patients and found a significant decrease in the percent disability as measured by the Oswestry Disability Index.[27] Others have found significant decreases in patient reports of pain.[4,28] Our work extends beyond initial HRQoL research on Tarlov cysts by evaluating validated measures including a Tarlov disease–specific HRQoL, an instrument whose validation our team described previously.[5] Specifically, our goal was to describe longitudinal change on a variety of validated HRQoL measures preoperatively to 1 year following surgery for a cohort of patients who were treated surgically for sacral Tarlov cysts.

METHODS

Study Population

For more than a decade our neurosurgical practice has specialized in the treatment of spinal meningeal cysts, such as perineal or Tarlov cysts, which occur most commonly in the sacrum. In this study, we present a prospectively collected longitudinal analysis of patients who underwent surgery for symptomatic sacral Tarlov cysts between 2018 and 2021. Consented patients were included in the study if older than 18 years, underwent surgery for 1 or more sacral Tarlov cysts, and did not have prior attempted surgical treatment. Surgical procedures were performed by a single neurosurgeon. Patients resided in 1 of 35 states within the United States or Canada. All patients had failed non-operative management with physical therapy, medications, or both. Prescription drugs included oral pain medications such as narcotics (hydrocodone, oxycodone, and tramadol), neuromodulating medications (gabapentin, duloxetine [Cymbalta], pregabalin [Lyrica]), nonsteroidal anti-inflammatory drugs, and muscle relaxants (methocarbamol, cyclobenzaprine [Flexeril], baclofen, tizanidine). Preoperative injections included lumbar epidural steroid injections, caudal injections, or sacroiliac injections. This study was approved by the North Texas institutional review board.

Diagnosis and Surgical Intervention

Patients were selected based on correlation between sacral radiculopathy symptoms and imaging studies demonstrating sacral nerve root compression by Tarlov cysts in the sacral spinal canal. In cases where the diagnosis was in question, diagnostic nerve root blocks were used to confirm that the Tarlov cysts were the source of the symptoms. A posterior surgical approach was used under general anesthesia. A window was made in the sacral lamina to gain access to the Tarlov cysts in the spinal canal. The spinal fluid from within each of the nerve roots that was a Tarlov cyst was drained, and then, the nerve root was wrapped in the form of a sleeve with a layer of bovine pericardium dural substitute such that the nerve root was more normal in caliber and no longer caused compression of adjacent spinal nerve roots. Care was taken that the dural substitute sleeve did not constrict the nerve root contents. Following Tarlov cyst treatment, the sacral laminar window was covered with a resorbable plate secured with resorbable screws. These procedures were previously published in our own work.[5]

Our protocol is for patients to spend 2 nights in the hospital. On the day following surgery the patients undergo progressive elevation and mobilization for preventative purposes, and removal of the Foley catheter followed by a voiding trial.

Via survey, patients were asked about symptoms, symptom onset, and prior treatments. Outcome data were collected prior to surgery, then at 3, 6, and 12 months following surgery. Patients also underwent follow-up magnetic resonance imaging (MRI) 3 months following surgery.

Health-Related Quality of Life

The Tarlov Cyst Quality of Life Outcome Scale (TCQoL), a disease-specific HRQoL measure, was used as our primary outcome. The TCQoL is a validated, 11-item measure using an 8-point Likert-type scale from (0) never had symptom to (7) extreme symptom (**Figure 1**). A psychometric validation of this scale has been published with good internal consistency of 0.82.[5]

The TCQoL is the sole Tarlov disease–specific health-related quality of life psychometrically validated measure that our team is aware of. This measure was published by our team and is relatively unknown among the neurosurgical community, thus, we felt it was important to include other commonly used and validated general HRQoL scales. We consider these HRQoL measures to be our secondary outcomes and measure general aspects of health. These secondary outcome measures included: a visual analog scale (VAS) as a measurement for pain, the Short Form-36 (SF-36), and the Oswestry Disability Index (ODI). Patients' reports of leg pain at rest and activity were measured using an 11-point VAS scale, with 0 indicating no pain and 10 reflecting extreme pain. Patient physical and mental health were assessed using the 8

	Never experienced symptom	No Current Symptoms	Mild Symptoms	Mild to Moderate Symptoms	Moderate Symptoms	Moderate to Severe Symptoms	Severe Symtoms	Extremely Severe Symptoms
Sacral (tail bone) pain	○	○	○	○	○	○	○	○
Perineal pain (private parts)	○	○	○	○	○	○	○	○
Perineal numbness (private parts)	○	○	○	○	○	○	○	○
Discomfort while sitting	○	○	○	○	○	○	○	○
Lower extremity pain	○	○	○	○	○	○	○	○
Lower extremity weakness	○	○	○	○	○	○	○	○
Lower extremity numbness	○	○	○	○	○	○	○	○
Bladder function	○	○	○	○	○	○	○	○
Bowel function	○	○	○	○	○	○	○	○
Dyspareunia (painful intercourse)	○	○	○	○	○	○	○	○
Persistent genital arousal disorder	○	○	○	○	○	○	○	○

Figure 1. Tarlov Cyst Quality of Life outcome scale.

subscales from the 36-item SF-36 health survey. These 8 scales were physical functioning, physical role limitations, emotional role limitations, energy/vitality, emotional wellbeing, social functioning, bodily pain, and general health. Patient disability was obtained from the ODI and reported in percentage.

Higher scores reflected better health for the SF-36 domains and lower scores reflected better health for the ODI, VAS, and TCQoL scales. Patient-reported outcomes were collected preoperatively and postoperatively by mail or telephone.

Change from preoperative to any postoperative time point was compared to established minimal clinically important difference thresholds. The minimal clinically important difference (MCID) of the disease-specific TCQoL has been reported in its psychometric validation paper as 0.78.[5] MCIDs used for the general HRQoL measures were determined using surgery cohorts. An ODI score of 12.8 was determined in a cohort of surgical spine patients by Copay and colleagues in 2008[29] and recently used by Singh and colleagues in 2023.[30] The VAS MCID of 5.0 was adopted by Parker and colleagues[31] using a sample of patients who underwent lumbar spine surgery and has also been more recently used.[32] We were unable to find published MCIDs that were neurosurgery-related for each of the separate SF-36 subdomains. Thus, we adopted MCIDs from an orthopedic study conducted by Clement and colleagues in 2022.[33] MCIDs were as follows: physical function 3.9, physical limitations 4.0, bodily pain 6.4, general health 5.3, vitality 2.9, social functioning 7.3, emotional limitations 1.7, and mental health 4.4.

Statistical Analysis

Patient demographics and clinical and survey data are reported as mean (SD) for continuous variables and frequencies with percentages for discrete variables. Normality for continuous variables was evaluated by examining histograms and skewness and kurtosis statistics. Due to non-normality, the natural log of symptom duration was used for analyses. Pearson correlations were used to compare change scores with patient age and cyst size. Change scores for each outcome were computed by subtracting year 1 subscale scores from preoperative scores. Based on clinical standards, sacral cyst diameter of 1.5 cm or greater were considered large cysts and <1.5 cm as small cysts.[20,34] We assessed significant trends in HRQoL measures from preoperative to 12 months postoperative using repeated-measures general linear models with cyst size as a covariate. Model-estimated marginal means with standard errors are reported from these adjusted models. Partial eta-squared statistics were reported as measures of effect size. A related-samples Wilcoxon rank test was used to assess for changes in maximum tolerable sit time at each time point. Paired samples t tests were used to assess for change in the number of times a patient reported taking narcotics in a typical day. This test included only patients who reported using narcotics preoperatively for pain control. P values were considered statistically significant at a threshold of 0.05. All statistical analyses were performed using SPSS software version 27 (IBM Corp; Armonk, NY).

RESULTS

Cohort and Patient Characteristics

A total of 209 patients underwent surgical treatment for 1 or more Tarlov cysts between 2018 and 2021 and agreed to participate in the study. Exclusions were location not sacral (n = 3), prior surgery for Tarlov cyst (n = 5), and missing baseline survey data (n = 10) or 1-year survey data (n = 47), leaving a cohort of 144. A patient flow diagram is shown in Figure 2. All 144 patients were eligible for 12-month follow-up. The mean age at surgery was 52.3 ± 11.3 years (range age, 19–76 years; Table 1). Preoperative treatments included physical therapy (89.6%), injections (48.6%), diagnostic nerve root blocks (18.1%), and oral medications (94.4%). Additionally, a more than one-third (36.2%) of our female patients underwent a hysterectomy prior to establishing with our clinic. In our sample, 130 (90.3%) patients were female. There was not a significant difference between male versus female patient s in age at surgery (51.8 ± 17.4 years vs. 52.4 ± 10.6 years, P = 0.859), number of cysts (3.8 ± 1.7 vs. 4.4 ± 2.1, P = 0.400), or preoperative cyst size in centimeters (2.2 ± 0.6 vs. 1.9 ± 0.9, P = 0.313).

The majority of patients were treated for multiple cysts (91.7%). The most frequent nerve roots treated were S3 (96.5%) followed by S2 (71.5%) and S4 (54.9%). S5 was the least frequent (2.8%). Five (3.5%) patients had 1 or more L5 nerve root Tarlov cysts in addition to sacral cysts (Table 1). Patients were hospitalized for an average of 2.1 ± 0.3 days. One patient required hospital readmission. This patient had an extended initial hospitalization of 4 days, was discharged to a rehabilitation facility and then readmitted for pain and vertigo. Two patients presented to the

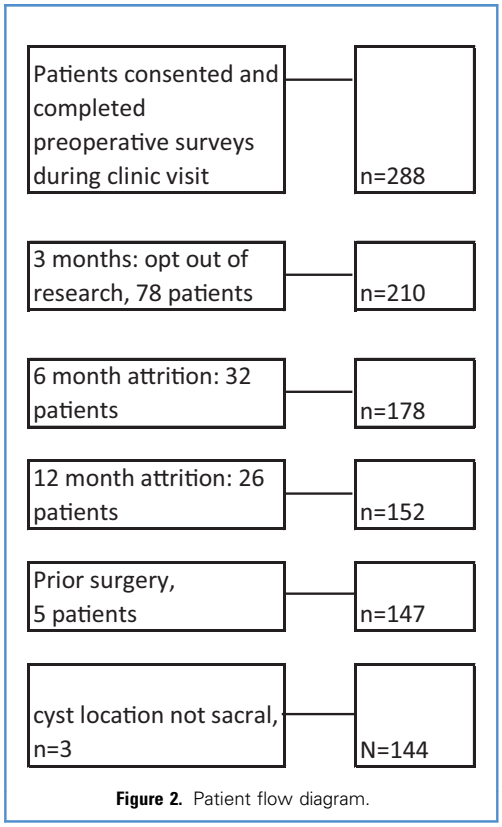

Figure 2. Patient flow diagram.

emergency department within 30 days following surgery for nausea and vertigo (1 patient) and a surgical site infection but not readmitted. (1 patient). There were no instances of spinal fluid leakage identified. There was no recurrent or residual treated Tarlov cyst found on 3-month MRI. Patient physical and mental health comorbidities are shown in Table 2. The most common physical comorbidities were migraines (20.1%) followed by hypertension (18.8%) and irritable bowel syndrome (11.1%). The most common mental health comorbidities were depression (n = 32, 22.2%) and anxiety (n = 31, 21.5%). Of note, 20 patients were diagnosed with both depression and anxiety. Forty-three of 144 (30.0%) patients in our study had a minimum of 1 mental health comorbidity.

Disease-specific HRQoL. Each of the 11 items averaged to create the TCQoL are listed in Table 3 with the mean at each time point. This table is shown for descriptive purposes. The most severe symptom both preoperatively and 12 months postoperative was discomfort while sitting (5.6 ± 1.7 and 3.4 ± 2.0).

Patient Age and HRQoL. No significant correlations emerged between patient age and TCQoL, VAS pain scales, the ODI, or SF-36 scales preoperatively ($P > 0.05$ for all correlations). There were also no significant correlations between the change in each measure with age ($P > 0.05$ for all correlations). Patient age and cyst size in diameter were not significantly correlated $r(144) = 0.032$, $P = 0.706$.

Table 1. Patient Demographics

	Values (N = 144)
Age at surgery (years)	52.3 ± 11.3
Sex, female	130 (90.3%)
Preoperative treatments	
Physical therapy	129 (89.6%)
Injections	70 (48.6%)
Diagnostic nerve root block	26 (18.1%)
Hysterectomy (n = 130)	47 (36.2%)
Oral pain medications, any	136 (94.4%)
Oral pain medications, narcotics	59 (41.0%)
Number of cysts	
1	12 (8.3%)
2	24 (16.7%)
3	20 (13.9%)
4	24 (16.7%)
5	16 (11.1%)
6	24 (16.7%)
7	13 (9.0%)
8	10 (6.9%)
9	1 (0.7%)
Cyst Size, cm	1.8 (1.3–2.4)
Cyst size ≥2.4 cm	37 (25.7%)
Cyst size ≥1.5 cm	94 (66.2%)
Single vs. multiple cysts	
Single cyst	12 (8.3%)
Multiple cysts	132 (91.7%)
Tarlov cyst nerve root	
Lumbar 5	5 (3.5%)
Sacral 1	57 (39.6%)
Sacral 2	103 (71.5%)
Sacral 3	139 (96.5%)
Sacral 4	79 (54.9%)
Sacral 5	4 (2.8%)

Values are presented as count (%), mean ± SD, or median (25th–75th p.rcentile).

Preoperative Cyst Size and Outcome. The average size of the largest treated cyst in each patient was 1.8 cm (range, 1.3–2.4 cm). The majority of patients were considered to have large cysts on a 1.5-cm threshold (n = 96, 66.7%). The association between cyst size and patient improvement for the 12 outcome scales are shown in Table 4. The percentages in Table 4 reflect the percentage of patients who reported improvement from their preoperative report to their 12-month postoperative report. This table does not address the extent of improvement. When cysts of all sizes

Table 2. Patient Comorbidities

	Count	Percent
Physical health		
Migraines	29	20.1%
Hypertension	27	18.8%
Irritable bowel syndrome	16	11.1%
Fibromyalgia	9	6.3%
Arthritis	8	5.6%
Atrial fibrillation	5	3.5%
Obesity	5	3.5%
Osteoporosis	5	3.5%
Hyperlipidemia	5	3.5%
Insomnia	5	3.5%
Osteoarthritis	5	3.5%
Hypothyroidism	4	2.8%
Peripheral neuropathy	4	2.8%
Ehlers-Danios syndrome	4	2.8%
Multiple sclerosis	3	2.1%
Postural orthostatic tachycardia syndrome	3	2.1%
Deep vein thrombosis	3	2.1%
Lyme disease	2	1.4%
Trigeminal neuralgia	2	1.4%
Lupus	2	1.4%
Rheumatoid arthritis	2	1.4%
Asthma	2	1.4%
Chronic obstructive pulmonary disease	1	0.7%
Smoking	1	0.7%
Diabetes mellitus	1	0.7%
Mitral valve prolapse	1	0.7%
Anemia	1	0.7%
Hyperthyroidism	1	0.7%
Sleep apnea	1	0.7%
Hepatitis C	1	0.7%
Mast cell activation syndrome	1	0.7%
Benign prostatic hyperplasia	1	0.7%
Hashimoto's	1	0.7%
Mental health		
Depression	32	22.2%
Anxiety	31	21.5%
Bipolar	4	2.8%
Post-traumatic stress disorder	1	0.7%

were considered, improvement ranged from 60% of patients for VAS pain at rest to 91.0% for the SF-36 physical limitations subscale. Patients with large cysts were significantly less likely to report improvement in 6 of the 12 domains (ODI, bodily pain, social functioning, mental health, vitality, and physical functioning). Significant improvement would be considered at the trend level ($P > 0.05$ and $P < 0.10$) for another 3 domains, TCQoL general health, and emotional limitations.

Health-Related Quality of Life Characteristics. A repeated measures model was used to evaluate change in each HRQoL over time. Means with standard errors and 95% confidence intervals are shown for all models in Table 5 and are reviewed below. Mean scores address the average change for our cohort and do not refer to the number of patients who improved.

Visual Analog Scale

A linear main effect for pain emerged such that patients self-reported pain decreased for both pain at rest ($P < 0.001$) and pain during activity ($P < 0.001$) from preoperation to post-operation (Table 5; Figure 3A). In both models, post-hoc tests demonstrated significant decreases from preoperation to 3 months, 6 months, and 1 year postoperation (pain at rest $P < 0.001$; pain during activity $P < 0.001$), however, nonsignificant changes between the 3, 6, and 12 months postoperation ($P = 1.000$ for all comparisons).

The number of patients reporting medicating with narcotic prescriptions decreased from 49.3% ($n = 71$) at preoperative to 35.4% ($n = 51$) at 1-year follow-up ($P< 0.001$). Additionally, the number of times patients reported taking a narcotic in a typical day decreased from 3.1 ± 1.7 to 2.2 ± 2.7, $P = 0.026$.

Tarlov Cyst Quality of Life

Similar to the VAS scales, a main effect emerged for the TCQoL such that patients reported improvement over time ($P < 0.001$), however in quadratic fashion (Table 5; Figure 3A). Post-hoc comparisons revealed improvement with significant comparisons preoperatively to 3 months ($P < 0.001$), 6 months ($P < 0.001$), and 12 months ($P< 0.001$) postoperatively, but not between post-operative time points ($P > 0.05$ for all comparisons).

Oswestry Disability Index

ODI scores, reflecting average percent disability, decreased with a significant main effect ($P < 0.001$) and with post-hoc tests suggesting statistically significant differences from preoperation to 3, 6, and 12 months postoperation ($P < 0.001$ for all comparisons). ODI scores continued to decrease from 3 months to 6 months postoperation ($P = 0.005$) and from 3 months to 12 months ($P < 0.001$), but not from 3 to 6 months postoperation ($P = 0.215$) (Table 5; Figure 3B), again reflecting a quadratic association. Based on ODI interpretation, on average, preoperative patients reported severe disability (41%–60%) and improved to moderate disability at all postoperative time points (21%–40%).

Table 3. The Tarlov Cyst Quality of Life Item Scores

Item	Preoperative	3 Months Postoperative	6 Months Postoperative	12 Months Postoperative
Sacral (tail bone) pain	4.9 ± 1.8	3.3 ± 1.9	3.2 ± 1.9	2.9 ± 2.0
Perineal pain (private parts)	2.9 ± 2.3	1.9 ± 2.1	1.5 ± 1.9	1.5 ± 1.9
Perineal numbness (private parts)	2.1 ± 2.1	1.6 ± 1.9	1.5 ± 1.8	1.2 ± 1.7
Lower extremity pain	4.2 ± 2.2	3.0 ± 2.0	2.6 ± 2.0	3.0 ± 2.0
Lower extremity weakness	3.1 ± 2.3	2.2 ± 2.0	1.9 ± 1.9	2.1 ± 2.1
Lower extremity numbness	3.1 ± 2.1	1.7 ± 1.8	1.7 ± 1.8	1.8 ± 2.0
Bladder function	2.8 ± 2.2	1.5 ± 1.7	1.6 ± 1.8	1.6 ± 1.8
Bowel function	3.0 ± 2.2	2.1 ± 2.0	1.9 ± 2.1	1.6 ± 2.0
Dyspareunia (painful intercourse)	2.5 ± 2.5	1.5 ± 2.3	1.3 ± 2.0	1.2 ± 2.0
Discomfort while sitting	5.6 ± 1.7	4.0 ± 1.7	3.5 ± 2.0	3.4 ± 2.0
Persistent genital arousal disorder	0.9 ± 1.9	0.7 ± 1.7	0.6 ± 1.6	0.6 ± 1.4

Values are presented as mean ± SD.

Short Form-36

We observed a statistically significant improvement in 6 of the 8 SF-36 domains (Table 4). There was not a significant change in the general health ($P = 0.115$) or the mental health ($P = 0.078$) domains over time. All remaining models were significant at $P < 0.001$, with linear effects demonstrated for physical functioning, physical limitations, and vitality and quadratic effects for bodily pain, social functioning, and emotional limitations.

Model Effect Size

Large effect sizes as evidenced by eta-square >0.14 were noted for the ODI, physical functioning, and social functioning models (Table 5). VAS at rest and activity, TCQoL, physical limitations, vitality, and bodily pain models demonstrated eta-squared values between 0.06 and 0.14 and were considered moderate. Eta-squared values of less than 0.06 for emotional limitations, mental health, and general health suggested a small effect size for these models.

Minimal Clinically Important Difference

Mean change from preoperative to any postoperative time point shown in Table 5 can be compared to the MCID thresholds to determine if our study met the MCID on each outcome. For our primary outcome, TCQoL, we have exceeded 0.78 change from preoperative to all postoperative time points, indicating the MCID

Table 4. Patient-Reported Improvement at 1 Year for Study Outcomes by Cyst Size

	Percent Improve	Percent Improve-Small Cyst (n = 48, 33.3%)	Percent Improve-Large Cyst (n = 96, 66.7%)	*P* Value
Primary outcome				
Tarlov Cyst Quality of Life	107 (82.3%)	40 (90.9%)	67 (77.9%)	0.066
Secondary outcomes				
Oswestry Disability Index	113 (81.9%)	43 (91.5%)	70 (76.9%)	0.035
VAS Pain at rest	84 (60.0%)	28 (58.3%)	56 (60.9%)	0.771
VAS Pain at activity	90 (64.7%)	30 (62.5%)	60 (65.9%)	0.687
SF-36 General health	91 (63.2%)	35 (72.9%)	56 (58.3%)	0.087
SF-36 Bodily pain	114 (82.0%)	45 (93.8%)	69 (75.8%)	0.009
SF-36 Social functioning	122 (84.7%)	45 (93.8%)	77 (80.2%)	0.033
SF-36 Mental health	97 (67.4%)	39 (81.3%)	58 (60.4%)	0.012
SF-36 Vitality	111 (77.1%)	44 (91.7%)	67 (69.8%)	0.003
SF-36 Emotional limitations	120 (87.0%)	45 (93.8%)	75 (83.3%)	0.084
SF-36 Physical limitations	131 (91.0%)	45 (93.8%)	86 (89.6%)	0.411
SF-36 Physical functioning	118 (82.5%)	44 (91.7%)	74 (77.9%)	0.041

Table 5. Summary of Patient-Reported Health-Related Quality of Life Outcomes Over Time

Tarlov Cyst Quality of Life, Oswestry Disability Index, and Visual Analog Scale Scores

	Tarlov Quality of Life Mean ± SE (95% CI)	VAS Pain at Rest Mean ± SE (95% CI)	VAS Pain at Activity Mean ± SE (95% CI)	Oswestry Disability Index Mean ± SE (95% CI)
Preoperative	3.2 ± 0.1 (2.9–3.5)	4.3 ± 0.3 (3.8–4.9)	5.7 ± 0.3 (5.0–6.4)	45.6 ± 1.6 (42.3–48.8)
3-months postop	2.1 ± 0.1 (1.9–2.4)	2.7 ± 0.3 (2.2–3.2)	3.6 ± 0.3 (3.1–4.2)	35.5 ± 1.7 (32.0–39.0)
6-months postop	1.9 ± 0.1 (1.7–2.2)	2.4 ± 0.2 (1.9–2.8)	3.4 ± 0.3 (2.8–3.9)	31.7 ± 1.8 (28.1–35.4)
1-year postop	1.9 ± 0.1 (1.7–2.2)	2.5 ± 0.3 (2.0–3.1)	3.3 ± 0.3 (2.8–3.9)	29.4 ± 1.9 (25.7–33.2)
P-value	<0.001	<0.001	<0.001	<0.001
eta-squared	0.116	0.070	0.068	0.202
highest order	quadratic	linear	linear	quadratic

SF-36 Physical Health Subscales

	Physical Functioning Mean ± SE (95% CI)	Physical Limitations Mean ± SE (95% CI)	Bodily Pain Mean ± SE (95% CI)	General Health Mean ± SE (95% CI)
Preoperative	35.5 ± 2.6 (30.4–40.7)	14.8 ± 2.8 (9.3–20.4)	28.1 ± 2.1 (23.9–32.3)	59.2 ± 2.1 (55.1–63.3)
3-months postop	48.6 ± 2.5 (43.6–53.6)	23.9 ± 3.5 (17.0–30.8)	44.4 ± 2.4 (39.7–49.1)	61.6 ± 2.1 (57.4–65.8)
6-months postop	56.9 ± 2.7 (51.6–62.3)	32.0 ± 4.0 (24.2–39.9)	49.0 ± 2.5 (44.0–53.9)	63.6 ± 2.8 (58.1–69.3)
1-year postop	61.8 ± 2.7 (56.5–67.1)	41.1 ± 4.1 (33.0–49.3)	51.4 ± 2.5 (46.3–56.4)	61.6 ± 2.3 (57.0–66.2)
P-value	<0.001	<0.001	<0.001	0.115
eta-squared	0.177	0.101	0.130	0.019
Highest order	linear	linear	quadratic	–

SF-36 Mental Health Subscales

	Vitality Mean ± SE (95% CI)	Social Functioning Mean ± SE (95% CI)	Emotional Limitations Mean ± SE (95% CI)	Mental Health Mean ± SE (95% CI)
Preoperative	34.7 ± 2.2 (30.2–39.0)	37.5 ± 2.7 (32.2–42.9)	47.2 ± 4.4 (38.5–55.8)	62.7 ± 2.0 (58.7–66.7)
3-months postop	43.7 ± 2.3 (39.1–48.4)	52.6 ± 3.0 (46.5–58.6)	67.6 ± 4.1 (59.5–75.7)	70.7 ± 1.9 (66.9–74.5)
6-months postop	47.1 ± 2.1 (42.9–51.4)	60.7 ± 3.0 (54.7–66.6)	70.1 ± 3.9 (62.3–77.9)	73.8 ± 1.9 (69.9–77.6)
1-year postop	48.0 ± 2.3 (43.3–52.6)	64.5 ± 3.0 (58.6–70.4)	70.8 ± 4.0 (62.8–78.7)	72.4 ± 2.0 (68.3–76.4)
P-value	<0.001	<0.001	<0.001	0.078
eta-squared	0.119	0.182	0.053	0.022
Highest order	linear	quadratic	quadratic	–

has been achieved. For the SF-36, mean change from preoperative to 3-month postoperative surpassed the MCID thresholds for all subscales with exception of general health. Furthermore, the threshold was maintained through the 1-year postoperative time point. The VAS pain at rest and activity both failed to meet the MCID of 5.

Maximum Tolerable Sitting Time

Inability to tolerate sitting due to sacral pain is a symptom our patients frequently describe. Patients were asked to report the maximum amount of time they could remain seated by selecting 1 of 5 provided times in minutes: ≤5, 15, 30, 45, ≥60 (Table 6). The maximum sitting tolerance reported by patients increased significantly over time ($P < 0.001$) with median sit times of 15 (range, 5–30) minutes preoperatively, 30 (range, 15–45) minutes at 3 months postoperatively, and 45 (range, 30–60+) minutes at 6 and 12 months postoperatively. Notably, preoperatively, 32% of patients reported tolerating sitting for less than 5 minutes. This percentage decreased to 11% at 3

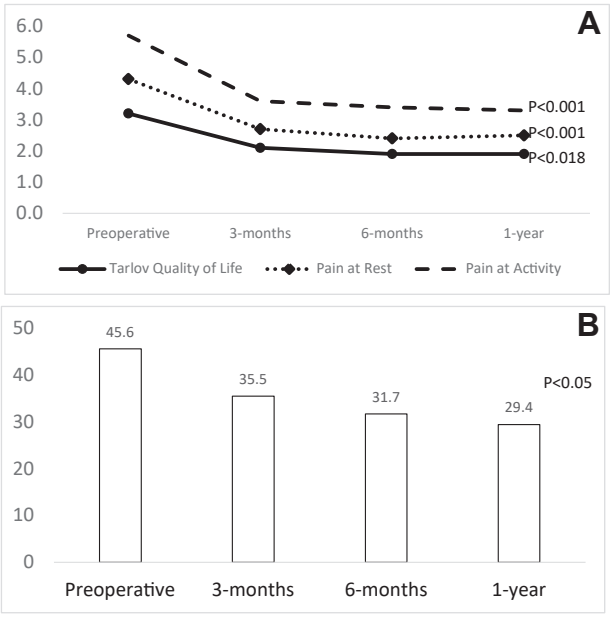

Figure 3. (**A**) Tarlov Cyst Quality of Life and visual analog scale at rest and activity. (**B**) Oswestry Disability Index scores.

months, 10% at 6 months postoperatively, and 8% at 12 months postoperatively.

Preoperative Symptom Duration

Median preoperative patient symptom duration for our cohort was 36.7 (range, 16.7–83.4) months. Symptom duration was not correlated with patient age, $r(144) = 0.026$, $P = 0.761$, or preoperative cyst size, $r(144) = 0.131$, $P = 0.117$. There was not a statistically significant difference in symptom duration based on sex, female 35.1 (15.6–79.1) months versus male 59.6 (31.7–119.9) months; $P = 0.089$. Symptom duration was negatively associated with patient reports of general health prior to surgery, $r(144) = -0.183$, $P = 0.028$, but not the remaining 7 SF-36 subscales, the ODI, TCQoL, or VAS. Symptom duration was not significantly correlated with preoperative to 1-year postoperative change on any scale ($P > 0.05$ for all correlations).

DISCUSSION

Research evaluating patients with Tarlov cysts has shifted from case series and very small sample sizes to larger studies using validated measures. This report detailing our experience with 144 patients surgically treated for symptomatic sacral Tarlov cysts and 12 months of postoperative follow-up data using validated patient reported outcomes is among the most robust reports in the medical literature. We prospectively analyzed our cohort in terms of patient characteristics, number of cysts, cyst size, symptom duration, and patient-reported outcomes measures. Our work extends beyond the current HRQoL literature on Tarlov cysts by using the most widely used HRQoL measures including the SF-36, the ODI, a VAS measure, and adding disease-specific measures (the TCQoL) as well as a measure of tolerable sitting time in a United States–based study.

Research on Tarlov cysts is working to establish an agreed upon improvement rate for both conservative and surgical treatment. Improvement varies widely based on the measure reported. For example, in our study, improvement reported using our secondary measures ranged from 60% on VAS pain at rest to 91% for the SF-36 physical limitations subscale. Rates of ODI improvement in 2 other published studies were 85%[4] and 94%.[27]

We believe our study to substantially add to the HRQoL literature in patients with Tarlov cysts by reporting long-term follow-up on the SF-36, the disease-specific measures of the TCQoL, and maximum tolerable sitting time in addition to the ODI and a VAS scale that have both been recently reported.[4,27] In our study, patients reported significant improvement in 6 of the 8 subscales of the SF-36, with exceptions of general and mental health. This lack of association for general health was especially interesting to our team as it has been our contention that general and mental health scales may not be sensitive enough to clinical change for these patients. For this reason, our team authored and validated the TCQoL scale that is composed of Tarlov cyst disease–specific symptoms and plan to use this scale in clinic and future research.[5] Inability to sit due to sacral pain is a major life-limiting symptom described by our patients. The maximum amount of time a person can sit comfortably has emerged in our clinic as an important metric in the study of patients with sacral Tarlov cysts. Some patients have reported feeling as though they are "sitting on a rock," which decreases quality of life and reduces the capacity to perform activities of daily living. From the preoperative assessment to the 12-month follow-up mark, the

Table 6. Summary of Patient-reported Tolerable Sitting Time

	Preoperative	3 Months Postoperative	6 Months Postoperative	12 Months Postoperative
≤5 minutes	46 (32.3%)	13 (10.6%)	11 (9.5%)	11 (7.7%)
15 minutes	39 (27.3%)	27 (22.0%)	17 (14.7%)	19 (13.3%)
30 minutes	31 (21.7%)	30 (24.4%)	26 (22.4%)	30 (21.0%)
45 minutes	12 (8.4%)	23 (18.7%)	20 (17.2%)	27 (18.9%)
≥60 minutes	15 (10.5%)	30 (24.4%)	42 (36.2%)	56 (39.2%)
Median time	15 minutes	30 minutes	45 minutes	45 minutes
25th - 75th percentile	5–30 min	15–45 min	30–60 min	30–60 min

proportion of patients who reported only being able to sit for less than 5 minutes was cut from 32% to 7%, and the median tolerable sitting time tripled from 15 minutes to 45 minutes.

More than 2 decades ago Voyadzis and colleagues reported that patients with cysts smaller than 1.5 cm were not likely to benefit from surgery.[34] In this study, patients with small cysts were significantly more likely to improve compared with patients with large cysts on 6 of the 12 outcome measures. For our primary outcome of the TCQoL, there was no difference in improvement for patients with large versus small cysts (90.9% vs. 77.9% improvement). However, the *P*-value for this comparison was $P = 0.066$, and considered a trend-level finding by some researchers. It is our contention that the association of cyst size and patient outcome is worth exploring in the future. The threshold of 1.5 cm as a differentiator between small and large cysts for sacral Tarlov cysts may need to be explored.

The Tarlov cyst literature has yet to publish extensive research on patient comorbidities. In our study, 30% of patients, who are majority female, reported at least 1 mental health comorbidity, just slightly higher than the national average of women with mental health disorders (27.2%).[35] The most common physical comorbidity in our cohort was migraines, which is similar to the prevalence in the United States for women (20% vs. 21%). Further research is needed to examine risk factors (or side effects) of Tarlov cysts as other comorbidities in our sample are substantially lower than national averages such as asthma (1.4% in our sample vs. 9.9% nationally in women).[36]

Study Limitations

Our study was subject to several limitations. First, the study is based largely on patient reports despite the use of standard statistically validated outcome instruments. Second, detailed insight of specific symptom development and treatments prior to surgery would add value to this work. Our team continues to collect data using a modified survey that will allow for a more robust data set. We expect our future work to reflect considerable methodologic improvements. Finally, the goal of this study was to evaluate change in HRQoL following surgery. Little is reported about patient response to conservative treatment. In our study all patients failed conservative treatment, however future work should address patient response to conservative treatment in a detailed manner.

CONCLUSIONS

This report describes our prospective cohort of patients surgically treated for symptomatic Tarlov cysts and, to our knowledge, is the sole large-scale report of health-related quality of life patient outcomes after surgical intervention for this indication that includes both general and disease-specific outcomes. The demographics of patients in this study are generally consistent with those of other published studies, and our results suggest that surgical treatment of symptomatic Tarlov cysts leads to significant improvements in pain, maximum tolerated sitting time, and all SF-36 subscale domains with exception of general and mental health. Larger cyst size was associated with decreased improvement, implying that earlier diagnosis and treatment are preferable. Age and duration of symptoms were not associated with outcome. The next step in researching these cysts may be to develop a standard treatment protocol which will spur additional studies with larger samples, consistent methodologies, and the continued use of validated scales.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Frank Feigenbaum: Writing — review & editing, Writing — original draft, Methodology, Conceptualization. **Susan E. Parks:** Writing — review & editing, Supervision, Data curation, Conceptualization. **Madelene P. Martin:** Writing — review & editing, Data curation. **Tanishu D. Ross:** Writing — review & editing, Data curation. **Kristina M. Kupanoff:** Writing — review & editing, Writing — original draft, Formal analysis.

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