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Clinical Study

Quality-of-life and postoperative satisfaction following pseudoarthrectomy in patients with Bertolotti syndrome

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Abstract

BACKGROUND CONTEXT: Bertolotti syndrome is a clinical diagnosis given to patients with back pain arising from a lumbosacral transitional vertebra (LSTV). A particular class of LSTV involves a pseudoarticulation between the fifth lumbar transverse process and the sacral ala, and surgical resection of the pseudoarticulation may be offered to patients failing conservative management. Bertolotti syndrome is still not well understood, particularly regarding how patients respond to surgical resection of the LSTV pseudoarticulation.

PURPOSE: To examine change in quality-of-life (QOL) and patient satisfaction following surgical resection of the LSTV pseudoarticulation in patients with Bertolotti syndrome.

DESIGN: Ambidirectional observational cohort study of patients seen at a single institution's tertiary spine center over a 10-year period.

PATIENT SAMPLE: Cohort consisted of 31 patients with Bertolotti Syndrome who underwent surgical resection of the pseudoarticulation.

OUTCOME MEASURES: Preoperative and postoperative Patient-Reported Outcomes Measurement Information System Global Health (PROMIS-GH) Mental and Physical Health T-scores, and a single-item postoperative satisfaction questionnaire.

METHODS: Patients were identified through diagnostic and procedural codes. Immediate preoperative PROMIS-GH scores available in the chart were gathered retrospectively, and postoperative PROMIS-GH and satisfaction scores were gathered prospectively through a mail-in survey.

RESULTS: Mean (SD) improvement of PROMIS-GH Physical Health T-score was 8.7 (10.5) ($p<.001$). Mean (SD) improvement of PROMIS-GH Mental Health T-scores was 5.9 (9.2) ($p=.001$). When stratifying PROMIS-GH T-scores by response to the patient satisfaction survey, there were significant group differences in mean change for Physical Health T-scores ($p<.001$), and Mental Health T-score ($p=.009$). Patients who stated, "The treatment met my expectations" had much greater mean improvement in the PROMIS-GH T-scores.

FDA device/drug status: Not applicable

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CONCLUSIONS: Patients undergoing a pseudoarticulation resection procedure may experience a significant improvement in quality-of-life as measured by PROMIS-GH Mental and Physical Health.

Keywords: Bertolotti syndrome; Lumbosacral transitional vertebra; Low back pain; Pseudoarticulation

Introduction

Bertolotti Syndrome is a clinical diagnosis given to patients who suffer from low back pain (LBP) due to the presence of a lumbosacral transitional vertebra (LSTV). LSTVs have a wide range of reported prevalence in the literature, from 4%−35% of the general population with an average prevalence of 12% depending on the study [1−5]. LSTVs consist of an enlarged fifth lumbar (L5) transverse process (TP) that may come in contact with or fuse to the sacrum and ilium. This phenomenon can occur unilaterally or bilaterally and has been classified into types I − IV [2]. Among LSTV classes, type II is of particular importance. Type II is described as a unilateral (IIa) or bilateral (IIb) "pseudoarticulation" between the L5 TP and the sacral ala, consisting of a semi-mobile cartilaginous joint [6] Fig. 1. is an illustration showing a posterior skeletal view of a Left type IIa LSTV in which the aberrant anatomy is highlighted. Type II LSTVs more likely to cause pain than any other type of LSTV, and because of the pseudoarticulation, they allow for unique treatment options not available to other types [7].

While the relationship between LSTVs and back pain is not yet well understood, the literature suggests that Bertolotti Syndrome is multifaceted. In the case of a type II LSTV, low back pain may be primarily mechanical due to degenerative changes occurring at the pseudoarticulation, resembling osteoarthritis histologically [6,8]. Transitional vertebrae have also been shown to alter adjacent segment biomechanics which can explain the increased prevalence of degenerative disease in levels adjacent to the LSTV, further complicating the clinical picture of Bertolotti Syndrome [3,6,9−12].

Treatment of patients with type II Bertolotti Syndrome is unique to other LSTVs as it can be directed at the pseudoarticulation specifically. Patients initially undergo conservative management with physical therapy and medication. With failure of conservative measures, patients may be offered intervention in the form of steroid injections or radiofrequency ablation at the pseudoarticulation with the

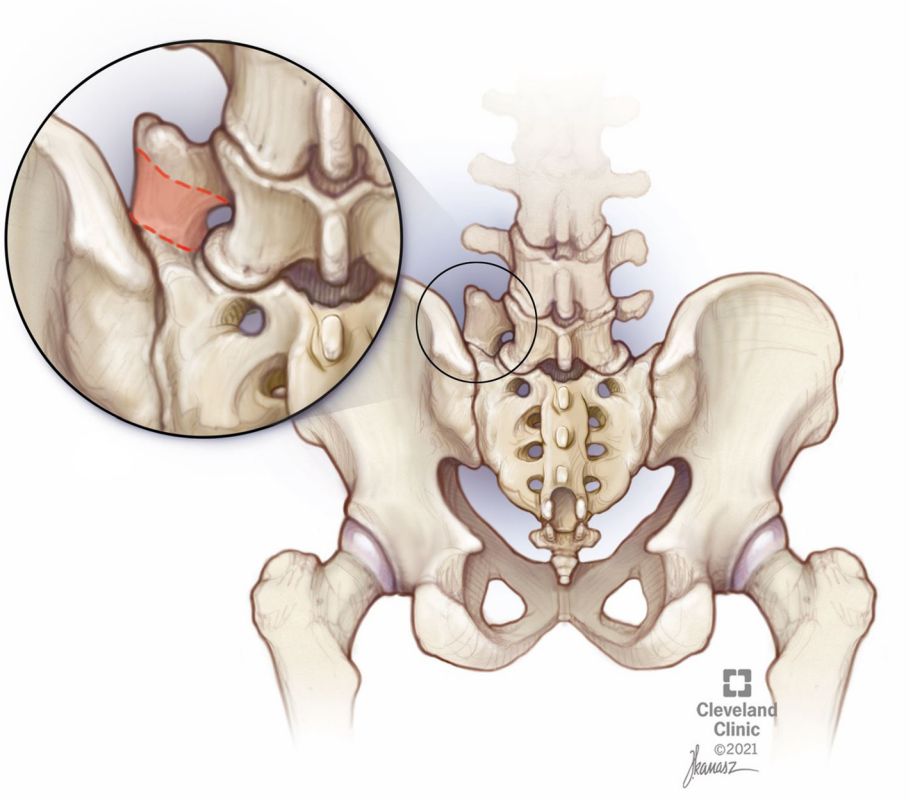

Fig. 1. Illustration of a posterior skeletal view of the spine and pelvis showing a Left type IIa LSTV with the aberrant portion of the L5 transverse process (TP) highlighted (red) (Color version of the figure is available online.).

goal of providing both pain relief, and diagnostic utility [13–15]. Patients who experience significant (albeit temporary) relief from an injection may be offered surgery in the form of pseudoarticulation resection (pseudoarthrectomy). It's important to note that some patients have reported significant long-term relief from injections alone, and therefore would not be considered surgical candidates; at this institution only patients who experience immediate short-term relief from these injections and eventually have their symptoms return are considered surgical candidates for resection. The pseudoarthrectomy procedure is well-documented in the literature, however available outcome data has lacked standardized outcome measures and therefore the true efficacy of this procedure has not yet been assessed [16,17]. The purpose of this study is to examine post-operative change in quality-of-life (QOL) and patient satisfaction following pseudoarticulation resection.

Methods

Study population

This is an ambidirectional (prospective and retrospective) study of patients receiving care at a tertiary academic medical center between 2010 and 2020. Patients were identified by receiving a non−specific diagnostic code associated with low back pain and Bertolotti Syndrome using the International Classification of Diseases, Tenth Revision (ICD-10) code Q76.49. For patients seen before 2015, ICD-10 codes were converted to ICD-9 codes in order to facilitate database query. Patients with either of these ICD codes who went on to receive surgery were identified using the Current Procedural Terminology (CPT) code 22102, indicating the patient underwent the pseudoarticulation resection procedure. All procedures were confirmed with provider notes. Only Castellvi type II Bertolotti Syndrome patients were included, as this type is the only LSTV with a pseudoarticulation present. Presence of a type II LSTV was confirmed with a lumbar computed tomography (CT) scan. Upon confirming the presence of a type II LSTV, patients were offered an analgesic (local anesthetic and corticosteroid) injection at the LSTV pseudoarticulation. Only patients who experience temporary symptomatic relief from the pseudoarticulation injection are offered surgical resection upon return of their symptoms, and therefore all patients included this study have Bertolotti Syndrome diagnosed via CT with the pseudoarticulation confirmed as a primary source of pain via injection response with return of symptoms following the injection. Patients under 18 years of age, those with spinal malignancies or significant spinal deformities other than Bertolotti Syndrome, and those who underwent prior spinal fusion were excluded.

Data collection

Quality-of-life variables were collected from the Knowledge Program [18], a program at this institution that collects and databases surveys completed by patients on-site as well as via telephone and by mail. Quality-of-life variables collected included pre-operative and post-operative Patient-Reported Outcomes Measurement Information System Global Health (PROMIS-GH) Mental and Physical Health T-scores [19,20] as well as a post-operative patient satisfaction survey adapted from the former North American Spine Society (NASS) Lumbar Outcome Assessment Instrument [21]. (Table 1) Retrospectively, PROMIS-GH results were collected from the electronic medical record (EMR) for the pre-operative and post-operative period when available. Prospectively, PROMIS-GH surveys and satisfaction surveys were either conducted during the post-operative follow-up appointment, mailed to patients, or conducted over the phone by study personnel.

Table 1
Patient satisfaction survey.

Score	Satisfaction measure	Place an "X" in the box below that best describes how you feel
1	The treatment met my expectations	
2	I did not improve as much as I had hoped, but I would undergo the same treatment for the same outcome	
3	I did not improve as much as I had hoped, and I would not undergo the same treatment for the same outcome	
4	I am the same or worse than before treatment	

Katz JN. Measures of adult back and neck function: The North American Spine Society (NASS) Lumbar Spine Outcome Assessment Instrument, Neck Disability Index, Oswestry Low Back Pain Disability Index, Quebec Back Pain Disability Scale, and Roland-Morris Low Back Pai. *Arthritis & Rheumatism*. 2003;49(S5):S43-S49. doi:10.1002/art.11399

Statistical analysis

Patient and clinical characteristics were summarized using descriptive statistics for the entire cohort and stratified by improvement in each of PROMIS-GH Physical Health and Mental Health T-scores. Improvement in score was defined as a 5-point increase from preoperative to post-operative score [22]. Comparisons were made using two-sample *t* tests for continuous variables and Fisher exact tests for categorical variables. We also computed descriptive statistics and performed the same tests to compare patients who responded "The treatment met my expectations" to those who did not on the patient satisfaction survey.

Means and standard deviations (SD) of PROMIS-GH Physical Health and Mental Health T-scores were computed for preoperative score, postoperative score, and change (postoperative score − preoperative score). Paired *t* tests were conducted to determine whether the change in score

was statistically significant. Sensitivity analyses were performed to examine whether results were different among patients who had more than 12 months of postop data.

Additionally, we summarized the frequency, and percent of responses to the patient satisfaction survey. We computed means (SDs) of change in PROMIS-GH T-scores, stratified by response to patient satisfaction survey. One-way analysis of variance (ANOVA) was conducted to determine if change in score differed across groups based on responses to the patient satisfaction survey.

Computations were performed in R, version 4.1.0. Tests were two-sided and statistical significance was set at 0.05.

Results

A total of 33 patients had preoperative data and 33 patients had postoperative data. However, only 31 patients were in both data sets (two in the preoperative data set were not in the postoperative data set, and vice versa). Among these 31 patients, average age was 40.1 (SD=12.3) years with 67.7% female, and 80.6% white (Table 2). The Elixhauser comorbidities shown in Table 2 are only those which were present in any patients (ie Elixhauser comorbidities not shown in Table 2 were not present in any of the 31 patients). No patients stayed more than 1 day (18 had 0 days for length of stay, 13 had 1 day length of stay). There were no statistically significant differences in any examined variables for those who improved versus those who did not on either the PROMIS-GH physical health subscale or the mental health subscale (all p>.05) Table 3. shows descriptive statistics for the 24 patients who completed the patient satisfaction survey and stratified by whether the patient answered, “The treatment met my expectations.” There were no statistically significant group differences for any variables examine.

Mean (SD) PROMIS-GH Physical Health T-scores at preop and postop were 37.1 (5.7) and 45.8 (11.0), respectively. The mean improvement of 8.7 (10.5) T-score points was statistically significant (p<.001). Mean (SD) PROMIS-GH Mental Health T-scores at preop and postop were 42.6 (9.4) and 48.5 (10.0), respectively. The mean improvement of 5.9 (9.2) T-score points was statistically significant (p=.001). (Table 4)Of the included patients, 11 had <12 months of postop data. Among the 20 patients who had more than 12 months postop data, the mean (SD) PROMIS-GH Physical Health T-scores at preop and postop were 37.9 (5.3) and 46.4 (11.5), respectively. The mean improvement of 8.5 (9.5) T-score points was statistically significant (p<.001). Mean (SD) PROMIS-GH Mental Health T-scores at preop and postop were 43.7 (9.1) and 48.0 (10.9), respectively. The mean improvement of 4.2 (7.9) T-score points was statistically significant (p=.027). (Table 4)

Of the 31 included patients, 24 had complete data for the patient satisfaction survey. Of these, 11 (45.8%) said “The

Table 2
Patient and clinical characteristics for entire cohort and stratified by whether the patient improved by 5 T-score points or more on PROMIS-GH physical health or mental health scale.

		Improved in PROMIS-GH Physical Health			Improved in PROMIS-GH Mental Health		
	All Patients	Yes	No	p-value	Yes	No	p-value
N	31	19	12		14	17	
Age, mean (SD)	40.1 (12.3)	39.3 (13.2)	41.3 (11.2)	.673	42.9 (10.0)	37.9 (13.7)	.259
Female	21 (67.7%)	14 (73.7%)	7 (58.3%)	.447	9 (64.3%)	12 (70.6%)	1.000
White	25 (80.6%)	15 (78.9%)	10 (83.3%)	1.000	12 (85.7%)	13 (76.5%)	.664
Body Mass Index, mean (SD)	27.17 (4.95)	25.88 (5.28)	29.11 (3.84)	.063	27.39 (5.64)	27.01 (4.53)	.843
Elixhauser Comorbidities							
Chronic Pulmonary Disease	3 (9.7%)	2 (10.5%)	1 (8.3%)	1.000	2 (14.3%)	1 (5.9%)	.576
Coagulopathy	1 (3.2%)	1 (5.3%)	0 (0.0%)	1.000	1 (7.1%)	0 (0.0%)	.452
Depression	2 (6.5%)	2 (10.5%)	0 (0.0%)	.510	2 (14.3%)	0 (0.0%)	.196
Hypothyroidism	2 (6.5%)	1 (5.3%)	1 (8.3%)	1.000	1 (7.1%)	1 (5.9%)	1.000
Obesity	3 (9.7%)	2 (10.5%)	1 (8.3%)	1.000	3 (21.4%)	0 (0.0%)	.081
Valvular Disease	1 (3.2%)	1 (5.3%)	0 (0.0%)	1.000	1 (7.1%)	0 (0.0%)	.452
Comorbidity Count							
Mean (SD)	0.53 (0.94)	0.67 (1.08)	0.33 (0.65)	.303	0.92 (1.26)	0.24 (0.44)	.079
0	21 (67.7%)	12 (63.2%)	9 (75.0%)	1.000	8 (57.1%)	13 (76.5%)	.109
1	6 (19.4%)	4 (21.1%)	2 (16.7%)		2 (14.3%)	4 (23.5%)	
2	3 (9.7%)	2 (10.5%)	1 (8.3%)		3 (21.4%)	0 (0.0%)	
4	1 (3.2%)	1 (5.3%)	0 (0.0%)		1 (7.1%)	0 (0.0%)	
van Walraven Elixhauser Comorbidity Index, mean (SD)	-0.23 (1.43)	-0.33 (1.85)	-0.08 (0.29)	.580	-0.77 (1.92)	0.18 (0.73)	.113
Length of Stay (d), mean (SD)	0.43 (0.50)	0.56 (0.51)	0.25 (0.45)	.098	0.46 (0.52)	0.41 (0.51)	.795
Operative Time (min), mean (SD)	140.9 (63.3)	141.4 (67.0)	140.2 (60.2)	.957	158.6 (72.2)	127.4 (53.8)	.206
Estimated Blood Loss (mL), mean (SD)	79.5 (111.2)	76.5 (95.5)	83.9 (135.8)	.872	92.7 (108.3)	69.4 (115.6)	.575
LE Radiculopathy	22 (71.0%)	13 (68.4%)	9 (75.0%)	1.000	9 (64.3%)	13 (76.5%)	.693
Post-op Complications	2 (6.5%)	1 (5.3%)	1 (8.3%)	1.000	1 (7.1%)	1 (5.9%)	1.000
Return to Hospital w/in 90 D	2 (6.5%)	2 (10.5%)	0 (0.0%)	.510	0 (0.0%)	2 (11.8%)	.488

Table 3
Patient and clinical characteristics for patients who did or did not answer, "The treatment met my expectations" on the patient satisfaction survey.

	All Patients	Answered "The treatment met my expectations"	Did Not Answer "The treatment met my expectations"	p-value
N	24	11	13	
Age, mean (SD)	38.91 (11.52)	36.09 (12.29)	41.50 (10.61)	.274
Female	18 (75.0%)	10 (90.9%)	8 (61.5%)	.166
White	19 (79.2%)	10 (90.9%)	9 (69.2%)	.327
Body Mass Index, mean (SD)	27.13 (5.43)	26.19 (6.11)	27.99 (4.83)	.446
Elixhauser Comorbidities				
Chronic Pulmonary Disease	2 (8.3%)	1 (9.1%)	1 (7.7%)	1.000
Coagulopathy	1 (4.2%)	1 (9.1%)	0 (0.0%)	.458
Depression	1 (4.2%)	1 (9.1%)	0 (0.0%)	.458
Hypothyroidism	2 (8.3%)	1 (9.1%)	1 (7.7%)	1.000
Obesity	2 (8.3%)	2 (18.2%)	0 (0.0%)	.199
Valvular Disease	1 (4.2%)	1 (9.1%)	0 (0.0%)	.458
Comorbidity Count				
Mean (SD)	0.43 (0.95)	0.73 (1.27)	0.17 (0.39)	.187
0	18 (58.1%)	7 (63.6%)	11 (84.6%)	.517
1	4 (12.9%)	2 (18.2%)	2 (15.4%)	
2	1 (3.2%)	1 (9.1%)	0 (0.0%)	
4	1 (3.2%)	1 (9.1%)	0 (0.0%)	
van Walraven Elixhauser Comorbidity Index, mean (SD)	-0.13 (1.52)	-0.55 (1.97)	0.25 (0.87)	.238
Length of Stay (d), mean (SD)	0.48 (0.51)	0.55 (0.52)	0.42 (0.51)	.558
Operative Time (min), mean (SD)	141.78 (69.02)	149.91 (78.84)	134.33 (61.25)	.605
Estimated Blood Loss (mL), mean (SD)	92.39 (123.48)	102.73 (115.44)	82.92 (134.81)	.708
LE Radiculopathy	17 (70.8%)	7 (63.6%)	10 (76.9%)	.659
Post-op Complications	1 (4.2%)	0 (0.0%)	1 (7.7%)	1.000
Return to Hospital w/in 90 D	1 (4.2%)	0 (0.0%)	1 (7.7%)	1.000

treatment met my expectations," 7 (29.2%) said "I did not improve as much as I had hoped, but I would undergo the same treatment for the same outcome," 3 (12.5%) said "I did not improve as much as I had hoped, and I would not undergo the same treatment for the same outcome," and 3 said "I am the same or worse than before treatment." Table 5 shows mean change in PROMIS-GH Physical Health and Mental Health T-scores, stratified by response to the patient satisfaction survey. There were significant group differences in mean change for Physical Health T-scores (p<.001) and Mental Health T-score (p=.009). Patients who stated, "The treatment met my expectations" had much greater mean improvement in the PROMIS-GH T-scores.

Table 4
Means (standard deviations) of change in PROMIS-GH T-scores (postoperative score − preoperative score).

All patients (N=31)		
	Change in score	p-value
Mental Health T-Score	5.9 (9.2)	.001
Physical Health T-Score	8.7 (10.5)	<.001
>12 mo postoperative (N=20)		
	Change in score	p-value
Mental Health T-Score	4.2 (7.9)	.027
Physical Health T-Score	8.5 (9.5)	<.001

Discussion

The pseudoarticulation resection procedure is considered the surgical standard of care for type II Bertolotti Syndrome at this institution and is a well-documented treatment option in the literature [16,17,23–27] Fig. 2. depicts patient positioning and instrument planning that takes place for a minimally-invasive pseudoarthrectomy, the standard approach at this institution. This procedure consists of using a drill to remove the aberrant portion of the L5 TP in contact with the sacrum, with the intention of removing the contacting portion, and providing pain relief. (Fig. 3) Preoperative and postoperative coronal CT scans demonstrating successful removal of the aberrant portion of the transverse process can be seen in Fig. 4. Before this study, outcome data on this procedure was sparse. One literature review by Holm, et al. found 33 patients receiving LSTV pseudoarticulation resection across eight studies and compared the outcome data to other treatment options, however due to small sample sizes among individual studies, and a lack of standardization among outcome measures the results of this review were inconclusive. Small sample size is common pitfall in the Bertolotti Syndrome literature and has limited the ability to make data-driven decisions in clinical management. The lack of available outcome data is likely due to the fact that the most common clinical presentation of Bertolotti

Table 5
Means (standard deviations) of change in PROMIS-GH T-scores (postoperative score − preoperative score). There were significant group differences in mean change for Physical Health T-score (p<.001) and Mental Health T-score (p=.009).

Patient Satisfaction Survey Response	N	Change in PROMIS-GH Physical T-score	Change in PROMIS-GH Mental T-score
The treatment met my expectations	11	17.2 (10.9)	12.8 (8.9)
I did not improve as much as I had hoped, but I would undergo the same treatment for the same outcome	7	6.1 (4.8)	2.5 (7.3)
I did not improve as much as I had hoped, and I would not undergo the same treatment for the same outcome	3	0.0 (2.5)	-3.3 (1.5)
I am the same or worse than before treatment	3	0.7 (4.3)	3.2 (3.7)
	p-value	<.001	.009

Syndrome is very similar to other more commonly-encountered lumbar pathologies (ie disc herniation or spondylolisthesis). Additionally, with a reported prevalence of LSTVs between 4%, and 35% of the general population with up to 73% of these patients reporting symptoms, the overall burden that LSTVs place on the chronic low back pain population is still not well understood and therefore a large majority of these symptomatic patients may go undiagnosed and never receive appropriate treatment [1–5,17]. Because of the poorly understood relationship between LSTVs and the clinical presentation of symptomatic individuals, Bertolotti Syndrome places patients under significant physical, psychological, and financial burden. Studies have demonstrated that Bertolotti Syndrome patients may undergo more extensive clinical and surgical workup and suffer from worse baseline quality-of-life compared with those without this condition and those with lumbar radiculopathy [17,28,29].

The prior literature regarding baseline QOL of Bertolotti Syndrome patients has incited the need for further research on how the QOL in these patients is affected by surgical intervention. In this study the authors used the Patient-Reported Outcomes Measurement Information System - Global Health (PROMIS-GH) scoring system. PROMIS-

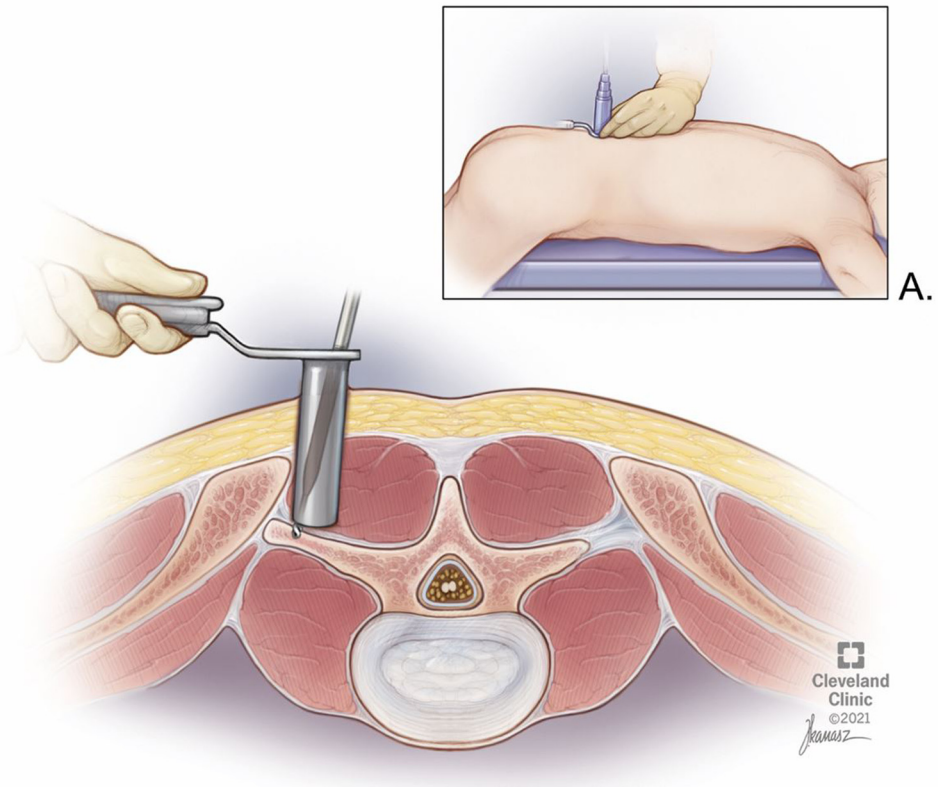

Fig. 2. Illustration showing an axial cross section of instrumentation planning and drill trajectory for a minimally invasive pseudoarthrectomy procedure. For this procedure, the patient is placed in the prone position (A).

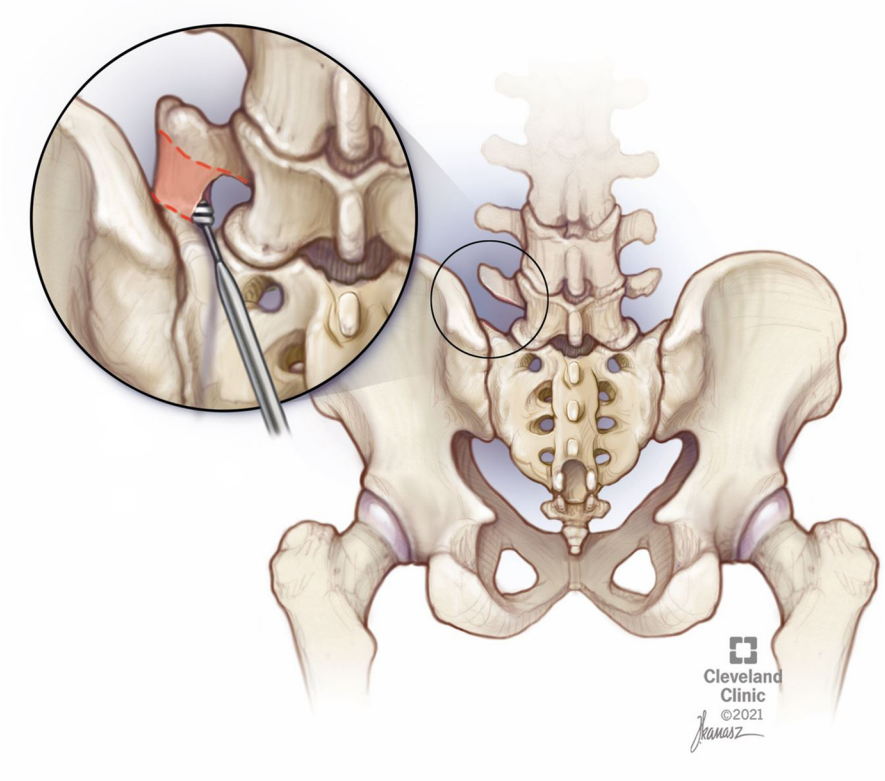

Fig. 3. Illustration of a posterior skeletal view of a Left type IIa LSTV depicting drill removal of the abbarent portion of the L5 TP within resection margins (red) (Color version of the figure is available online.).

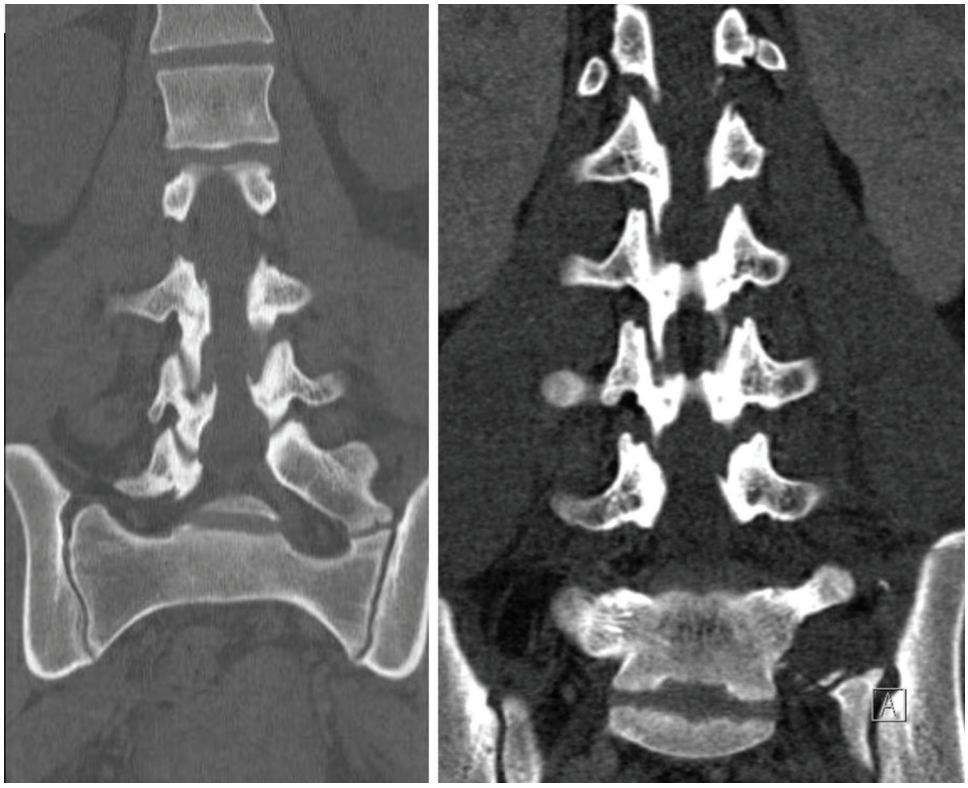

Fig. 4. Coronal computed tomography (CT) scans of the lumbar spine showing: Left type IIa LSTV (Left) and postoperative pseudoarticulation resection of a Left type IIa LSTV (Right).

GH is measure of overall health, consisting of 10 items that produces two separate scores (Mental and Physical Health). These scores are reported as standardized T-scores with a mean (standard deviation) of 50 (10) [30,31].

In this study, it was found that patients undergoing pseudoarticulation resection for type II Bertolotti Syndrome experienced significant improvements in both Mental, and Physical Health PROMIS-GH scores. While statistically significant, it's important to discuss the clinical application of these results, as the minimally important clinical difference (MCID) of PROMIS-GH scores has not yet been clearly defined for lumbar spine surgery. The MCID, or the minimal change in an outcome score determined by the patient to be beneficial, can be used as a valuable reference point when discussing the present findings [32]. Although the MCID for PROMIS-GH has not yet been defined specifically for lumbar surgery, previous studies have suggested that a change of +3.0 −6.0 points is a valid MCID for all PROMIS T-scores, including PROMIS-GH Physical, and Mental Health [33−35]. With this in mind, we find that the post-operative change for both Physical, and Mental Health scores exceeded the established MCID for these outcome measures. Furthermore, results from the post-operative satisfaction survey demonstrated that 75% of these patients were satisfied enough with the outcome that they would undergo the same procedure again for the same results. For a procedure that is commonly offered to treat type II Bertolotti Syndrome, this study presents evidence of clinical improvement through reproducible means − something that has not been done previously. Ultimately, the authors hope that this study promotes physician awareness of Bertolotti Syndrome among the LBP population in addition to providing these patients with access to efficacious surgical management of their condition.

Strengths and limitations

To our knowledge, this study is the largest to assess patients undergoing the pseudoarticulation resection procedure for Bertolotti Syndrome, and the first to examine post-operative outcomes using standardized and validated patient-reported outcome (PRO) measures. However, this study is not without limitations. This study was limited by its relatively small sample size, despite being the largest single study examining surgical outcomes in this population. Additionally, surgical candidacy for this procedure required that the patient experience symptomatic relief from a pseudoarticulation injection, indicating that these results may not necessarily translate to all patients with type II Bertolotti Syndrome. The authors believe however that the manner in which these patients are treated is the safest way to do so, as this treatment protocol minimizes the risk of patients undergoing unnecessary surgery. An additional limitation is that while QOL was compared between the pre- and postoperative period, change in QOL may not have necessarily been directly related to surgery. In order to navigate this limitation, statistical methods were used to stratify change in QOL with satisfaction survey response, in which it was found that those who were more satisfied with surgery experienced an increase in QOL.

Conclusions

The pseudoarticulation resection procedure, when offered to type II Bertolotti Syndrome patients who experience symptomatic relief from a pseudoarticulation injection, may result in significant improvements in quality-of-life as measured by PROMIS-GH Mental, and Physical Health. Further research is still needed to assess the efficacy of this procedure in more robust Bertolotti Syndrome cohorts.

Classification

Ambidirectional Cohort.

Declaration of competing interest

This project received no financial support of any kind. The authors have no relevant disclosures or conflicts of interest to report.

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