Minimally invasive tubular resection of the anomalous transverse process in patients with Bertolotti’s syndrome

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Clinical article

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Object. Bertolotti’s syndrome consists of low-back pain caused by lumbosacral transitional vertebrae (LSTVs) and LSTV-associated biomechanical spinal changes. There is a lack of consensus regarding the cause, clinical significance, and treatment of this condition. The authors aim to characterize the clinical presentation of patients with Bertolotti’s syndrome and describe a minimally invasive surgical treatment for this condition.

Methods. Seven patients who underwent minimally invasive paramedian tubular-based resection of the LSTV for Bertolotti’s syndrome were identified over the course of 5 years. Diagnosis was based on patient history of chronic low-back pain, radiographic findings of LSTV, and pain relief on trigger-site injection with steroid and/or anesthetics. Electronic medical records were reviewed to identify demographics, operative data, and outcomes.

Results. All patients presented with severe, chronic low-back pain lasting an average of 8 years that was resistant to nonoperative care. At presentation, 6 (86%) of 7 patients experienced radicular pain that was ipsilateral to the LSTV. Radiographic evidence showed a presence of LSTV in all patients on the left (43%), right (29%), or bilaterally (29%). Degenerative disc changes at the L4–5 level immediately above the anomalous LSTV were observed in 6 of 7 (86%) patients; these changes were not seen at the level below the LSTV. Following pseudo-joint injection, all patients experienced transient relief of their symptoms. All patients underwent a minimally invasive, paramedian tubular-based approach for resection of the LSTV. Three (43%) of 7 patients reported complete resolution of low-back pain, 2 (29%) of 7 patients had reduced low-back pain, and 2 patients (29%) experienced initial relief but return of low-back pain at 1 and 4 years postoperatively. Three (50%) of the 6 patients with radicular pain had complete relief of this symptom. The median follow-up time was 12 months. No intraoperative complication was reported. Two (29%) of 7 patients developed postoperative complications including one with a wound hematoma and another with new L-5 radiculopathy that resolved 2 years after surgery.

Conclusions. Diagnosis of Bertolotti’s syndrome should be considered with adequate patient history, imaging studies, and diagnostic injections. A minimally invasive surgical approach for resection of the LSTV is presented here for symptomatic treatment of select patients with Bertolotti’s syndrome whose conditions are refractory to conventional therapy and who have pain that can be attributed to the LSTV. Several short-term complications were noted with this procedure, but overall this procedure is effective for treating symptoms related to Bertolotti’s syndrome.

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Key Words • Bertolotti’s syndrome • minimally invasive • sacrum • pseudoarticulation • transverse process • lumbar spine

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Abbreviation used in this paper: LSTV = lumbosacral transitional vertebra.

congenital abnormality occurs in 4%–30% of the general population.4,7,9,11,13,21,22,25,28 The majority of LSTV cases are asymptomatic and are identified incidentally. The cause of low-back pain in Bertolotti’s syndrome is likely multifactorial and largely unknown. Various studies have postulated that the symptoms are due to pathology of the intervertebral disc, spinal canal, and/or...
operative images were also examined. Undergone lumbar spinal surgery. Preoperative and postback pain. Patients were excluded if they had previously the sacrum, verified with imaging, and associated low-hypermobility at the level above the LSTV. This can further contribute to low-back pain. The enlarged LSTV can also lead to sciatica due to extraforaminal stenosis. Some authors have denied any association between LSTV and low-back pain. Limited understanding of the pathophysiology of Bertolotti’s syndrome has led to a lack of uniformity in the diagnosis and treatment of patients with this condition.

Initial treatment of Bertolotti’s syndrome typically includes pain management and physical therapy. Injections of steroids or local anesthetics into the articulation site can be both diagnostic and provide immediate, albeit temporary, pain relief. Many patients often require surgical intervention for Bertolotti’s syndrome, which involves resection or fusion of the anomalous transverse process. Resection of the anomalous transverse process is sometimes performed when pseudoarticulation exists between the L-5 enlarged transverse process and the sacrum. Radiofrequency sensory ablation of the affected nerve root or microendoscopic extraforaminal decompression of the compressed nerve root by the enlarged transverse process have also been described. The number of studies and case reports in the literature reporting on the diagnosis and surgical outcomes of patients with Bertolotti’s syndrome is sparse.

Our experience has supported resection of the enlarged transverse process in the presence of a pseudoarticulation between L-5 and the sacrum. We have previously published our experience with the minimally invasive surgical treatment of this condition. The present study provides a larger clinical series in which this surgical technique was used. The diagnostic evaluation, surgical approach, and outcomes are described. Additionally, a decision-making algorithm is proposed to guide the surgeon in the evaluation of back pain concurrent with LSTV.

**Methods**

The electronic medical records were queried for all patients between 2007 and 2011 who underwent surgery performed by the senior author (M.P.S.) for symptoms related to Bertolotti’s syndrome. Patient charts were retrospectively reviewed. Data collected included demographic information, presenting symptoms, diagnostic methods, surgical approaches, and clinical outcomes. All included patients had enlargement of the transverse process of the lowermost lumbar vertebra with a pseudoarticulation to the sacrum, verified with imaging, and associated low-back pain. Patients were excluded if they had previously undergone lumbar spinal surgery. Preoperative and post-operative images were also examined.

**Surgical Procedure**

All procedures were performed using a minimally invasive approach with the majority utilizing intraoperative image guidance. Typically this is a unilateral resection of the symptomatic LSTV; bilateral resection can be done if both sides are symptomatic. The patient is placed prone on a Jackson table under general endotracheal anesthesia. The lumbosacral area is prepared and draped in the usual sterile fashion. For image guidance, a small stab incision is made immediately lateral to the contralateral posterior superior iliac spine. A trocar is inserted through the incision, and a post is inserted into the posterior superior iliac spine to hold the reference arm for the image guidance system. An O-arm is then brought into the operating room field, and image data are acquired. For fluoroscopy, anteroposterior imaging is used to localize the transverse process, sacrum, and pseudoarticulation. A 2.5-cm vertical incision is made directly over the pseudoarticulation (Fig. 1). The fascia is opened sharply, followed by placement of a series of nested dilators and a 26-mm tubular portal (Stryker Instruments), which is connected to the operating room table (Fig. 2). Using either computer-assisted navigation or fluoroscopy, the enlarged transverse process and pseudoarticulation are localized (Fig. 3 left). Using an operating microscope, the muscular/ligamentous attachments are removed to expose the transverse process and sacral ala. A high-speed drill is then used to thin the full extent of the transverse process from its junction with the vertebral body to the pseudoarticulation (Fig. 3 right). Potential nerve root compression by the enlarged transverse process is shown in Fig. 4 left, and resection of the LSTV can help relieve the symptoms of nerve root impingement (Fig. 4 right). Curettes are used to clear soft tissue under the remaining transverse process followed by complete removal using Kerrison rongeurs. Forward-angled curettes are used to clear the remaining articulation between the transverse process and the sacral ala. Complete resection of the pseudoarticulation must be confirmed. This is done using image guidance or fluoro-
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scopic imaging. In cases utilizing the O-arm, a new “spine” image is obtained, and the 3D images are reviewed to confirm resection. The tubular retractor is then removed along with the reference post. The wound is closed in layers. Postoperatively, the patients are mobilized immediately and are allowed to return to activity without restriction after 1 week.

Results

Patient Characteristics Prior to Surgery

A retrospective review was performed of 7 consecutive patients (3 males and 4 females) who underwent minimally invasive, paramedian tubular resection of LSTV for Bertolotti’s syndrome performed at the Cleveland Clinic between 2007 and 2011 by the senior author (M.P.S.) (Table 1). The mean age at the time of surgery was 43.3 years and the mean age at diagnosis of Bertolotti’s syndrome was 40.2 years. The median duration of low-back pain and/or radicular symptoms was 8 years prior to surgery.

Common presenting symptoms included severe low-back pain along with radiographic findings of LSTV upon routine diagnostic imaging for low-back pain (plain radiography, CT scanning, and/or MRI). All had evidence of a pseudoarticular between the anomalous transverse process and the sacrum. All patients in the study described their low-back pain as sharp and aching and stated that it was either constant or intermittent. The pain was located on the side of the anomalous transverse process and was primarily located in the gluteal and/or “hip” region. The median self-reported pain level for the patients was 6 on a scale of 1 to 10 (Table 1). Of the 7 included patients, 6 (86%) experienced radicular pain that was located ipsilateral to the LSTV or bilaterally if bilateral LSTV was present. One patient (Case 6) additionally experienced numbness and tingling sensations in the lower extremity ipsilateral to the LSTV. While all patients reported severe low-back pain, only 2 patients (29%) experienced gait difficulties due to pain and decreased range of motion. None of the patients had any weakness.

All patients tried multiple combinations of conservative therapies, including analgesics, steroids, epidural steroid injections, and physical therapy, but none experienced satisfactory relief of their symptoms.

Radiographic Findings Prior to Surgery

Preoperative and postoperative images, including lumbar radiographs, CT, and MRI scans as well as radiology reports, were examined for all patients to determine the presenting radiographic signs and symptoms. Five (71%) of the 7 patients had unilateral LSTV, and 2 (29%) patients had bilateral LSTV. Representative preoperative CT images are shown in Fig. 5, and common postoperative images are shown in Fig. 6. Degenerative disc changes such as narrowing disc space and facet arthrosis were determined by CT. Disc bulging and nerve compression were characterized by MRI. Degenerative disc changes were observed on preoperative imaging in 6 (86%) of 7 patients at the L4–5

Fig. 2. A 26-mm tubular portal connected to the operating room table is inserted to allow a working field. Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2013. All Rights Reserved.

Fig. 3. The enlarged transverse processes and pseudoarticulation are localized and their extent detailed using computer-assisted navigation or fluoroscopy. Left: The inset shows the area to be resected as viewed through the tubular retractor. Complete resection of the pseudoarticulation is confirmed using image guidance or fluoroscopic imaging. Right: The inset shows the postresection view through the tubular retractor. Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2013. All Rights Reserved.

Fig. 4. The enlarged transverse process may lead to compression of the spinal nerve root at the level of the pseudoarticulation (left). Resection of the pseudoarticulation can help to relieve pain from the nerve root impingement (right). Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2013. All Rights Reserved.
disc level, above the level of the anomalous pseudoarticulation (Table 1). Two (29%) of the 7 patients had mild degenerative changes at the level immediately below the LSTV. Disc bulging (central or paracentral) was seen in 2 patients (29%) on MRI. Two patients (29%) exhibited a narrowing disc space on CT. Foraminal stenosis was also seen in 2 patients (29%). One patient (Case 5) showed nerve root clumping on MRI due to foraminal stenosis.

Response to Anesthetic Injection at Pseudoarticulation

Prior to resection of the abnormal transverse process, all patients underwent injection of a diagnostic anesthetic block with lidocaine and corticosteroids at the abnormal pseudoarticulation. The diagnostic injection is crucial in determining whether the presence of the LSTV is the cause of the patient’s low-back pain and radicular symptoms. This was used as an exclusionary test for surgery. Specifically, if the injection did not provide relief, the patient was not considered a surgical candidate. The injections were performed by an interventional spine medicine physician. With this injection all patients experienced complete, or partial, temporary relief of their low-back pain and radicular symptoms (Table 1). Based on our group’s experience and a review of the literature, we present a decision-making algorithm for the treatment of Bertolotti’s syndrome (Fig. 7).

Patient Outcomes After Minimally Invasive Resection of LSTV

The surgical approach for all patients was a minimally invasive resection of the abnormal transverse process using a paramedian tubular approach. Unilateral resection was performed in all patients with unilateral LSTV. Two patients had bilateral symptomatic LSTV, and these patients were offered bilateral resections. One

![Fig. 5. Case 4. Preoperative coronal (left) and axial (right) CT images. The arrows indicate the anomalous pseudoarticulation.]
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Fig. 6. Case 6. Postoperative anteroposterior radiograph (left) and axial CT scan (right) showing a resected transverse process and pseu-
doarticulation (arrow).

of these patients (Case 3) underwent bilateral LSTV re-
section, and the other patient (Case 5) chose to minimize
surgical intervention and underwent a unilateral LSTV
resection of the more symptomatic side. Five of 7 cases
were performed using O-arm and computer-assisted im-
age guidance, and the remaining 2 cases were performed
via fluoroscopy. Resection was possible in all cases and
was confirmed via either intraoperative imaging utilizing
the O-arm or postoperative CT scanning. The time from
surgery to discharge was 1 day for all patients (Table 2).
The operative time from incision start to closure ranged
from 2 hours and 1 minute to 3 hours and 29 minutes
with an average operative time of 2 hours and 28 minutes.
There were no intraoperative complications.

After resection of the transverse process, 3 patients
(43%) experienced complete resolution of their low-back
pain and 2 patients (29%) experienced permanent im-
provement in their low-back pain. Three (50%) of 6 pa-
tients who presented with radicular symptoms had com-
plete relief of radicular pain, and 1 (17%) of 6 patients
experienced improvement of radicular pain. The remain-
ing 2 patients (29%) (Cases 5 and 6) experienced initial
improvement in low-back pain and radicular pain but had
recurrence of their preoperative symptoms. The patient in
Case 5 had recurrence of preoperative symptoms after 1
year. This patient also had evidence of bone regrowth at
the original site of resection and underwent reoperation.
This second operation failed to provide any relief 1 year
after this procedure. The patient in Case 6 had complete
resolution of radicular and low-back pain for 4 years, at
which time the symptoms returned.

Two postoperative complications were noted in
the patient cohort (29%). One patient (Case 7) had evi-
dence of a wound hematoma 2 weeks after surgery. She
had pain localized to the incision that was severe in na-
ture. The hematoma was drained and the patient’s pain
resolved. Another patient (Case 3) developed new pain
in an L-5 dermatome. The pain was described as sharp,
burning, and constant. There was diminished sensation
in the L-5 dermatome and evidence of hyperpathia. The
patient’s motor strength remained normal. Postoperative
MRI was performed and did not demonstrate hematoma,
fluid collection, or compression of the L-5 nerve root. The
L-5 nerve root was not visualized or mobilized during the
operation. This pain resolved by 2 years after surgery.

Discussion

Bertolotti’s syndrome may account for 4%–8% of
adult patients with low-back pain and more than
11% of patients younger than 30 years old with low-back
pain.23,26 The difficulty in diagnosing and treating this
condition was clearly seen in the present study population
who had relatively long durations of chronic low-back
pain and in whom conservative management had failed.
It is important to consider Bertolotti’s syndrome as a pos-
sible diagnosis for low-back pain when LSTV is present
on imaging, particularly in younger patients.17

In patients with Bertolotti’s syndrome, the presence
of an LSTV or pseudoarticulation has been suggested to
contribute to the pain, but there are conflicting reports.29 Several groups have conducted MRI- or
CT-based studies to characterize the degenerative changes
that occur in Bertolotti’s syndrome. Tini et al. conducted a
study of 4000 patients and found no correlation between
LSTV and low-back pain.29 In contrast, Taskaynatan et al.
compared patients with and without LSTV and found in-
creased severity of low-back pain and an increase in nerve
root problems when LSTV was present.27 In the present
study as well, the anomalous LSTV pseudoarticulation
was thought to be associated with low-back pain as all pa-
tients experienced either total or partial relief of their pain
from steroid or anesthetic infiltration at the pseudoarticula-
tion. However, none of the patients experienced long-term
relief of symptoms after these injections, which warranted
the exploration of resection as a longer-lasting treatment.
Similarly, Marks and Thulbourne reported a case series of
10 patients with an anomalous LSTV articulation, in which
8 of the 10 patients who underwent steroid or anesthetic
injections in this region experienced immediate relief of
symptoms. Five of those 8 patients experienced a return of
symptoms after an average of 8.2 days.29

There are prevailing hypotheses regarding the root
of pain in patients with Bertolotti’s syndrome. These include
potential biochemical changes in the lumbosacral spine and
pelvis leading to degeneration of the lumbar disc primarily
above the LSTV pseudoarticulation, secondary ex-
traforaminal stenosis, nerve root compression caused by
the LSTV pseudoarticulation, and local irritation and
inflammation from presence of the pseudoarticulation.

Several treatment methods have been advocated
for Bertolotti’s syndrome. These treatments are largely
aimed at treating the pain associated with this disease.
Conservative therapies such as local injection of anesthe-
ic and corticosteroids within the pseudoarticulation have
been used. In our experience, these typically only result
in temporary pain relief. The long-term effect of other
conservative therapies, such as physical therapy, chiro-
practic manipulation, and others, has not been effectively
studied in this condition. Radiofrequency ablation has
also been advocated.23

Surgical treatment is based largely on 2 approaches:
spinal fusion, typically of the level below (caudal to) the

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aberrant spinous process, or resection of the process itself. Both approaches have been used with success in this patient population.2,7,23,24,30 Recent case reports have described successful treatment of patients with Bertolotti’s syndrome via resection of the LSTV.3,7,30 Santavirta et al. reported improvement in pain at the 9-year follow-up in 10 of 16 patients who underwent either posterolateral fusion at the level immediately below the LSTV or resection of the LSTV.24 No difference in outcomes between the cohorts was found. Posterolateral fusion at the L5–S1 level may not be effective in patients with notable degenerative disc changes above the LSTV, which is a common finding in this patient population.

Our group has previously published a case report of the minimally invasive resection of an aberrant L-5 transverse process pseudoarticulation with good results.30 Since that original experience, the senior author (M.P.S.) has performed the same procedure in the 7 patients detailed in the present study. Early in our experience, we used anteroposterior and lateral fluoroscopy for positioning of the tubular retractor and during the resection. We have found that it is difficult at times to confirm complete resection of the pseudoarticulation because there are many “blind” corners when looking through the tubular dilator with a microscope. Complete resection is further difficult to confirm using 2D fluoroscopic imaging. Our group has considerable experience with using computer-assisted navigation for both open and minimally invasive spine fusions, and we have rationalized that this navigation would make resection of the transverse process and pseudoarticulation much easier as well. This study is underpowered to make comparisons between navigation and fluoroscopy, but anecdotally, localization and understanding of the visualized anatomy, resection, and confirmation of complete resection were much easier and quicker using navigation.

We have also learned some pearls during this initial experience. Our original case involved complete resection of the transverse process all the way to the vertebral body.30 Complete resection of the transverse process entails a slightly larger dissection and involves working around the neural foramen. This may be a benefit when a foraminotomy is planned as part of the procedure, such as for 1 patient (Case 7) presented in this series. As our experience has grown, we now only resect the aberrant process that extends caudally toward the sacrum as well as the pseudoarticulation. This leaves a remnant of the trans-

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**Fig. 7.** Diagnostic algorithm for selecting treatment for patients with Bertolotti’s syndrome. Based on another algorithm proposed by Almeida et al.4
verse process still attached to the vertebral body as well as its muscular and ligamentous attachments. The iliac crest often precludes placement of the tubular retractor directly over the pseudoarticulation. In our opinion, image guidance aids the navigation and permits complete resection. Lastly, we no longer use cautery after the dorsal cortex of the transverse process has been resected. Generous bipolar cautery, sharp dissection, and bone wax have replaced the use of cautery. The large anomalous process is often very close to the L-5 nerve root. Cautery near the nerve may result in thermal injury to the root. One patient (Case 3) in our series developed a postoperative radiculopathy that was thought to be possibly related to thermal exposure.

In the present study, 5 (71%) of 7 patients experienced improvements in low-back pain and 5 (83%) of 6 patients experienced improvement in radicular symptoms by their last follow-up time. The rate of improvement was variable in this group of patients. One patient had minor improvement and experienced recurrence of symptoms 1 year later, and another patient had symptoms recur 4 years later. The patient who experienced recurrence of low-back pain and radicular pain 1 year postsurgery had bilateral LSTV but chose to undergo unilateral resection on the more symptomatic side to minimize surgical interventions. Perhaps more extensive resection of both sides of the LSTV would have provided longer pain relief. In the patient who experienced recurrence of symptoms 4 years postsurgery, the new symptoms were attributed to further degeneration of the adjacent disc space. In addition, 2 patients developed short-term complications: one patient needed drainage of a postoperative wound hematoma, and another patient developed new radiculopathy that needed further follow-up. Both postoperative complications were resolved. Our results suggest that minimally invasive resection of the LSTV should be considered as a treatment option for symptomatic relief in patients with Bertolotti’s syndrome whose conditions are refractory to conventional therapies. However, improvement rates vary between patients, and potential postoperative complications should be taken into consideration. Further studies with a larger sample size and longer follow-up time are needed to better demonstrate the effectiveness of this surgical procedure.

The limitations of this study are well recognized. It is a retrospective review of a small number of patients, with substantial heterogeneity of patient medical records and patient follow-up time. Due to the small number of patients, statistical analysis could not be performed and the findings are descriptive in nature. The strengths of this study include the detailed nature of the analysis of patient history, examination findings, surgical approaches, and follow-up history. Patients were from a single institution and underwent surgery performed by a single surgeon (M.P.S.), which limits any confounding by variations in surgeon or institutional practice. This study is also one of the largest case series on Bertolotti’s syndrome and the use of minimally invasive resection as a treatment. Looking forward, it will be important to develop larger prospective studies investigating surgical treatments of patients with Bertolotti’s syndrome.

Conclusions

In the present retrospective case series, radiographic imaging, as well as diagnostic trigger point injections, were found to be useful in identifying patients with Bertolotti’s syndrome. Moreover, in patients who did not respond to conservative treatment, minimally invasive resection of the anomalous transverse process was found to help provide long-term pain relief for select patients. The improvement rate was variable in this patient group. Short-term postoperative complications were noted in 2 patients as well. We suggest that minimally invasive resection of the LSTV should be used in select patients in whom conservative therapy has failed and who have pain attributed to the LSTV. Further prospective investigations, with larger patient cohorts,
are needed to better understand the association between the anomalous transverse process and degenerative disc changes that occur frequently with Bertolotti’s syndrome.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper. Dr. Mroz owns stock in PearlDiver and is a consultant for Globus. He is on the board of AO Spine North America and is the editor of SpineLine (North American Spine Society). Dr. Steinmetz is a consultant for Biomet Spine.

Any contributions to the study and manuscript preparation include the following. Conception and design: all authors. Acquisition of data: Steinmetz, Li, Lubelski. Analysis and interpretation of data: Steinmetz, Li, Lubelski. Drafting the article: Steinmetz, Li, Lubelski. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Steinmetz. Statistical analysis: Li, Lubelski. Administrative/technical/material support: Steinmetz, Li, Lubelski. Study supervision: Steinmetz, Li, Lubelski, Mroz.

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