Case Study

# A Proposed Treatment Algorithm for Low Back Pain Secondary to Bertolotti's Syndrome

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**Background:** Chronic low back pain is widely prevalent, and there are a range of conditions that may result in the low back pain. In general, treatment of low back pain starts with conservative management such as medications, physical therapy, and home exercise regimens. If conservative measures fail, a range of interventional techniques can be employed to manage back pain. An uncommonly recognized cause of back pain is Bertolotti's syndrome which is a result of back pain due to lumbosacral transitional vertebrae (LSTV). LSTV is a congenital abnormality either characterized by the lumbarization of the sacrum where the first sacral bone fails to fuse with the rest of the sacrum or the sacralization of the lumbar spine where the L5 vertebra fuses with the sacrum creating a longer sacrum. In many cases, the condition can be recognized by imaging techniques such as an x-ray, computed tomography, or magnetic resonance imaging.

**Objectives:** To propose a treatment algorithm for patients with low back pain secondary to Bertolotti's syndrome.

**Study Design:** Case study and treatment algorithm proposal

**Methods:** A treatment algorithm for patients with low back pain secondary to Bertolotti's Syndrome which involves starting with local anesthetic and steroid injection of the pseudo-articulation, followed by radiofrequency ablation of the pseudo-articulation, and then complete endoscopic resection of the pseudo joint.

**Results:** The proposed stepwise treatment guideline has the ability to diagnose Bertolotti's syndrome as the cause of low back pain and provide symptomatic relief.

**Limitations:** Several limitations exist for the study including the fact that the algorithmic approach may not fit every patient. Additionally, there would be benefit in future research studies comparing each step of the algorithm with conservative measures to compare efficacy and long-term outcomes of the procedures.

**Conclusions:** Our stepwise approach to diagnosing and managing the pain resulting from Bertolotti's syndrome is an effective method of treatment for the condition.

**Key words:** Chronic pain, low back pain, Bertolotti's syndrome, pseudo joint, radiofrequency ablation, endoscopic resection

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Chronic low back pain is widely prevalent and has been cited as the leading cause of disability in Americans younger than 45 years (1). Furthermore, chronic low back pain is the second most common reason to visit a physician for a chronic ailment (2). Low back pain is considered chronic if it is present for more than three months and it can be characterized as mechanical or non-mechanical. Mechanical back pain is often aggravated by the loading of the spine (i.e., by sitting or standing) and forward bending positions and it usually improves when the spine is offloaded (i.e., by lying supine). Conversely, patients with back pain due to non-mechanical causes, including vascular or visceral pathology, will have constant back pain

regardless of their position, and they require further diagnostic evaluation. A thorough physical exam can uncover if patients are predisposed to develop back pain by identifying biomechanical and compensatory changes. For example, leg-length discrepancies, scoliosis, and postural dysfunction can all play a role in the development of back pain. Special tests, such as the straight leg test that checks for radiculopathy, can influence the next steps in diagnosis and treatment.

The overall treatment for low back pain generally begins with a conservative approach involving physical therapy (PT), spine care education, exercise, medications, and other non-invasive treatment modalities. PT is focused on strengthening the surrounding musculature, improving mobility, postural correction and utilizing various modalities to reduce pain. If the conservative treatment is not effective, interventional spine procedures are utilized to exacerbate the chronic pain and allow patients to better participate in their therapy program while delaying or avoiding surgery. Furthermore, injections are often used as a diagnostic tool to localize the pain generator. Epidural steroid injections, intraarticular facet blocks, medial branch blocks, medial branch radiofrequency neurotomy, and spinal cord stimulation are some of the most common spinal interventions used to treat back pain (3).

Overall, chronic back pain can be difficult to treat because its etiology is often multifactorial, involving psychosocial, structural, and biomechanical causes. Additionally, the origin of the back pain can be difficult to localize. While the most common diagnosis for back pain is muscular strain, there are multiple structures that can be producing the pain, including the ligaments, muscles, facet joints, vertebrae and intervertebral discs (4). The origin of a patient's chronic back pain is often attributed to degenerative changes found upon imaging. However, studies have shown that there is no correlation between symptoms of chronic back pain and the degree of degeneration (5).

Lumbosacral transitional vertebrae (LSTV) is a congenital abnormality characterized by the lumbarization of the sacrum occurring when the first sacral bone fails to fuse with the rest of the sacrum, creating an L6 vertebra. Conversely, LSTV can also be characterized by the sacralization of the lumbar spine when the L5 vertebra fuses with the sacrum creating a longer sacrum. In LSTV, the degree of lumbarization or sacralization is a spectrum and there have been intermediate incomplete transitions recognized (6). LSTV has been further classified according to the Castellvi classification: type I is an enlarged and dysplastic transverse process, type II involves the pseudo-articulation of the sacrum and transverse process, with incomplete lumbarization or sacralization and the enlargement of the transverse process with pseudo-arthrosis, and type III involves the fusion of the transverse process with the sacrum and complete lumbarization or sacralization with an enlarged transverse process that is completely fused. Each type of LSTV can be further subdivided into unilateral or bilateral. Type IV LSTV is a combination of type IIa on one side and type IIIa on the contralateral side (7).

Importantly, there is a variance in the transitional anatomy of individuals which is not necessarily responsible for a patient's chronic back pain. The abnormal connection between L5 and S1 vertebrae places more stress on the adjacent vertebral level and creates a higher incidence of disc herniation and facet arthrosis (8,9). When low back pain occurs in patients with LSTV, it is classified as "Bertolotti's syndrome" (10). The incidence of LSTV is reported to be between 4 and 30% (11). However, the incidence of Bertolotti's syndrome is much lower, between 4 and 8%, which indicates that Bertolotti's syndrome might be underdiagnosed (12). Patients with Bertolotti's syndrome often complain of nonspecific back pain that can radiate to the buttock and lateral hip. A comprehensive physical examination needs to be performed to rule out other syndromes such as lumbar spondylosis, degenerative disc disease, lumbar radiculopathy, sacroiliac joint dysfunction and lumbar spinal stenosis with neurogenic claudication. Nonspecific tenderness, focal tenderness, and a decrease in range of motion are common symptoms found in patients with Bertolotti's syndrome. Plain radiographs are a useful diagnostic tool which may show the enlargement of the L5 transverse processes and the apophysis of L5 that articulates with the sacrum. The Ferguson radiograph, an anterior-posterior (AP) view of the lumbosacral function with 30 degrees of cephalad angulation, is the reference standard method to detect LSTV (13). Computed tomography (CT) can also help clarify the degree of fusion. Furthermore, CT and magnetic resonance imaging (MRI) are both helpful for numbering of the vertebrae, which is critical for the treatment approach (9).

Similar to other causes of low back pain, the initial management of Bertolotti's syndrome involves a conservative approach with nonsteroidal anti-inflammatory drugs (NSAIDs) and PT. If conservative measures fail to provide relief of pain, interventional spine injections can be administered. Corticosteroid injections under

fluoroscopic guidance into the abnormal articulation can provide significant pain relief and help localize the pain generator for future management (14). Multiple case studies also report that radiofrequency sensory ablation is an effective technique to reduce pain caused by LSTV (15,16). Furthermore, if conservative measures fail, and the diagnostic injection at the pseudo joint provides only a temporary improvement of symptoms, surgical resection of the enlarged transverse process has been shown to provide long-lasting relief (14,17). If the spine is unstable at the L5-S1 segment, it has been demonstrated that performing a spinal fusion can provide long-lasting relief. However, as with all spinal fusions, there may be adjacent segment degeneration over time (18).

Overall, there is a lack of clarity regarding the treatment of Bertolotti's syndrome after a patient has failed to show improvement conservative measures. In this review article, we propose a treatment algorithm in increasing order of invasiveness to treat Bertolotti's syndrome.

## Methods

### Case Report

We present the case of a 73-year-old woman who presented with left-sided low back, buttock pain, chronic left leg weakness and left foot drop from chronic left L5 radiculopathy. On physical examination, the patient presented with 4/5 strength on the muscle strength grading scale in the left EHL and tibialis anterior. Prior to presentation at the clinic, the patient used a rollator walker for ambulation for short distances before reporting fatigue and requiring to sit down. MRI was significant for identifying the extruded far lateral L5-S1 disc herniation and an L5-S1 pseudo-articulation compressing the exiting left L5 nerve root. In this case, the patient underwent the treatment algorithm outlined below and eventually underwent an endoscopic resection of the pseudo-articulation. A 22-gauge spinal needle was introduced to the left L5-S1 pseudo joint on the lateral aspect of the L5-S1 facet. The position of the injection was checked under AP and contralateral oblique fluoroscopy. The site of the pseudo joint was anesthetized using a 50/50 mixture of 0.5% bupivacaine and 1% lidocaine with epinephrine. Then, a #11 blade was used to make a 1.5 cm horizontal incision down through the thoracolumbar fascia. The blunt tip dilator was placed and pushed down to the pseudo joint line under fluoroscopic guidance. Once the dilator tip placement looked appropriate on fluoroscopy, a working channel was placed over it and its position was checked too. The dilator was then removed, and an endoscope was placed. Continuous normal saline irrigation was maintained through the endoscope throughout the procedure. The bipolar radiofrequency cautery and pituitary Rongeur was used to remove the soft tissues over the pseudo joint. Then, the pseudo joint line was identified via the endoscope. At the pseudo joint line, a diamond burr was used to take down the inferior edge of the transverse process of L5 all along the pseudo joint from the lateral to the medial aspect. The entire pseudo joint articulation was also drilled out from the dorsal to the ventral aspect of the joint. At the anterior aspect of the pseudo joint, the far lateral L5-S1 herniated disc material was visualized. Using pituitary forceps and bipolar trigger flex cautery, the extruded disc material was resected until the existing L5 nerve was seen to be free coming out of the left L5-S1 foramen. Hemostasis was achieved with trigger flex cautery and then the endoscope and working tube were taken out.

### Description of Procedures

#### *Local Anesthetic & Steroid Injection to Pseudo Joint*

To conduct this procedure, a fluoroscopic C-arm device, local anesthetic (bupivacaine), steroid (triamcinolone), and contrast solution were required. For this procedure, the patient was prepped in a prone position to visualize the pseudo-articulation, sacral ala, and the L5 transverse process. The C-arm was typically placed in the anterior/posterior (A/P) position. With fluoroscopic guidance, a 22-gauge, 3.5 inch spinal needle was guided to the pseudo joint line under anteroposterior and contralateral oblique fluoroscopic views. Once the needle tip was seen and felt to be inside the joint capsule, 0.5 mL of triamcinolone (40mg/mL) mixed with 1 mL of bupivacaine was injected at the pseudo-articulation (15). After the procedure, the patient was asked to maintain a pain diary recording pain intensities for a week after the procedure. Figure 1 depicts fluoroscopic images of needle placement at the pseudo joint.

#### *Radiofrequency Ablation of Pseudo Joint*

Similarly, to conduct this procedure, a fluoroscopic C-arm device, local anesthetic (lidocaine), 18-gauge radiofrequency cannulas, and radiofrequency probes were used. For this procedure, the patient was

prepped in a prone position to visualize the pseudo-articulation, sacral ala, and the L5 transverse process with the C-arm placed in an A/P position. After injection of local anesthetic on the skin and subcutaneous tissues, two 18-gauge radiofrequency cannulas were placed 2-3 mm both above and below the pseudo-articulation margins. Thermal radiofrequency lesions were created between the cannulas at 80°C for 90 seconds as described in one of the first documented cases of radiofrequency ablation (RFA) for Bertolotti Syndrome (15). Figure 1 depicts fluoroscopic images of thermal lesioning cannula placement above and below the pseudo joint line.

### *Complete Endoscopic Resection of Pseudo Joint*

A complete endoscopic resection of the pseudo joint can be conducted when the pain is refractory to other procedures but is known to be caused due to the pseudo-articulation as evidenced by short-term relief from injections or RFA. For this procedure, a patient typically underwent general anesthesia and was placed in a prone position on a Wilson frame. EMG needles were placed over the tibialis anterior muscle as well as extensor hallucis longus muscle for continuous monitoring of the corresponding L5 nerve root to ensure safety during this surgery. Initially, a 22-gauge spinal needle was introduced into the L5-S1 pseudo joint.

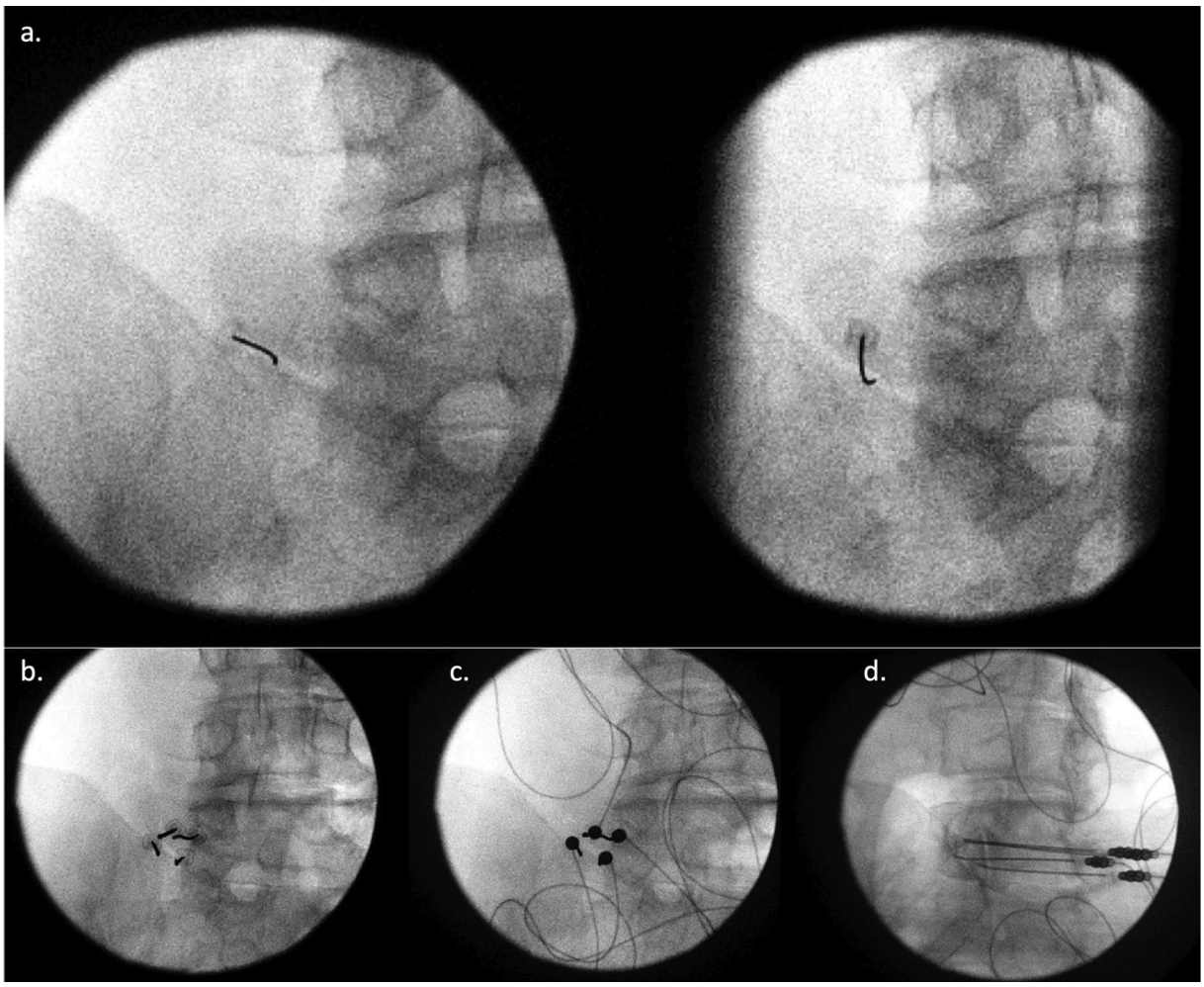


Fig. 1. *Fluoroscopic A/P view of needle placement for Bertolotti pseudo joint anesthetic injection (a), with radiofrequency cannula placement above and below pseudo joint line (b), with bipolar thermal lesioning (c), as well as bipolar thermal lesioning in fluoroscopic oblique view (d).*

Fluoroscopy in the A/P and contralateral oblique view, as seen in Fig. 1, were used to confirm the position of the needle. After confirmation, the site of the pseudo joint was anesthetized with an equal mix of 0.5% bupivacaine and 1% lidocaine with epinephrine. After local anesthesia was applied, a 1.5 cm horizontal incision was made on the skin through the thoracolumbar fascia using a #11 blade. After access was obtained, the blunt tip dilator was advanced to the level of the pseudo joint with confirmation of the path and placement using fluoroscopy. Next, the working tube was placed over the dilator and its position was checked to ensure that it was directly over the pseudo joint line. The dilator was removed and an endoscope was placed using continuous normal saline irrigation during the procedure. Then, bipolar radiofrequency cautery and pituitary Rongeur was used to remove soft tissue material overlying the pseudo joint. After identifying the pseudo joint line with the endoscope, a diamond burr was used to dissect the inferior edge of the transverse process of L5 along the pseudo joint going from lateral to medial. Next, the entirety of the pseudo joint was resected from the dorsal to the ventral aspect of the joint using a combination of diamond burr, Kerrison, bipolar cautery and pituitary rongeurs until the soft tissue anterior to the L5-S1 articulation was visualized. Hemostasis was achieved with using bipolar trigger flex cautery and the endoscope, and the working tube was taken out. Figure 2 depicts fluoroscopic (A/P) views of the pseudo joint before and after the endoscopic resection procedure. Figure 3 depicts endoscopic images with visualization of the pseudo joint as well as post-resection visualization of retroperitoneal fat.

## Results

### Case Report – Follow-up

One week post-procedure, the patient reported complete resolution of her left sided lower back and buttock pain. On examination, the patient demonstrated an objective improvement to a 4+/5 strength during left ankle dorsiflexion and left EHL dorsiflexion. During the 3-month postoperative follow up, the patient reported a 5/5 strength during left ankle dorsiflexion and left EHL and reported increased ability to ambulate without a walker for over one mile.

### Treatment Algorithm

We propose an algorithm for the treatment of Bertolotti's Syndrome in a stepwise approach. The first step for treatment involves conservative treatment with the use of NSAIDs, PT, and a home-exercise regimen. If patients find relief with the conservative treatment, further interventional procedures are likely not needed. In the next step for treatment, patients undergo an injection with local anesthetic and steroid at the pseudo-articulation. If patient experience temporary pain relief, they can proceed to RFA of the pseudo-articulation. If patients do not experience any temporary pain relief, other possible causes of the low back pain must be

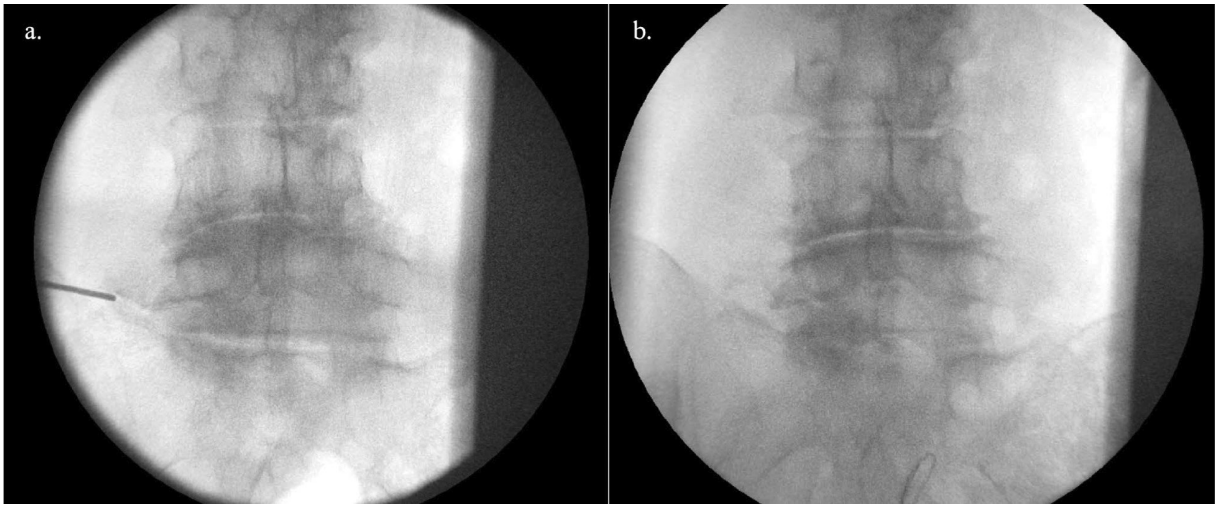


Fig. 2. *Fluoroscopic A/P view of the Bertolotti pseudo joint pre (a) and post (b) endoscopic resection procedure.*

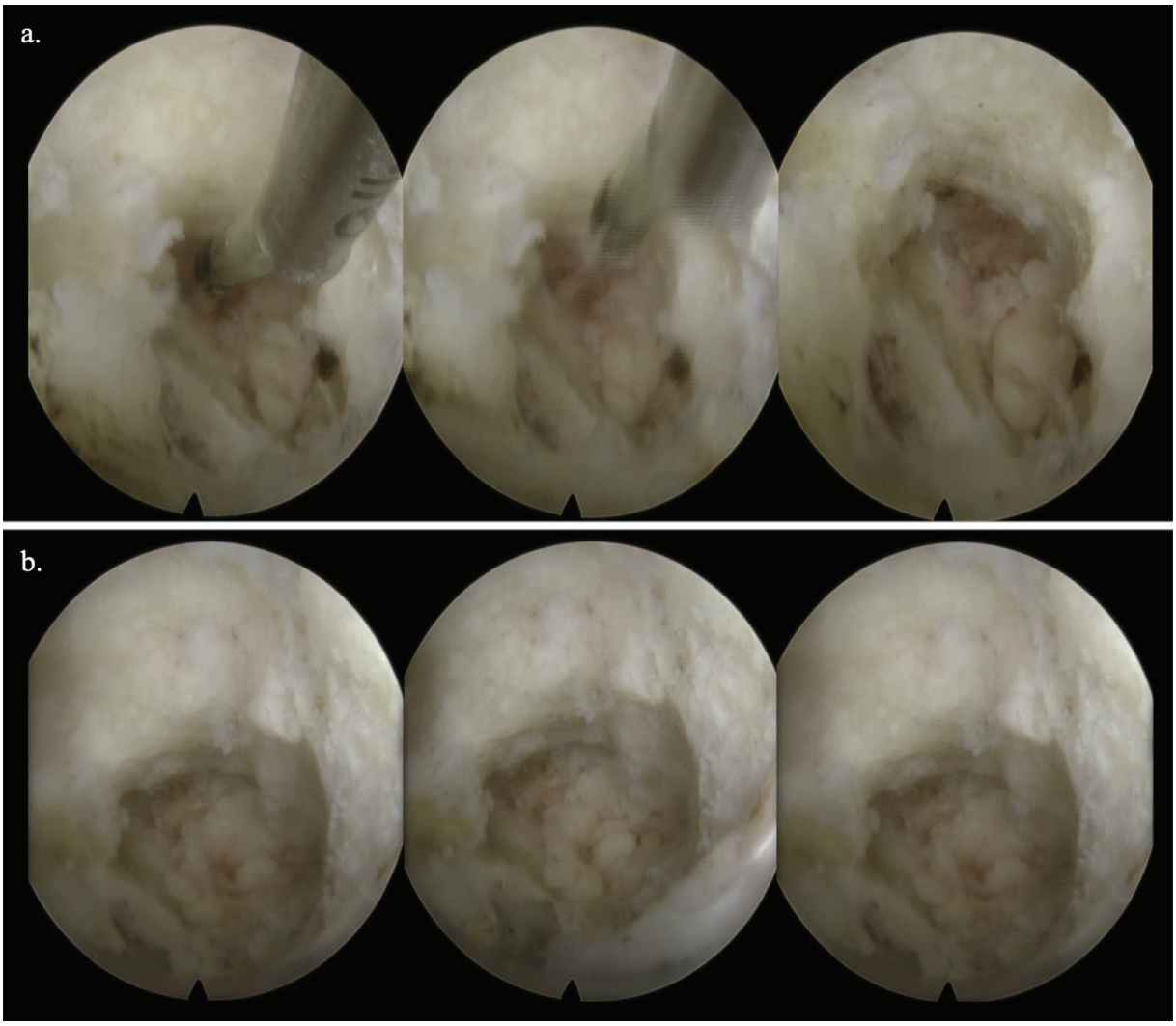


Fig. 3. *Endoscopic images with visualization of pseudo joint (row a) and visualization of retroperitoneal fat after resection (row b).*

evaluated. After proceeding with a RFA, if patients experience adequate pain relief, further treatment with conservative measures and PT can be conducted alongside. If patients do not have long-lasting pain relief after RFA, operative management with endoscopic resection of the pseudo-articulation can be pursued as outlined in the procedure section (18). The proposed treatment algorithm can be seen in Fig. 4.

### Level of Evidence – Grading

Overall, with the case report presented, the treatment algorithm has a Level of Evidence of 4.

## Discussion

### Initial Conservative Approaches

As with other cases of low back pain, the initial conservative treatment of Bertolotti's syndrome involves NSAIDs and PT. Two case reports of patients with Bertolotti's syndrome showed complete resolution of low back pain after stretching, exercise, and chiropractic manipulation (19,20). The authors theorized that the LSTV results in decreased mobility, which changes weight distribution at the involved spinal level. Ultimately these changes are thought to add stress to the muscles in the lumbosacral and sacroiliac regions that support the af-

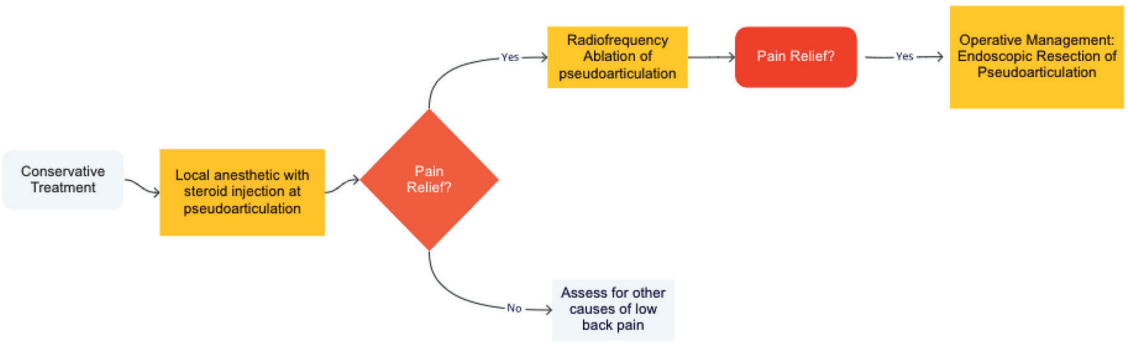


Fig. 4. *A proposed treatment algorithm for management of Bertolotti's syndrome.*

fected side. Therefore, PT helps by relieving stress to the altered lumbopelvic musculature by muscle strengthening, postural correction and improving range of motion (19,20).

## Interventional Techniques for Bertolotti's Syndrome

Injections of local anesthetics or steroids into the pseudo joint can provide temporary pain relief. Avimadje et al. performed a retrospective study of 12 patients with low back pain and an expanded L5 transverse process articulating with the sacrum or ilium. 9 patients reported a 50% decrease in pain after one month, and on reevaluation after 6 to 24 months, 7 of the patients were improved or free of symptoms (21). Furthermore, injection at the pseudo joint provides diagnostic value by guiding the treatment target. In a study of 7 patients with Bertolotti's syndrome, patients were required to experience temporary relief of back pain after steroid and/or anesthetic injection in order to be included in the treatment group that received resection of the LSTV (22). Radiofrequency sensory ablation is another treatment approach, which demonstrated 100% relief of buttock pain for 16 months in a patient with unilateral LSTV (15). In another case, there was complete resolution of a patient's low back pain after denervation at the area between the transverse process of the 5th lumbar vertebra and the sacral ala (16).

## Posterolateral Fusion vs. Resection vs. Conservative Approaches for Bertolotti's Syndrome

Santavirta et al (23) surgically treated 16 patients with Bertolotti's syndrome. Eight of the patients had posterolateral fusion and the other 8 patients had resection of the pseudo joint. Ten of the 16 postoperative patients demonstrated improvement of back pain, and the pain improvement was similar in the fusion and resection groups. The surgically treated group had slightly lower Oswestry Disability Index (ODI) pain scores compared to the conservatively treated controls, but the total ODI scores did not differ. Based on the results, the authors suggested providing operative treatment to select patients with Bertolotti's syndrome. Specifically, they recommended resection for patients that have pain proven to be from the transitional joint, for whom conservative management was unsuccessful, if they have no disc degeneration in the area. Posterolateral fusion may be an option if the transitional disc is degenerated but the disc above the pseudo joint is intact (23).

## Local Anesthetic and Joint Resection

In patients with Bertolotti's syndrome, surgical resection of the LSTV is thought to improve symptoms by relieving the mechanical stress caused by pseudo-articulation (24). However, it is of utmost importance to determine whether the LSTV is the primary pain generator prior to such an intervention. Indeed, an anesthetic block (via low volume lidocaine injection) localized at the pseudo-articulation is typically performed for verification prior to a more invasive procedure such as resection or fusion. While no large-scale prospective trials have been published to date investigating the role of resection in treatment of Bertolotti's syndrome, multiple retrospective reviews, and cases with promising findings provide the basis for a treatment guideline and an impetus for more robust future studies.

In a retrospective review by Almeida et al (14), 5 patients with suspected low back pain secondary to Bertolotti's syndrome received anesthetic block injections

(2 mL lidocaine) at the neo-articulation, which provided significant temporary relief in all patients. Each patient subsequently underwent a radioscopy-guided radiofrequency denervation at the neo-articulation which allowed 2 patients to experience significant pain relief. The 2 patients who experienced relief from both the anesthetic injection and the RFA procedure then underwent surgical resection of the transverse mega-apophysis and reported experiencing complete pain relief at the one-year follow up (26).

In a retrospective review, Mikula et al (27) compared 27 patients who underwent surgical resection (n = 18) versus fusion (n = 9). 78% of patients who underwent surgical fusion and 28% of patients in the resection group experienced long-term pain relief. Of note, 19 of the 27 patients had received a preoperative anesthetic injection at the Bertolotti joint which resulted in 16 patients experiencing subsequent pain relief. However, specifics regarding the volume, formulation, technique and patient responses with regards to the anesthetic injection are not described. The baseline characteristic "back pain at presentation" was also notably heterogenous between study groups and was only present in 12 out of 18 patients in the resection group versus 9 out 9 patients in the fusion group (27).

The largest relevant study to date is a retrospective review by Ju et al (24) which identified 256 patients diagnosed with Bertolotti's syndrome, 87 of whom underwent resection. Of this group, 26 patients were excluded due to diagnosis of another concurrent spinal disease. Of the remaining 61 patients, all had received an anesthetic injection (1 mL 2% lidocaine) into the pseudo-articulation and had experienced pain relief. Select patients also had an anesthetic injected at the L4 nerve root if pain relief from the pseudo-articulation injection was deemed less pronounced. If patients experienced greater pain relief from the L4 nerve root block, which was the case for 22 patients, decompression of the L4 nerve root via soft tissue curettage was also performed during the resection procedure. The mean visual analog scale (VAS) score prior to resection was 7.54 and the mean post-procedure VAS score was 2.86, with 87% of patients demonstrating significantly improved pain measures at a mean follow up period of 6.5 months (24).

Further research on the treatment of Bertolotti's syndrome is sparse, however, in the other studies published, the consensus is that confirming the pseudo-articulation as the primary pain generator prior to the resection procedure is of utmost importance. These studies detail how small volume anesthetic injections directly at the pseudo joint are followed by patients experiencing pain relief. Together, the case study in this review and previously published studies can be used to produce a holistic treatment guideline to relieve pain caused by Bertolotti's syndrome.

A treatment guideline should specify the volume, injectate, technique and the magnitude and timing of pain relief necessary to move forward in the treatment. A treatment guideline should also address the possibility of concurrent or recent steroid injections which may obscure the clear localization of symptom etiology. Steroid injections can diffuse its effects across multiple potential mechanical sources of pain and could lead to false positive relief ascribed to the pseudo-articulation. Therefore, RFA acts as a confirmatory step in ensuring that the pain is derived from the pseudo-articulation resulting from Bertolotti's syndrome.

Resection of the pseudo-articulation via endoscopic approach provides for a minimally invasive, theoretically permanent solution for patients with pseudo-articulation derived chronic low back pain. Improvements to this technique have been reported via recent cases and reviews, described below, showing promising results.

An early study examining this approach is a retrospective review by Li et al (22), which observed 7 patients who underwent minimally invasive tubular resection via paramedian approach after receiving an anesthetic block injection for confirmation. Five of 7 patients experienced pain relief, with one patient having recurrence of pain at the one-year follow-up and another patient experiencing pain recurrence 4 years post-procedure. There is notably considerable heterogeneity between patients in this study.

A 2022 retrospective review by Afana et al (27) followed 8 patients with isolated Bertolotti's syndrome who underwent a resection procedure the authors described as a new modified mini-open tubular microsurgical transverse processectomy. Pain relief shortly after surgery was reported by all 8 patients with an average VAS score reduction from 6.6 to 1.5. However, long-term follow up results are not presented in the study.

A case study published by Chang et al (28) describes a Bertolotti's syndrome patient who underwent a minimally invasive microscopic tubular articular resection with intraoperative 3-dimensional C-arm image guidance. The patient experienced full symptom relief post-procedure and at the 2-year follow up.

A case study published in 2023 by Stein et al (19) describes a bilateral Bertolotti's syndrome patient who

previously received anesthetic injections, RFA and spinal cord stimulator placement but experienced limited relief. The patient then underwent endoscopic resection of the entire length of the pseudo-articulation. The patient experienced partial pain post-procedure and at subsequent follow-up visits, with no further intervention required. The authors noted that they were continuing to improve their technique and have since reported further cases of patients treated via their refined technique who have experienced complete pain relief. They discuss the utility of this minimally invasive procedure in patients exhausting nonsurgical measures, including anesthetic injections and RFA, as well as the importance of isolating the pseudo-articulation as the source of pain. The treatment algorithm proposed in the current review takes this concept a step further, noting relief with RFA as one of the inclusion criteria for successful resection.

### Pitfalls of Endoscopic Resection

As with any surgical procedure, various pitfalls and complications may exist. The review by Afana et al (27) reports two postoperative events occurring after endoscopic resection of a pseudo-articulation. One postoperative complication included wound dehiscence due to a small transverse surgical approach. Another postoperative complication experienced by a patient was radicular postoperative pain described as sharp, burning, and constant. Additionally, the patient reported diminished sensation in the L5 dermatome and the study concluded that this was due to intraoperative nerve injury (27). In our surgical cases, we mitigate the risk of an L5 nerve root injury by neuromonitoring during endoscopic surgery for pseudo joint resection. During the surgical procedure, continuous EMG monitoring during the surgical procedure was conducted to assess the function of the tibialis anterior and extensor hallucis longus muscles to ensure that no nerve injury occurs. Another study by Mikula et al (26) compares the use of resection to fusion for the treatment of Bertolotti's syndrome and concluded that the fusion group had an overall higher rate of long-term pain improvement which further points towards a potential pitfall of endoscopic resection as a treatment option. Finally, when conducting endoscopic resection, the presence of the lumbar branch of the iliolumbar artery is important to note as it traverses the space involved in the procedure.

## Conclusion

Patients experiencing chronic low back pain with no clear surgical cause generally undergo conservative treatment involving medications and dynamic modalities, such as PT and home exercise. With the significant shift away from opioid management and the justified aversion to initiating opioids as a long-term chronic low back pain management option in non-cancer patients, success with interventional strategies is of increasing importance for this patient population. During the process of diagnosis, physical exam special tests and imaging can help determine the root cause of the pain. Physicians should keep Bertolotti's syndrome on their differential and actively seek to identify the presence of LSTV in chronic low back pain patients. However, the presence of this anatomical variant alone is insufficient to diagnose this condition or pursue surgical treatment. It is of utmost importance to diagnose Bertolotti's syndrome as the true cause of low back pain before considering surgical intervention. The stepwise approach outlined here proposes a rule-in approach utilizing commonly employed interventions in order to assuredly identify a patient for surgical resolution via minimally invasive, advanced endoscopic techniques. We have found this surgical approach to be significantly effective when diagnostically qualifying under the proposed algorithm.

### Author Contributions

AC, RK, ZD, SK were all involved in the draft of the initial manuscript, the conceptualization of the paper outline and idea, and the critical revision of the manuscript. SK provided all the images in the paper.

### Ethics Statement

1) This material is the authors' own original work, which has not been previously published elsewhere; 2) This paper is not currently being considered for publication elsewhere; 3) This paper reflects the authors' own research and analysis in a truthful and complete manner.

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