Evolution of the Surgical Management of Cauda Equina Syndrome

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors were involved in the design and conception of this manuscript.

ABSTRACT

Cauda equina syndrome arises secondary to lumbosacral nerve root entrapment, mostly a result of lumbar disc herniation. Clinically, it manifests as sciatica, saddle anesthesia, lower limb weakness, and bowel/bladder dysfunction. Surgical management has developed significantly over the past decades. This literature review aims to shed light on surgical interventions for this condition. Results from 22 original articles have been summarized. Most authors advocate for emergency surgical intervention in all cases. Surgery is performed via an open or endoscopic technique. Open surgery involves lumbar discectomy with laminectomy. It can be carried out with a conventional operative microscope. In contrast, endoscopic discectomy utilizes a minimally invasive incision that minimizes blood loss and the duration of hospital stay. Recent radiologic advances including intraoperative X-ray fluoroscopy, CT scan and ultrasonography have also markedly improved surgical outcomes for lumbar discectomy.*

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Keywords: Cauda equina; management; surgery; evolution.

1. INTRODUCTION

Cauda equina syndrome, although rare, is clinically severe. Cauda equina syndrome derives its name from Latin, with cauda meaning “tail” and equina meaning “horse”. The cauda equina of the spine constitutes the lumbar and sacrococcygeal nerve roots (L2 to Co1 spinal nerves) that arises from the terminal spinal cord (L1-L2 in adults and L3 in children). These nerve fibers can be compressed with trauma (intervertebral disc herniation) or underlying pathologic lesions (e.g. spinal tumors, myelitis, lumbar spinal stenosis, etc.) and thus, can produce symptomatology, broadly termed as the cauda equina syndrome [1].

Epidemiologic data states the overall incidence of cauda equina syndrome ranges between 7 and 9 per 100,000/year in the adult working population in the developed world [2,3]. Minimal data assess age, racial features, and job/profession as the etiological factors [4]. Several clinical manifestations are a result of this syndrome including lower limb pain (sciatica), sensorimotor defects, loss of lower limb deep tendon reflexes, lower back pain, urinary and/or bowel dysfunction, anogenital sensory loss (saddle anesthesia), and poor sexual function [5].

History and clinical examination followed by magnetic resonance imaging (MRI) are used to diagnose cauda equina syndrome [6]. Other diagnostic evaluations include CT scans or spine x-ray/myelograms. Urodynamic studies (residual urine volume) are significantly important in monitoring urinary symptoms related to detrusor hyperactivity or hypoactivity [7]. Management of this neurologic condition has changed tremendously in the past decades. Symptomatic relief of pain is brought about with the use of an extensive steroid or non-steroidal anti-inflammatory drug (NSAID) therapy. Moreover, limited evidence suggests an advantageous role of vasodilator drugs (e.g. prostaglandin analogs) in the management of pain [8]. On the other hand, the surgical intervention aims at managing the underlying cause of cauda equina syndrome. Most of the operative interventions are conducted as follows:

1.1 Lumbar Discectomy

[9,10,11] Most etiological data reveals that lumbar disc protrusion is one of the most common causes of cauda equina syndrome. Therefore, lumbar decompression via discectomy is an important intervention for relieving lumbosacral nerve root compression. This can be substituted by microdiscectomy in which the lumbar disc is microsurgically resected through a small incision. Also, endoscopic instrumentation has revolutionized this surgical technique.

The discectomy procedure involves targeting the lamina and carrying out a laminectomy or laminotomy thus, accessing the protruded disc to relieve pressure on the affected nerve root. The first discectomy operation was performed by F. Krause (early 1900s) where the surgeon entirely resected the pathological lesion of the spine with the aid of laminectomy followed by a transdural discectomy. Upon follow-up, the patient showed complete relief of pain. A few years later, A. Taylor successfully carried out an extradural discectomy.

1.2 Hemilaminectomy/Laminectomy [11, 12]

This includes surgical resection of either one or both laminae of the involved vertebrae which allows surgical decompression of the nerve roots. Such an approach is necessary for cauda equina syndrome occurring secondary to posterior lamina trauma etc. Laminectomy or laminotomy may be carried out through open or endoscopic procedures. The first laminectomy was performed by W. MacEwen or V. Horsley in the 1880s. However, the first-ever hemilaminectomy is believed to be carried out by Taylor et al.

1.3 Development of Endoscopic Procedures for Discectomy/ Laminectomy [13,14,15]

The endoscopic intervention technique has potentially changed the scenario of spine surgery by making it as minimally invasive as possible. Lumbar spine surgery has now become convenient with a smaller incision, minimal scar formation, and shorter duration of hospital stay. The historical invention of an endoscope is credited to Philipp Bozzini (in the 19th century). In 1973, Kambin et al described the first percutaneous nucleotomy procedure for cord decompression. In the next decade, the arthroscopic view of the intervertebral region was first established by Forst et al. Moreover, in the past 2-3 decades, the intervertebral transforaminal approach has been developed to gain
endoscopic access to a prolapsed disc. Neurosurgeons have now combined the microsurgical operative technique with endoscopy to achieve a better view of the pathological site. Also, the development of laparoscopic lumbar surgery via the anterior approach has been considered a major milestone in the era of spine surgery. Presently, fluoroscopic X-ray techniques are being adopted intraoperatively to guide a neurosurgeon during lumbar discectomy procedures.

2. MATERIALS AND METHODS

This study was designed as a literature review. All the articles pertaining to the surgical management of Cauda Equina Syndrome were obtained through search engine sources, including PubMed Central (PMC) and Google Scholar. The following keywords were utilized: Management of Cauda Equina Syndrome; Cauda Equina Decompression Surgery; Lumbar Discectomy; Open and Endoscopic Lumbar Discectomy; Lumbar Laminectomy. Thirty-two articles were selected in the first phase. The inclusion criterion was to include all those clinical studies, retrospective studies, and case series/case reports that encompassed results related to the surgical management of cauda equina syndrome (arising from lumbar disc herniation) in the past two decades i.e. from 2000 onwards. All those articles which discussed any systematic review or meta-analysis related to the subject were excluded from the literature review. After exclusion, a total of 22 articles were incorporated into the final review. They were thoroughly studied for their clinical/surgical output and their result summaries were organized accordingly.

3. RESULTS

Abstracts from all of the selected articles were thoroughly studied and were further categorized according to the intervention modality discussed by the authors. The main findings from the literature review are explained in the Tables 1-3.

4. DISCUSSION

This study has reviewed the major surgical intervention methods utilized for the efficacious management of cauda equina syndrome. Operative techniques include open and endoscopic procedures. Open surgery consists of lumbar discectomy combined with laminotomy/laminectomy or hemilaminectomy, mostly performed microsurgically. Endoscopic operation is a modern closed surgical approach for accessing a herniated lumbar disc to allow cauda equina decompression. Another technique involves microsurgical sectioning of the dorsal root entry zone of the lumbar spinal segments. Moreover, a lumboperitoneal shunting procedure can also be conducted in cases of cauda equina syndrome arising from ankylosing spondylitis.

Cauda equina syndrome is considered an emergency requiring a rapid clinical and radiologic diagnosis as well as an accurately timed surgical intervention. The timing of surgery in such cases has been given due importance by many neurosurgeons. Kohles, S et al. [38] state that decompression carried out within the first 48 hours of emergency admission is likely to be helpful in the post-operative recovery phase. On the other hand, older literature suggests that there is no statistically significant correlation between the timing of surgery and post-operative patient prognosis. Kostuik, J. P et al. [39] reviewed 31 cauda equina syndrome cases retrospectively. The authors concluded that there was no major difference between the operative outcomes of the cases intervened within 6-48 hours and those operated between 1-5 days of onset of symptoms. In short, the timing of decompression surgery in cases of cauda equina syndrome remains controversial.

Timely management of cauda equina syndrome can be achieved through open or closed procedures. Limited research material is available which draws a comparative analysis between the two techniques. Phan, K., Xu, J et al. [40] have compared the efficacy of three different modalities of lumbar spine decompression surgery i.e. full endoscopic, micro-endoscopic, and open disectomy operations. By analyzing the patient outcome with the help of the Visual Analog Scale and Oswestry Disability Index, there was no major discrepancy noted between the efficacies of open discectomy and endoscopic procedures. A shorter duration of operative surgery was noted in the case of the endoscopic procedure. Moreover, average blood loss was found to be comparatively lower in the endoscopic approaches. However, no considerable difference was observed in the case of the incidence of surgical complications (dural tears, wound infections, etc.). In a similar sense, other authors have also concluded that endoscopic discectomy is equally efficacious for the management of herniated lumbar disc and cauda equina syndrome. However, there is still need for further research in this area [41,42].
Table 1. Surgical outcomes from open via discectomy and laminectomy

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<th>Sr. no.</th>
<th>Title of the article</th>
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<tr>
<td>1.</td>
<td>Lumbar herniated disc presenting with cauda equina syndrome: Long-term follow-up of four cases [16]</td>
<td>Chang, H. S., Nakagawa, H et al</td>
<td>Surgical Neurology</td>
<td>2000</td>
<td>This study included 144 cases of lumbar disc herniation out of which only 4 had cauda equina syndrome. These 4 cases were regularly followed in the post-operative months. Long term follow-up revealed a significant recovery in the urinary disturbance. Therefore, the authors have stressed not to rely upon short-term post-surgical surveillance for improvement in bladder function.</td>
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<td>2.</td>
<td>Cauda Equina Syndrome Caused by Intervertebral Lumbar Disc Prolapse: Mid-Term Results of 22 Patients and Literature Review [17]</td>
<td>Buchner, M. &amp; Schiltenwolf, M</td>
<td>Orthopedics</td>
<td>2002</td>
<td>A total of 22 patients were treated with discectomy for their cauda equina syndrome secondary to lumbar disc prolapse. Seventeen patients showed a markedly improved bladder function. Four continued to have stress incontinence whereas 1 case even needed catheterization. Similarly, marked rehabilitation of sensorimotor function was observed upon follow-up. No significant correlation was observed between the period from the appearance of symptoms to surgical intervention and postoperative outcome.</td>
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<td>3.</td>
<td>Cauda equina syndrome: outcome and implications for management [18]</td>
<td>Hussain, S. A., Gullan, R. W et al</td>
<td>British Journal of Neurosurgery</td>
<td>2003</td>
<td>In this retrospective study, a total of 20 patients were included who had been diagnosed with cauda equina syndrome through MRI or CT scan. All cases were operated through laminectomy combined with discectomy. Emergency decompression was performed in nine cases (&lt;5 hours). The remaining 11 patients were also operated within 24 hours of presentation. A markedly improved urinary function and better life quality were observed in both the groups postoperatively. Moreover, no significant differences were seen for patient prognosis at follow-up analysis.</td>
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<td>4.</td>
<td>Cauda equina syndrome treated by surgical decompression: the influence of timing on surgical outcome [19]</td>
<td>Qureshi, A. &amp; Sell, P</td>
<td>European Spine Journal</td>
<td>2007</td>
<td>This study involved a review of 33 cases of cauda equina syndrome (due to lumbar disc herniation) that were treated surgically. Operative techniques included microdiscectomy or laminectomy/hemilaminectomy combined with a discectomy procedure. Twelve patients were operated within 48 hours of the appearance of first symptoms while 7 underwent surgery within the first 24 hours. No significant correlation was established.</td>
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<td>5.</td>
<td>Cauda Equina Syndrome (CES) From Lumbar Disc Herniations [20]</td>
<td>Olivero, W. C., Wang, H et al</td>
<td>Journal of Spinal Disorders &amp; Techniques</td>
<td>2009</td>
<td>This study reviewed statistics from 31 patients of cauda equina syndrome associated with lumbar disc herniation. Twenty-eight patients had been catheterized due to urinary dysfunction secondary to cauda equina compression. A total of 6 cases underwent decompression surgery within the first 24 hours, 8 cases were operated between 24 to 48 hours and the remaining 17 underwent surgery after 2 days. All of the cases were treated with either laminotomy/laminectomy, following which 27 patients regained urinary continence. Moreover, no statistically significant correlation was found between the timing of surgical intervention and surgical outcome.</td>
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<td>6.</td>
<td>Surgical treatment of cauda equina compression as a result of metastatic tumors of the lumbosacral junction and sacrum [21]</td>
<td>Quraishi, N. A., Giannoulis, K. E et al</td>
<td>European Spine Journal</td>
<td>2013</td>
<td>Twenty patients received cauda equina decompression surgery for metastatic lesions present in the lumbosacral region. Fourteen cases presented with complaints of pain and neurological deficit due to underlying cauda equina syndrome. Moreover, 3 patients had developed urinary dysfunction. Spinal decompression was performed in all of the cases following which, 19/20 cases either improved or stabilized. Moreover, urinary function remained normal in 19 cases post-operatively. A complication rate of 30% was observed at follow-up.</td>
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<td>7.</td>
<td>Does Early Surgical Decompression in Cauda Equina Syndrome Improve Bladder Outcome? [22]</td>
<td>Srikandarajah, N., Boissaud-Cooke, M. A. et al</td>
<td>Spine</td>
<td>2015</td>
<td>Data were collected from 200 individuals who were operated on for cauda equina decompression. The surgeons categorized these CES cases with respect to their presenting urinary complaints i.e. CESI (incomplete) – 139 cases and CESR (with urinary retention) – 61 cases. For those cases of CESI that were operated within 48 hours (64), approximately 84% had improved bladder function. On the contrary, only 44% of those cases operated after 48 hours of diagnosis (75) showed a remarkably improved urinary function. However, operation timing showed no</td>
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<td>8.</td>
<td>Urgent discectomy: Clinical features and neurological outcome [23]</td>
<td>Schebesch, K. M., Albert, R et al</td>
<td>Surgical Neurology International</td>
<td>2016</td>
<td>Emergency microsurgical discectomy was performed in at least 72 patients out of a total of 526 lumbar disc herniation cases. Important clinical presentations were of cauda equina syndrome i.e. radicular pain, sensorimotor deficit, sensory loss in the anogenital region, and sphincter dysfunction. The surgical intervention resulted in the marked recovery of sensory and motor functions as interpreted at regular follow-ups.</td>
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<td>9.</td>
<td>A Successful Outcome Despite Delayed Intervention for Cauda Equina Syndrome in a Young Patient with a Posterior Epidural Disc Extrusion [24]</td>
<td>Mugge, L., Caras, A et al</td>
<td>Cureus</td>
<td>2019</td>
<td>This case report describes a case of cauda equina syndrome secondary to lumbar disc protrusion. A 19-year old type 1 diabetic patient presented with symptoms of foot drop, anogenital sensory loss, and severe lower backache. Spine MRI revealed L3-L4 disc herniation and associated cord compression. Cauda equina decompression surgery was carried out microsurgically. Laminectiony (done bilaterally at L3 and partly at L4) was performed which revealed an underlying protruded lumbar disc. Post-surgically, the patient showed a prompt recovery of CES symptoms.</td>
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Table 2. Surgical Outcomes from Endoscopic Lumbar Decompression

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<tr>
<td>1.</td>
<td>Endoscopic Spinal Surgery for Herniated Lumbar Discs [25]</td>
<td>Shim, Y. B., Lee, N. Y et al</td>
<td>Journal of Korean Neurosurgical Society</td>
<td>2007</td>
<td>The researchers analyzed records of 71 cases of lumbar disc herniation that had been operated via 73 endoscopic procedures. Up to 80% of cases had a significant recovery post-surgically. One of these cases had to undergo a secondary open discectomy and laminectomy procedure. For those with a poor outcome (5), two patients were re-operated which resulted in an improved result. There were two instances of discitis seen that were managed either conservatively or with lumbar fusion surgery.</td>
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<td>2.</td>
<td>Complications of Endoscopic Lumbar Decompression Surgery [26]</td>
<td>Sairyo, K., Sakai, T, et al</td>
<td>Minimally Invasive Neurosurgery</td>
<td>2010</td>
<td>In this study, a total of 138 cases underwent endoscopic decompression surgery. The authors monitored the operative complications. It was observed that overall 11 patients (8.6%) developed surgery-related complications including dural tears, hematoma formation, and neurological deficits.</td>
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<td>3.</td>
<td>Endoscopic lumbar discectomy: Experience of first 100 cases [27]</td>
<td>Jhala, A., &amp; Mistry, M</td>
<td>Indian Journal of Orthopaedics</td>
<td>2010</td>
<td>In this study, 100 individuals underwent microendoscopic discectomy. All patients were checked with a pre-operative MRI and 11% also had a post-operative MRI. The mean operation duration was recorded at 70 minutes while the average loss of blood was about 20-30 ml. Post-surgical MRI (11 patients) revealed a total spinal decompression. Almost 90% of the cases showed a good prognosis. Only 4 patients had a recurrence of pain or other symptoms.</td>
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<td>4.</td>
<td>Revisional Percutaneous Full Endoscopic Disc Surgery for Recurrent Herniation of</td>
<td>Shin, K. H., Chang, H. G et al</td>
<td>Asian Spine Journal</td>
<td>2011</td>
<td>In this study, 41 patients were re-operated for recurrent lumbar disc herniation, severe lumbar spinal nerve compression, or intense refractory spinal pain.</td>
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<td>4.</td>
<td>Previous Open Lumbar Discectomy [28]</td>
<td>Malik et al</td>
<td>AJORR, 4(1): 17-29, 2020</td>
<td>Article no.AJORR.59932</td>
<td>All the cases underwent <strong>percutaneous endoscopic lumbar discectomy</strong>. Post-operatively, marked improvement was seen in a majority of patients by using the <strong>Visual Analog Scale</strong>. Two cases had a recurrence of herniation while 4 developed other complications.</td>
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<td>5.</td>
<td>Treatment of cauda equina syndrome caused by lumbar disc herniation with percutaneous endoscopic lumbar discectomy [29]</td>
<td>Li, X., Dou, Q et al</td>
<td>Acta Neurologica Belgica</td>
<td>2016</td>
<td>In this study, <strong>16 patients</strong> diagnosed with <strong>cauda equina syndrome</strong> secondary to <strong>lumbar disc herniation</strong> were included. <strong>Percutaneous endoscopic discectomy</strong> was performed in all of the patients. Macnab criterion and visual analog scale were used for evaluation of patient prognosis. Initial complaints of leg pain and backache were remarkably resolved following the surgical intervention. A few complications were seen in the form of motor weakness.</td>
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<td>6.</td>
<td>Five-year outcomes and predictive factors of transforaminal full-endoscopic lumbar discectomy [30]</td>
<td>Ahn, Y., Lee, U et al</td>
<td>Medicine (Baltimore)</td>
<td>2018</td>
<td>A total of <strong>204 patients</strong> who underwent <strong>transforaminal endoscopic lumbar discectomy</strong> were retrospectively reviewed and the patient prognosis was assessed with the aid of a <strong>visual analog scale</strong> and <strong>Oswestry Disability Index</strong>. All of the patient parameters improved substantially following the surgical intervention. Overall satisfaction with the procedure was seen in 94% cases.</td>
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<td>7.</td>
<td>Full-endoscopic discectomy via the interlaminar approach for disc herniation at L4-L5 and L5-S1 An observational study [31]</td>
<td>Hua, W., Tu, J et al</td>
<td>Medicine (Baltimore)</td>
<td>2018</td>
<td>In this study, <strong>84 subjects</strong> were included who had been operated for <strong>endoscopic lumbosacral discectomy</strong>. The postoperative outcome was evaluated via the <strong>Visual Analog Scale</strong> and <strong>Oswestry Disability Index</strong>. The patient scores got significantly better at follow-up analysis. The main surgical complications were epineurium injury or cauda equina syndrome.</td>
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**Studies comparing Open and Endoscopic Surgical Approaches:**

<p>| 8.     | Percutaneous Endoscopic                | Jin-Sung            | Pain Physician               | 2016                | This study included <strong>43 cases</strong>. <strong>Twenty patients</strong> |</p>
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<td></td>
<td>Lumbar Discectomy as an Alternative to Open Lumbar Microdiscectomy for Large Lumbar Disc Herniation [32]</td>
<td>Kim</td>
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<td>underwent percutaneous endoscopic lumbar discectomy whereas 23 were treated with open microdiscectomy. Both treatment groups revealed a marked improvement with respect to leg and back pain post-operatively. Moreover, the endoscopy group had a much better improvement in backache comparatively while the overall patient satisfaction rate was also greater in the endoscopy group. The average operation time and duration of hospital stay was shorter for those treated endoscopically. There were no surgery-related complications seen in both groups.</td>
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<td>9.</td>
<td>Clinical comparison of unilateral bi-portal endoscopic technique versus open microdiscectomy for single-level lumbar discectomy: a multicenter, retrospective analysis [33]</td>
<td>Kim, S. K., Kang, S. S et al</td>
<td>Journal of Orthopaedic Surgery and Research</td>
<td>2018</td>
<td>This study identified 141 patients that underwent lumbosacral discectomy for their degenerative disc disease. Sixty patients were managed with an endoscopic approach while the remaining 81 cases underwent open microsurgical operation. The visual analog scale, Oswestry Disability Index, and Macnab criterion were used to assess the patient prognosis. Those individuals undergoing endoscopic treatment had a comparatively lesser blood loss than the patients undergoing open surgery, while the hospital stay was also found to be much shorter in the former. However, the total length of surgery was significantly greater for those in the endoscopy group.</td>
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Table 3. Miscellaneous Surgical Techniques for Cauda Equina Associated Sequelae

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<tr>
<td>1.</td>
<td>Dorsal root entry zone lesions for intractable pain after trauma to the conus medullaris and cauda equina [34]</td>
<td>Sampson, J. H., Cashman, R. E et al</td>
<td>Journal of Neurosurgery</td>
<td>1995</td>
<td>This was a retrospective analysis of 39 patients who were surgically treated with <strong>dorsal root entry lesioning</strong> following traumatic damage to the <strong>conus medullaris / cauda equina</strong> region. Post-surgical follow-up analysis showed that &gt;50% had their pain resolved. The operative outcome was better in those cases who presented with only a partial neurological defect. Post-operative complications (~20%) were seen in the form of motor weakness, CSF leakage, and urinary dysfunction.</td>
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<td>2.</td>
<td>Microsurgical DREZotomy for pain due to spinal cord and/or cauda equina injuries: long-term results in a series of 44 patients [35]</td>
<td>M. Sindoua, P. Mertens et al</td>
<td>Pain</td>
<td>2001</td>
<td>A total of 44 patients were included in this study all suffering from severe neuropathic pain secondary to a spine injury. <strong>Four</strong> of these patients had developed serious cauda equina damage. <strong>Dorsal root entry zone microsurgery</strong> or <strong>DREZotomy</strong> was carried out in all of the patients to relieve their pain. Almost 60% of the cases received long term pain relief post-operatively. Some major complications included CSF leakage, infection, and hematoma. No deaths were seen.</td>
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<td>3.</td>
<td>The Utility of Intraoperative Ultrasound for Tumors of the Cauda Equina [36]</td>
<td>Friedman, J. A., Wetjen, N. M et al</td>
<td>Spine</td>
<td>2003</td>
<td>A total of nine patients were included in this study that had been diagnosed with a <strong>cauda equina tumor</strong> via an MRI scan. Also, 4 cases were examined through <strong>transdural ultrasound intraoperatively</strong>. Among 3 of these cases, intraoperative US showed significant migration of tumor mass (as far as one complete vertebral segment) when compared with pre-operative MRI findings. Hence, this allowed the neurosurgeons to undertake essential changes in the surgical approach for laminectomy.</td>
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<td>4.</td>
<td>Cauda Equina Syndrome in Ankylosing Spondylitis: Successful Treatment With Lumboperitoneal Shunting [37]</td>
<td>Ea, H. K., Lioté, F et al</td>
<td>Spine</td>
<td>2010</td>
<td>The researchers included 9 cases of <strong>ankylosing spondylitis</strong> in this study out of which 8 had developed <strong>cauda equina syndrome</strong>. Initially, major symptoms included urinary dysfunction, sensory loss, and lower backache. Later, a few patients also developed motor dysfunction and loss of sphincter control. Pre-operative MRI revealed dural sac dilatation in all of the 9 cases. <strong>Lumbo-peritoneal shunting</strong> was performed in 5 patients and was associated with subsequent recovery of sensory function, sphincteric disturbance, and pain symptoms.</td>
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Modern intraoperative imaging technology has been extensively useful in the realm of cauda equina decompression surgery. X-ray fluoroscopy often plays a vital role in judging the correct vertebral level intra-operatively [15]. Moreover, ultrasonography and CT scan have also proven to be extremely beneficial for this purpose. Wei, S et al [43] have carried out a retrospective analysis of 89 patients undergoing percutaneous endoscopic lumbar discectomy. In each instance, neurosurgeons utilized intraoperative three-dimensional CT scanning technology which helped them modify the trajectory of the endoscopic intervention remarkably. More than 85% of patients showed a favorable prognosis at follow-up.

5. CONCLUSION

Cauda equina syndrome, though rare, often deteriorates acutely and requires an efficient surgical intervention. Surgical management of this neurological condition has gone through immense changes over the past decades. Associated with lumbar disc herniation mostly, it can be conveniently managed with the aid of discectomy paired with laminectomy. Apart from the conventional open microsurgical approach, endoscopic or micro-endoscopic surgery has recently been introduced and now is considered an important alternative to open discectomy.

DATA SHARING

All data pertaining to this research article are included within the manuscript as written.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES


35. Sindou M, Mertens P, Wael M. Microsurgical DREZotomy for pain due to spinal cord and/or cauda equina injuries:


