

Differential Diagnosis & Surgical Outcome of Primary Cauda Equina Tumors

JoongWon Yang

Department of Medicine

The Graduate School, Yonsei University

Differential Diagnosis & Surgical Outcome of Primary Cauda Equina Tumors

Directed by Professor Keung Nyun Kim

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JoongWon Yang

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This certifies that the Master's Thesis
of JoongWon Yang is approved.

Thesis Supervisor : Keung Nyun Kim

Thesis Committee Member#1: Seong Yi

Thesis Committee Member#2 : Seung-Koo Lee

The Graduate School
Yonsei University

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JoongWon Yang

<TABLE OF CONTENTS>

ABSTRACT -----	1
I. INTRODUCTION-----	3
II. MATERIALS AND METHODS-----	5
III. RESULTS-----	11
IV. DISCUSSION-----	18
V. CONCLUSION-----	21
REFERENCES-----	22
ABSTRACT (IN KOREAN)-----	24

LIST OF TABLES

Table 1. Demographics of groups of cauda equina tumors-----	6
Table 2. Presenting symptoms & signs of groups of cauda equina Tumors-----	7
Table 3. Functional outcome scale-----	9
Table 4. MRI findings of cauda equina tumors-----	12
Table 5. Perioperative VAS score and modified JOA score between TNS & TNNS-----	16

LIST OF FIGURES

Figure 1. MRI of TNS-----	12
Figure 2. MRI of TNNS -----	13
Figure 3. Postoperative complication of groups of cauda equina tumors-----	17

Abstract

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Objective: This study was designed to identify surgical outcomes of primary cauda equina tumors and help differential diagnosis.

Patients & Methods: We retrospectively reviewed 60 patients who underwent surgery for cauda equina tumors from April 1999 to May 2009 at Severance spine and spinal cord center. We analyzed clinical features, preoperative MRI findings, extent of surgical resection, histology and surgical outcomes. The surgical outcome was analyzed on the basis of Visual Analog Scale(VAS) score, the modified Japanese Orthopaedic Association(JOA) score.

Results: The tumors of cauda equina were divided into two groups: tumors of neural sheath origin(TNS)(42), tumors of non-neural sheath origin(TNNS)(18). There were schwannomas (Sch)s(42) in the TNS, hemangioblastoma(HGB)s(5), cellular ependymoma(CEP)s(6), myxopapillary ependymoma(MEP)s(5) and paraganglioma(PG)s(2) in TNNS. Leg pain was more common symptom in TNS, but neurological deficit was common in TNNS. TNS and TNNS were hyperintense or isointense on T2-weighted(T2W) images, isointense or hypointense on T1-weighted(T1W) images and are enhanced on postcontrast images, however flow voids on T2W images are more prominent in TNNS. Total resection was achieved in all cauda equina tumors after first surgery. There was no recurrence after total resection of TNS whereas there were 4 recurrences after total resection of TNNS. Patients

with TNS complain more severe pain(VAS score, 5.51 ± 1.42) than patients with TNNS(VAS score, 4.27 ± 2.45) before surgery($p < 0.05$), but patients in two groups showed same pain intensity after surgery. Patients with TNNS showed poor neurological status before surgery($p < 0.05$), after surgery($p < 0.05$) compared to patients with TNS.

Conclusion: It is very important to differentiate TNS and TNNS before surgery, because there is significant difference in functional outcomes and TNNS carry a risk of partial resection, a recurrence risk even after total resection. Although they have similar clinical features and MRI findings, poor neurological status before surgery and flow voids on T2W images may facilitates differentiation of two tumor groups and planning of presurgical strategy.

Key Words : differential diagnosis, neurological deficit, flow voids, recurrence, presurgical strategy

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JoongWon Yang

*Department of Medicine
The Graduate School, Yonsei University*

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I.INTRODUCTION

Cauda equina tumors are rare and account for 6% of primary spinal tumors¹. Among them, tumors of neural sheath origin(TNS) such as schwannoma(SCH)s are common, whereas tumors of nonneural sheath origin(TNNS) such as hemangioblastoma(HGB)s, ependymoma(EP)s, paraganglioma(PG)s are rare. TNS usually arise from the sensory root near the edge of its exist from spinal canal. Surgery for spinal SCHs usually results in good postoperative functional outcomes². TNNS usually arise from the filum terminale^{3,4,5}. There are a few reported cases of local recurrence and/or dissemination through cerebrospinal fluid throughout the neuraxis after total resection of EPs, PGs^{6,7}. TNS and TNNS have similar symptoms and pre-surgical radiologic findings, making preoperative differential diagnosis difficult. Because there are difference in surgical outcomes, recurrence between two groups, accurate differential diagnosis of two groups before surgery is very important. However, there have been no previous reports about differential diagnosis of TNS and

TNNS. The purpose of this study is to analyze the characteristics of clinical features and radiologic findings of cauda equina tumors and to enable correct differential diagnosis before the surgery which is very important for both presurgical planning and surgical outcome.

II. MATERIALS AND METHODS

We retrospectively reviewed 60 of 122 patients who underwent surgery for cauda equina tumor at Severance spine and spinal cord center from June 1999 to May 2009. 62 cases were excluded due to incomplete data collection. The tumors of conus origin, epidermoid cysts were excluded in this study, whereas tumors of cauda equina origin extended into conus were also included in our study.

The demographics, clinical presentations, radiologic characteristics, surgical findings, pathologic diagnoses and surgical outcomes were investigated. Preoperative and postoperative neurologic functions were defined by modified JOA score⁸. The postoperative neurologic function was measured immediately after surgery and followed. The extent of resection was divided into two groups, one group with gross total resection(GTR) and the other with subtotal resection(STR). The GTR was defined as removal of 95% of tumor by intraoperative view and comparison of pre and postoperative MRI. The STR was defined when removal of 80-95% of tumors was done.

Demographics

Our study included 62 patients who underwent surgery of primary cauda equina tumors, which were divided into two groups: tumors of neural sheath origin(TNS)(n=42), tumors of non neural sheath origin(TNNS)(n=18). The tumors of conus origin were not included in this study. There are 25 males and 17 females with a mean age of 46.4 years(16 - 74 years), a mean symptom duration of 12.9 months(0.75 - 60 months) and a mean follow-up period of 10.9 months(1 - 50 months) in TNS group. In TNNS group, there are 4 males and 14 females

with a mean age of 47.1 years(23 - 70 years), a mean symptom duration of 12.8 months(1 - 48 months) and a mean follow-up period of 12.8 months(1 - 64 months) (Table 1.)

Table 1. Demographics of two groups of cauda equina tumors

	TNS	TNNS
Number	42	18
M/F ratio	1.4:1	1:2
Mean ages	46.4 years	47.1 years
Mean duration of symptoms	12.9 months	12.8 months
Mean follow up	10.9 months	12.8 months

TNS; tumors of neural sheath origin, TNNS; tumors of non neural sheath origin

Clinical features

Leg pain was the most commonest symptom and was accompanied in 76.2 % of patients(n=32), low back pain in 40.5%(n=17), motor weakness in 9.5%(n=4) and sensory change(numbness or tingling sense) in 4.7%(n=2) in TNS group. Low back pain was the most commonest symptom and was accompanied in 55.5%(n=10), leg pain in 44.4% of patients(n=8), neurogenic bladder in 38.9%(n=7), motor weakness in 33.3%(n=6), and sensory change in 5.5%(n=1) in TNNS group. Patients of TNS group complained of leg pain more frequently, however neurological deficits were more commonly observed in TNNS group (Table 2.)

Table 2. Presenting symptoms & signs of groups of cauda equina tumors

Symptom & signs	TNS(%)	TNNS(%)
LP	76.2	44.4
LBP	40.5	55.5
Sensory change	4.7	5.5
Motor weakness	9.5	33.3
Neurogenic bladder	-	38.9

LP: leg pain, LBP: low back pain, TNS; tumors of neural sheath origin, TNNS; tumors of non neural sheath origin

Radiologic evaluation

Lumbar spine MRI with gadolinium(Gd) enhancement was performed in preoperative and postoperative period. Signal characteristic of tumor on T2W images, T1W images was classified as hyperintense, isointense or hypointense relative to the spinal cord. The flow voids on T2W images were defined as dilated and tortuous draining veins from both poles of tumors along ventral and dorsal surface of spinal cord, cauda equina or feeding arteries within tumor. Whole spine MRI with Gd enhancement was performed to check out another lesion and cerebrospinal fluid(CSF) seeding in the patients with HGBs, MEPs. The preoperative diagnostic angiography and embolization was performed in one patient with HGB.

Pain and functional outcome

To measure the intensity of preoperative and postoperative low back pain, leg pain, we used a VAS score. VAS score ranges from no pain(point 0) to worst pain imaginable(point 10). To measure preoperative and postoperative neurologic function, we used the modified JOA

score⁸. A modified JOA score was defined by excluding the motor and sensory function of upper extremity and adding the sensory function of perineal area to check out the sensory function of sacral nerves in original JOA score. Total score was 11 points in modified JOA score (Table 3.) The postoperative neurological function was measured immediately after the surgery and followed. Because neurological function was improved to some degree on follow-up period, modified JOA score on follow-up period was used to compare functional outcomes between two groups.

Table 3. Functional outcome scale

Summary of modified JOA(Japanese Orthopaedic Association) score

I.Motor function of lower extremity

0.Impossible to walk

1.Need cane or aid on flat ground

2.Need cane or aid only on stairs

3.Possible to walk without cane or aid but slow

4.Normal

II.Sensory function of lower extremity

0.Apparent sensory loss

1.Minimal sensory loss

2.Normal

III.Sensory function of Saddle area

0.Apparent sensory loss

1.Minimal sensory loss

2.Normal

IV. Bladder function

0.Complete retention

1.Severe disturbance(sense of retention, dribbling, incomplete continence)

2.Mild disturbance(urinary frequency, urinary hesitancy)

3.Normal

Statistical analysis

All data analyses were performed by using SPSS. Value were reported as means \pm standard errors of mean. For all statistical testing, significance was set at the 5% level.

III.RESULTS

Pathologic diagnosis

Three patients with TNS were suspected of having MEPs before surgery. All tumors of TNS group were proven to be SCHs after surgery. Eight patients with TNNS were suspected of having SCHs before surgery. Each tumors of TNNS group were proven to be 5 HGBs, 6 CEPs, 5 MEPs, 2 PGs after surgery.

MRI findings

Routinely MRI of lumbar spine with Gd enhancement was taken in preoperative period. TNS were isointense or hypointense on T1W images, hyperintense or isointense on T2W images, had homogenous or heterogenous enhancement and had cystic portion(58%), hemorrhagic portion(9.3%) within them. TNNS were isointense or hypointense on T1W images, hyperintense or isointense on T2W images, had homogenous or heterogenous enhancement. Tumor bleeding was seen in 1 HGB, 2 MEPs and 2 PGs. Cystic change of tumors was seen in 1 HGB, 2 MEPs, 1 PG. There were serpentine flow voids seen along ventral and dorsal surface of spinal cord near tumor and flow void within tumor in HGB, PG^{3,9}. These hypervascular tumors were not strongly enhanced on postcontrast images. One patient proved to have two intramedullary HGB at whole spine MRI. Another patient underwent resection of cerebellar HGB before surgery. CEPs had homogenous enhancement in the region of filum terminale below the conus (Table 4. Figure 1. 2.).

Table 4. MRI findings of cauda equina tumors

Group	Histology	T2W images	T1W images	EC	FV(%)	HR(%)	Cyst(%)
TNS	SCH	Hyper or iso	Hypo or iso	+	9	6	50
TNNS	HGB	Hyper	Hypo or iso	+	100	20	20
	CEP	Hyper or iso	Hypo or iso	+			
	MEP	Hyper	Hypo or iso	+	40	20	20
	PG	Hyper or iso	Hypo	+	100	100	50

TNS; tumors of neural sheath origin, TNNS; tumors of non neural sheath origin, EC; enhancement, FV; flow voids, HR; hemorrhage, SCH; schwannoma, HGB; hemangioblastoma, MEP; myxopapillary ependymoma, CEP; cellular ependymoma, PG; paraganglioma, + ; enhancement



Figure 1. MRI of TNS. SCH; (A) sagittal T2W image of lumbar spine shows isointense tumor with cystic degeneration. (B) sagittal T1W image shows isointense tumor (C) Post-contrast sagittal MRI shows heterogenous enhancement, TNS; tumors of neural sheath origin

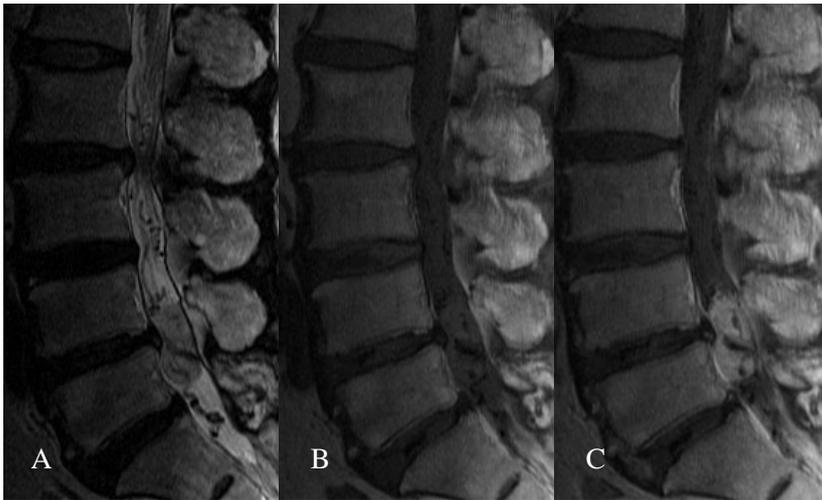
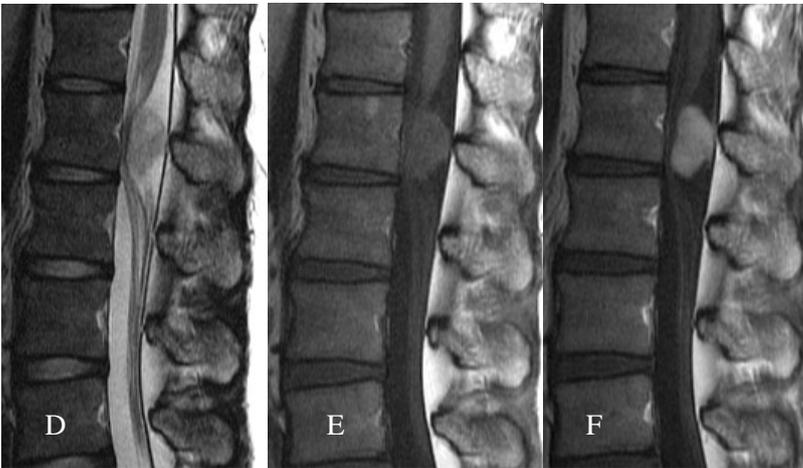


Figure 2. MRI of TNNS. HGB; (A) sagittal T2W image of lumbar spine shows serpentine flow voids along conus and cauda equina and intratumoral feeding artery within tumor with high signal intensity (B) sagittal T1W image shows isointense tumor (C) Post-contrast sagittal MRI shows strong enhancement which suggest hypervascular tumor, TNNS; tumors of non neural sheath origin



CEP;(D) sagittal T2W image of lumbar spine shows anterior displacement of cauda equine by isointense tumor (E) sagittal T1W image shows isointense tumor (F) Post-contrast sagittal MRI shows homogenous enhancement of tumor



PG;(G) sagittal T2W image of lumbar spine shows flow voids, hyperintense tumor with hemorrhagic portion(H) sagittal T1W image shows isointense tumor (I) Post-contrast sagittal MRI shows feeding artery on hemorrhagic portion and heterogeneous enhancement

Surgical resectability and recurrence

Sixty three surgeries were performed in 60 cases. In TNS group, GTR was achieved on all SCHs and there was no recurrence after GTR. In TNNS group, GTR was achieved on all tumors after first surgery. There were 4 recurrences(2 HGBs, 2 MEPs) even after GTR with mean recurrence period of HGB, 48 months(range 26 - 70 months) and MEP, 58 months(range 34 – 82 months) (GTR of 1 MEP in other hospital). The one patient received local radiotherapy after STR of local recurred HGB; the other patient received whole spine radiotherapy due to CSF seeding even after GTR of recurred HGB. The recurrence of HGB was detected on follow up MRI scan in 30 months in spite of radiotherapy after a second surgery. Patient received radiotherapy on thoracolumbar spine at other hospital though

recurrence of MEP was detected in 26 months after first surgery; another patient received whole spine radiotherapy due to remnant tumor and CSF seeding of MEP.

Pain and functional outcomes

Patients with TNS complain more severe pain(VAS score, 5.51 ± 1.42) than patients with TNNS(VAS score, 4.27 ± 2.45) before surgery($p < 0.05$), but patients in two groups showed same pain intensity after surgery($p > 0.162$). Patients with TNNS showed poor neurological status before surgery($p < 0.05$), after surgery($p < 0.05$) compared to patients with TNS(Table 5). In TNS group, five(12%) patients experienced improved neurological function, twenty nine(69%) patients remained stable, eight(19%) patients experienced deteriorated neurological function after surgery. In TNNS group, eight(44.4%) patients experienced improved neurological function, five(27.7%) patients remained stable, five(27.7%) patients experienced deteriorated neurological function after first surgery. Four(100%) patients who underwent second surgery for recurred tumors experienced deteriorated neurological function though those patients experienced improved neurological function after first surgery.

Table 5. Perioperative VAS score and modified JOA score between TNS & TNNS. P – values was taken by paired t-test between TNS & TNNS groups.

	TNS(N=42)	TNNS(N=22)	p-value
Preop. VAS	5.51±1.42	4.27±2.45	p=0.010
Postop. VAS	1.40±0.62	1.15±0.78	p=0.162
Preop. m JOA	10.79±0.51	9.05±2.44	p=0.002
Postop. m JOA	10.70±0.51	8.38±2.35	p=0.001

TNS; tumors of neural sheath origin, TNNS; tumors of non neural sheath origin, Preop.VAS; preoperative Visual Analog Scale score, Postop. VAS; postoperative Visual Analog Scale score, Preop. m JOA; preoperative modified JOA score, Postop. m JOA; postoperative modified JOA

Postoperative complication

In TNS group, motor weakness developed after GTR of a SCH on L2 level. Neurogenic bladder developed after GTR of a large SCH on L1-4 level. Sensory deficit developed in 6 patients after GTR of SCH. In TNNS group, motor weakness(n=5), sensory deficit(n=7), neurogenic bladder(n=4), CSF leakage(n=2) develop after surgery; motor weakness (n=2), sensory deficit(n=3), neurogenic bladder(n=2), CSF leakage(n=1) after removal of 6 HGBs and sensory change(n=2), CSF leakage(n=1) after removal of 6 CEPs and motor weakness (n=2), neurogenic bladder(n=1) after removal of 5 MEPs and motor weakness(n=1), sensory deficit(n=2), neurogenic bladder(n=1) after 2 PGs (Figure 3).

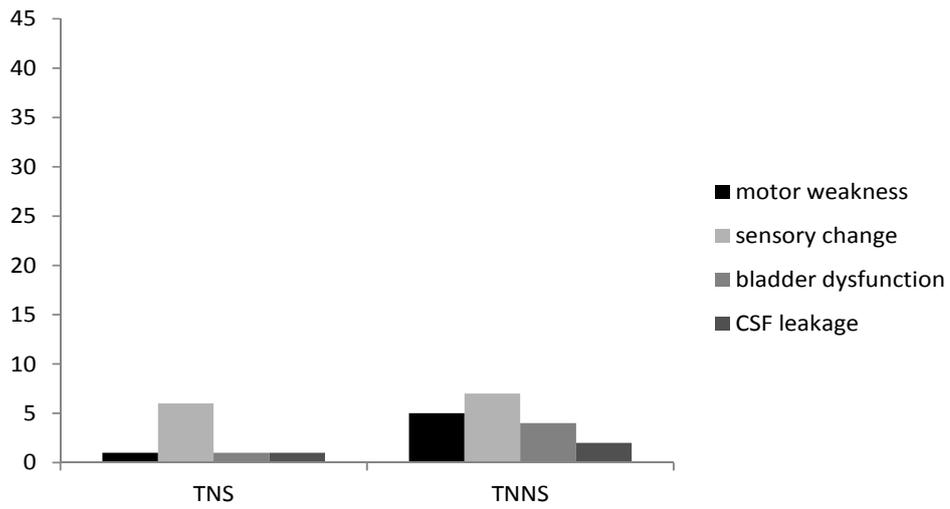


Figure 3. Postoperative complication of groups of cauda equina tumors. TNS; tumors of neural sheath origin, TNNS; tumors of non neural sheath origin

IV. DISCUSSION

Surgery was performed in 60 consecutive spinal tumors that occurred in the cauda equina at our institute. Primary cauda equina tumors were classified as TNS and TNNS according to criteria whether tumor origin is neural sheath or filum terminale. TNS includes neurogenic tumors such as SCHs. TNNS includes rare, nonneurogenic tumors such as HGBs, CEPs, MEPs, PGs. They are histologically benign, often encapsulated tumors. TNS and TNNS have similar clinical features and MRI findings, making preoperative differentiation difficult; three patients with TNS were preoperatively suspected of having MEPs whereas 8 patients with TNNS were preoperatively suspected of having SCHs. However, it is very important to differentiate TNS and TNNS before surgery because there is difference in surgical outcome, recurrence risk, presurgical strategy between two tumor groups.

In our study, there was significant difference in preoperative pain intensity between TNS group and TNNS group; patients with TNNS complain less severe pain than TNS. Also there was significant difference in functional outcomes of two groups. Patients with TNNS show poor neurological status perioperatively whereas patients with TNS show good neurological status perioperatively. Poor neurological status of TNNS group is related with neurological deficit before surgery and postoperative complications affect neurological status after surgery. Jeon JH et al reported in analysis of 40 spinal SCHs that GTR was achieved in 34 cases(85%) of 40 spinal SCHs and surgical outcomes of most spinal SCHs resection was good and without recurrence after GTR². GTR was achieved in all 42 SCHs(100%) of TNS group and all 18 tumors(100%) of TNNS group. There was no recurrence after GTR of all 42 SCHs in TNS group. However, there were 4 recurrences(2 HGBs, 2MEPs) even after GTR

of all tumors in TNNS group. Naorem et al reported that one of 7 PGs recurred in 12 months after GTR, though recurrence is unusual in PG whenever completely excised⁶. One local recurrence and one neuraxis recurrence by CSF seeding were detected on mean follow-up period, 48 months after GTR of HGBs. Like HGBs, one local recurrence and one neuraxis recurrence were detected on mean follow-up period, 58 months after GTR of MEPs. Celli et al reviewed 271 cases of ependymoma of the filum terminale and found that the recurrence rate varied with treatment; there were 4%(range 1% ~10%) even after GTR and 28% after partial resection and radiotherapy⁷. The surgical principle of primary cauda equina tumors is total resection. Unlike TNS, presurgical strategy for TNNS is very important because there are risk of partial resection and recurrence even after GTR. There is risk of partial resection in hypervascular tumors like HGBs, PGs. Capsule of HGBs is fragile, easy to rupture during operation^{10,11}. The internal, piecemeal decompression of HGB can make capsule rupture and produce massive bleeding in even smaller tumor, in that situation total resection is difficult. Rupture of HGBs capsule can increase risk of recurrence even after GTR. So circumferential dissection without rupture of tumor capsule and en block resection is mandatory for total resection of HGB^{11,12}. Also, preoperative angiography and embolization is necessary to prevent tumor bleeding and facilitate tumor resection if multiple feeding arteries are shown on T2W images, postcontrast T1W images¹¹. Preoperative embolization was done for preventing intraoperative tumor bleeding in one patient, who was referred to our institute after a failed surgery because of massive intraoperative bleeding of 3 feeders, unexpected preoperatively. Unlike SCHs, once tumor capsule perforates, MEPs infiltrate or adhere to the nerve root of cauda equina and/or conus medullaris and are then associated not only with high recurrence rate, but also with postoperative neurological deficit. It is especially

important for surgeon to keep MEP capsule intact because it may spread along cauda equina, spinal cord, eventually leading to CSF seeding at rupture of tumor capsule. Total removal of ependymoma located around the conus is difficult because of undemarcated tumor margin around conus, severe adhesion of tumor to sacral/distal nerve roots. The retraction injury of nerve roots must be avoided to prevent neurological deterioration in postoperative period.

Our analysis of clinical features and MRI findings between TNS and TNNS groups may aid in differentiating TNS and TNNS. Patients of TNNS group complain severe neurological deficit such as weakness of multiple root origin, neurogenic bladder whereas patients of TNS group complain mild neurologic deficit such as sensory change, weakness of single root origin. Because SCHs were originated from schwann cells which compose of myelin sheath of sensory nerve rootlet, sensory change may occur. However, motor weakness rarely occurs as initial symptom in the lumbosacral region and motor weakness of leg may not be obvious until the later stage, as in patients with lumbar stenosis. It may be possible to differentiate TNS and TNNS in clinical features because neurological deficit(weakness of multiple root origin, especially neurogenic bladder) is more prominent in TNNS group. It is difficult to differentiate TNS and TNNS on T2W images, T1W images and postcontrast images because they have same signal intensity on T2W images, on T1W images and are enhanced on postcontrast images. Flow voids on T2W images were detected on 7 cases (39%) of TNNS, whereas on only 3 cases (9%) of TNS. Araki et al suggest that this flow voids is a major clue to diagnose HGBs, PGs¹³. It may be possible to differentiate TNS and TNNS on T2W images because flow voids is more prominent in TNNS group.

V. CONCLUSION

It is very important to differentiate TNS and TNNS before surgery, because there is a significant difference in functional outcomes and TNNS carry a risk of partial resection, a recurrence risk even after GTR.(Functional outcome in TNNS group affects partial resection, recurrence after GTR. The proper presurgical strategy for TNNS can prevent partial resection, recurrence after GTR.) Although TNS and TNNS have similar clinical features and MRI finding, poor neurological status before surgery and flow voids on T2W images may facilitates differentiation of two tumor groups and planning of presurgical strategy. Authors recommend a routine MRI examination per year because radiological evidence of recurrence usually appears before clinical symptoms.

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ABSTRACT (IN KOREAN)

일차성 마미충 종양의 감별 진단 및 수술 결과

<지도교수 김공년>

연세대학교 대학원 의학과

양 중 원

목적: 이 연구의 목적은 일차성 마미충 종양의 수술결과를 확인하고 감별진단을 돕기 위함이다.

환자 및 방법: 우리는 세브란스 척추/척수센터에서 1999년 4월부터 2009년 5월까지 수술을 받은 60명의 환자를 조사하였다. 우리는 임상 증상, 수술전 MRI 소견, 종양 제거 정도, 조직학적 소견 및 수술 결과를 분석하였다. 수술 결과는 VAS 점수와 modified JOA 점수를 기준으로 분석하였다.

결과: 마미충 종양은 신경초(neural sheath)기원 종양과 비신경초기원 종양으로 나뉘었다. 신경초기원종양의 경우 총 42례가 있으며 모든 례가 신경초종이다. 비신경초종양에는 총 18례가 있으며 이중에서 혈관모세포종 5례, 세포성 상의세포종 6례, 점액유두상 상의세포종 5례, 부신경절종 2례가 있다. 다리통증은 신경초기원종양에서 더 흔하나 신경학적 장애는 비신경초기원종양에서 더 흔하다. 두 종양그룹 모두 T2W 영상에서 hyperintense or isointense, T1W영

상에서 isointense 혹은 hypointense했으며 조영증강영상에서 조영증강되었다. 그러나, T2W 영상에서 보이는 flow voids는 비신경초기원종양에서 더 저명했다. 일차 수술후 모든 종양은 완전절제되었다. 신경초기원종양은 완전절제후에 재발이 없었으나 비신경초기종양은 완전절제했음에도 불구하고 4례에서 재발 있었다. 신경초기원종양의 환자(VAS점수)는 비신경초기원종양 환자보다 수술 전 더 심한 심한통증을 호소하였으나 수술후에는 똑같은 통증강도를 보였다. 비신경초기원종양 환자는 신경초기원종양환자와 비교했을 때 수술전 신경학적 상태가 좋지 않았으며 수술후에 역시 좋지 않았다.

결론: 수술전 신경초기원종양과 비신경초기원종양을 감별하는 것은 매우 중요하다. 그 이유는 두 종양그룹간의 기능적 결과에 차이가 있고 비신경초종양의 경우 부분절제의 위험도와 완전절제에도 불구하고 재발의 위험도가 있기 때문이다. 두 종양그룹은 비슷한 임상적 특징과 MRI 소견을 보이지만, 수술전 나쁜 신경학적 상태와 T2W 영상에서의 flow voids는 두 종양 그룹간의 감별진단과 수술전 계획수립을 원활히 할 수 있다.

핵심되는 말 : 감별진단, 신경학적 장애, flow voids, 재발, 수술전략, 허리MRI