

Pathological Outcomes of Early Diagnosed Tethered Cord Syndrome (TCS) on Surgical Interventions: A Laboratory and Clinical Study

Dr. Salim Mardan Omer¹, Dr. Ammar Saeed Rashid², Dr. Saadoun Mohsin Saadoun³, Dr. Ali Qais Abdulkafi⁴

¹ Ministry of Higher Education and Scientific Research, Kirkuk University, College of Medicine, Kirkuk, Iraq.

² Kufa University College of Medicine, Najaf, Iraq.

³ Iraqi Ministry of Health, Baghdad Al-Rusafa Health Directorate, Dr. Saad AL Witry Hospital for Neurosciences, Baghdad, Iraq.

⁴ Iraqi Ministry of Health, Kirkuk Health Department, Kirkuk Teaching Hospital, Kirkuk, Iraq.

ABSTRACT

Objective: This study aimed to assess the impact of early diagnosis on the surgical outcomes of Tethered Cord Syndrome (TCS) among pediatric patients in Iraq, focusing on the role of preoperative diagnostic tools and their correlation with postoperative results. **Methods:** We retrospectively analysed data from 50 children diagnosed with TCS at various hospitals across Iraq from January 1, 2020, to February 2, 2022. The study evaluated the efficacy of surgical detethering procedures and investigated the predictive value of preoperative radiological measurements, including the distance of the conus medullaris from the anterior canal and the degree of spinal curvature. **Results:** Early detection of TCS was associated with improved surgical outcomes, particularly in alleviating pain and motor deficits. However, improvements in bladder dysfunction were less pronounced. Preoperative radiological indicators were effective in predicting surgical success and identifying patients at increased risk for postoperative complications. Despite the surgical benefits observed, the data underscores the need for further pathological and clinical studies to address the gaps in managing occult tethered cord syndrome (OTCS). **Conclusion:** Timely diagnosis and appropriate surgical intervention significantly enhance the prognosis for children with TCS. This study highlights the critical role of advanced diagnostic imaging in optimizing surgical outcomes and suggests a need for ongoing research to refine treatment strategies for TCS, particularly in occult cases. Pathological examinations and further scientific analysis are essential to better understand the underlying mechanisms and improve management protocols.

Keywords: TCS, Mother, Diagnosis, Early, Surgical, Pathological.

INTRODUCTION

Tethered Cord Syndrome (TCS) is a neurologically significant condition characterized by abnormal tension on the spinal cord, typically caused by a thickened filum terminale, lipomas, dermal sinus tracts, or adhesions from congenital malformations [1-3]. The persistent traction results in progressive neurological deterioration, manifesting as lower limb weakness, gait disturbances, back pain, and urological dysfunction, particularly in pediatric patients. Although it is more frequently diagnosed in children, TCS can also present in adults, often with more complex symptomatology and delayed diagnosis [4-6]. From a pathological perspective, TCS is frequently associated with occult spinal dysraphism, a group of disorders arising from incomplete fusion of the dorsal midline during embryogenesis [7-11]. These include anatomical abnormalities such as low-lying conus medullaris, spinal lipomas, and fibro lipomas of the filum terminale. The resulting tethering exerts chronic mechanical stress on the spinal cord, impairing neural conduction and leading to irreversible cellular injury if left untreated. Histopathological analysis of excised filum terminale often reveals fibroelastic hyperplasia, glial scarring, and ischemic neuronal changes, underscoring the importance of early intervention [12-15].

Early diagnosis plays a pivotal role in improving surgical outcomes. Radiological imaging, especially magnetic resonance imaging (MRI), serves as the cornerstone of diagnosis by visualizing the conus medullaris position [16-18], spinal cord tension, and associated anomalies. However, reliance on imaging alone may

overlook subtle pathophysiological changes. Laboratory-based diagnostic tools, including histological evaluation of intraoperative specimens, can provide critical insights into the severity of tethering and its potential for recurrence post-surgery. Moreover, future advances in molecular pathology and biomarker identification may enhance preoperative risk stratification and therapeutic decision-making [19-23]. Despite the success of surgical untethering procedures, recurrence and incomplete release remain clinical challenges. A standardized intraoperative grading system for tether release, combined with pathological confirmation of tissue changes, can offer a more objective assessment of surgical success and prognosis. Additionally, correlating preoperative radiological findings with laboratory and pathological results may guide clinicians in determining the optimal timing for surgery and anticipating functional recovery, particularly with respect to bladder dysfunction and motor impairment [24]. Given the complex nature of TCS, a multidisciplinary diagnostic approach integrating radiology, clinical pathology, and surgical evaluation is essential. This study aims to evaluate the role of early diagnosis and laboratory-confirmed pathological changes in guiding surgical management of pediatric TCS. By exploring the correlation between imaging features, intraoperative observations, and histopathological findings, the research contributes to a more precise understanding of TCS and supports the broader goal of improving patient outcomes through integrated diagnostic strategies [25, 26].

MATERIAL AND METHOD

Collection Sample

A prospective cohort study was conducted in Iraq with different hospitals for 50 children diagnosed with Tether Cord Syndrome (TCS), ages ranging from 3 to 16 years were. In this study, all patients with neurological deficits diagnosed as having a tethered cord were included.

The best way to collect a sample from a patient with Tethered Cord Syndrome (TCS) is to use a biological sample collection device that is capable of collecting a small volume of biological fluid in a controlled and sterile manner. Perform lumbosacral imaging, such as MRI, on all individuals with TCS to evaluate the degree of the problem. Neuraxial techniques are applicable for usage during birthing.

Outcome Measures

Age, weight, body mass index, and urodynamic abnormalities were among the key results analysed in this study, which gathered demographic data and information from multiple hospitals. Patients' symptoms were assessed using magnetic resonance imaging in addition to the patients' own observations of their symptoms. To assess the initial findings of the shape and location of the TSCS, doctors may use MRI to diagnose where the tethering is located, whether the patient's conus medullaris, the base of their spinal cord, is lower

than normal, or whether a tumour or fatty mass, known as a lipoma, is causing the. Regarding the secondary outcomes, where assessing the health outcomes of individuals using a distributed questionnaire to ascertain. Improvement of neurological deficiencies and return of urine function to normal. In this study, the initial results were identified, which witnessed significant development and improvement according to the neurological symptoms that occurred after surgery. A comparison was made according to a specific scale to determine the differences between before and after the surgical operation for Iraqi patients. As for the final results for the patients, which included complications in addition to length of time. The length of stay of patients in our hospital, where these complications were evaluated and classified according to a scale Clavien-Dindo.

Statistical Analysis

Demographic data were described and analysed according to the statistical analysis program SPSS Soft IBM 22. The variables in this research were evaluated as mean and standardized division. The percentage and frequency of patients were also identified. In addition, statistical differences were identified and defined as p-values < 0.05. Predictive values were also evaluated in this study by noting the factors that posed a greater risk to patients in secondary outcomes. The statistical relationship was also evaluated according to the type of correlation, whether positive or negative, in addition to the strength of the statistical relationship that was extracted.

Results

Table 1: General Characteristics of Patients

Variable	
Age (Mean±SD)	6.2±2.1
Median	4.5
BMI (mean±sd)	16±2.2
Symptoms	
Difficulty Walking, N (%)	7 (14)
Lower Back Pain N (%)	13 (26)
Numbness in the Legs N (%)	9 (18)
Radicular Pain in the Legs N (%)	9 (18)
Sensory Disturbances N (%)	1 (2)
Weakness N (%)	11 (22)
Abnormality Urodynamic	
Detrusor Over Activity N (%)	15 (30)
Detrusor Under Activity N (%)	7 (14)
Detrusor-Sphincter Dyssynergia N (%)	15 (30)
Urinary Incontinence N (%)	13 (26)
Shape	
Oval N (%)	15 (30)
Round N (%)	20 (40)
Tail N (%)	15 (30)
Total	50
Site	
Lumber N (%)	12 (24)
Lumbosacral N (%)	26 (52)
Sacral N (%)	12 (24)
Total N (%)	50 (100)
Skin	
Abnormal N (%)	10 (20)
Normal N (%)	40 (80)
Total N (%)	50 (100)

Table 2: Distribution of Patients According to Conus Location

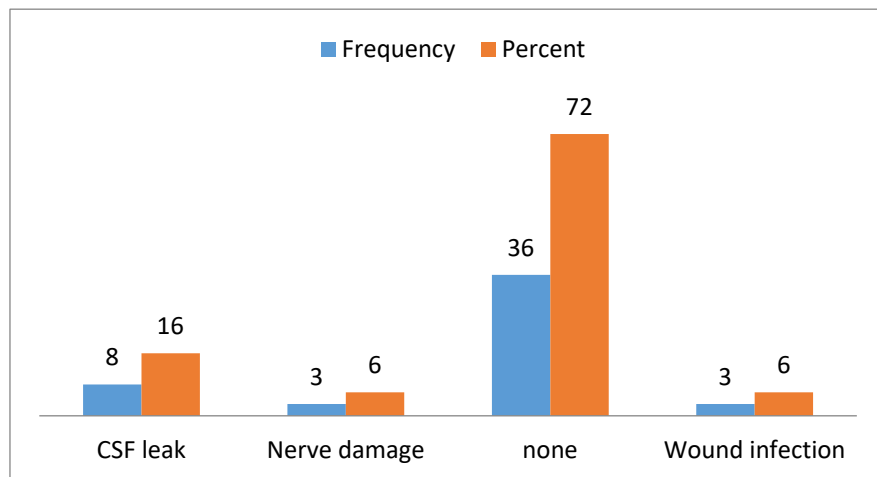
	Conus Location			
	Frequency	Percent	Valid Percent	Cumulative Percent
L3	1	2.0	2.0	2.0
L5	12	24.0	24.0	26.0
S1	21	42.0	42.0	68.0
S2-3	16	32.0	32.0	100.0
Total	50	100.0	100.0	

Table 3: Distribution of Patient According to Pathological Lesions

Descriptives ^b					
		Pathological lesions		Statistic	Std. Error
Age	Dorsal Type	Mean		33	1.77354
		95% Confidence Interval for Mean	Lower Bound	29.04	
			Upper Bound	36.9517	
	Lipomyelomeningocele	Median		33.0000	1.86264
		Std. Deviation		5.88218	
		Mean		31.5385	
		95% Confidence Interval for Mean	Lower Bound	27.4801	
			Upper Bound	35.5968	
		Median		31.0000	
		Std. Deviation		6.71584	
		Minimum		22.00	
	Thickened Filum Terminale	Mean		34.3077	1.87898
		95% Confidence Interval for Mean	Lower Bound	30.2137	
			Upper Bound	38.4016	
		Median		31.0000	
	Transitional	Std. Deviation		6.77476	1.86884
		Mean		33.2727	
		95% Confidence Interval for Mean	Lower Bound	29.1087	
			Upper Bound	37.4368	
		Median		34.0000	
		Std. Deviation		6.19824	
a. age is constant when pathological lesions = Conus li. It has been omitted.					
b. age is constant when pathological lesions = Intradur. It has been omitted.					

a. age is constant when pathological lesions = Conus li. It has been omitted.

b. age is constant when pathological lesions = Intradur. It has been omitted.

**Figure 1:** Evaluating Patient Outcomes According to Prevalent Complications**Table 4:** Evaluating Patients' Health Outcomes According to a Distributed Questionnaire

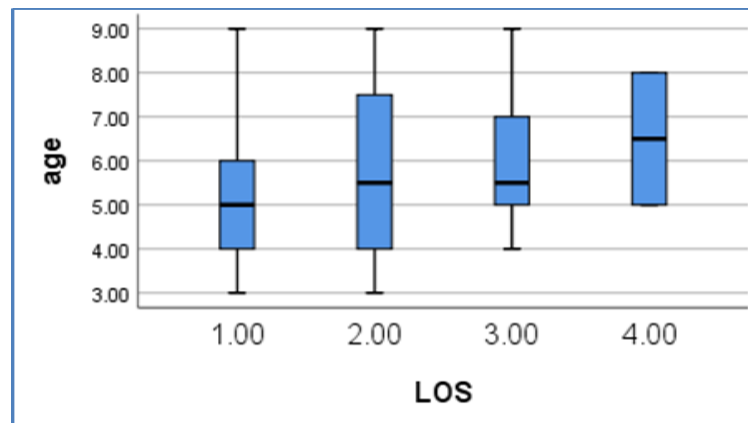
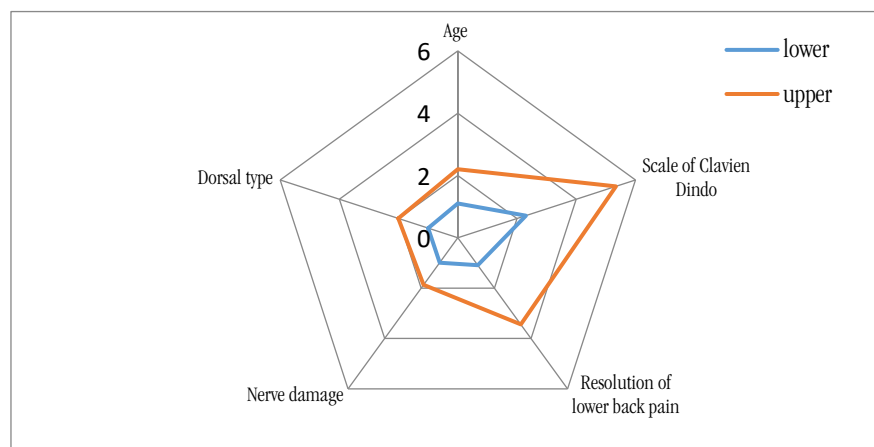
V	F	P %
Improvement in Neurological Deficits		
Yes	9	18.0
No	41	82.0
Normalization of Urinary Function		
Yes	12	24.0
No	38	76.0
Resolution of Lower Back Pain		
Yes	6	12.0
No	44	88.0
Improvement in Lower Extremity Weakness		
No	10	20.0
Yes	40	80.0

Table 5: Evaluating the Relationship Between Early Diagnosis of Patients and Improved Outcomes

Correlations				
Spearman's Rho	age	Correlation Coefficient	1.000	LOS
		Sig. (2-tailed)	.	.211
		N	50	50
	LOS	Correlation Coefficient	.180	1.000
		Sig. (2-tailed)	.211	.
		N	50	50

Table 6: Describe Outcomes of Patients According to Clavien Dindo

Pathological Lesions * ClavienDindo Crosstabulation					
		Count			
		Clavien Dindo			Total
		I	II	III	
Pathological Lesions	Conus Lipoma	0	1	0	1
	Dorsal Type	6	4	1	11
	Intradural Lipoma	1	0	0	1
	Lipomyelomeningocele	8	5	0	13
	Thickened Filum Terminale	10	3	0	13
	Transitional	7	4	0	11
Total		32	17	1	50

**Figure 2:** The Effect of Age on the Length of Stay in Hospital**Figure 3:** To Risk Analysis in Logistics Systems

Discussion

Occult Tethered Cord Syndrome" occurs due to a malformation that forms when the spinal cord is incompletely developed (usually in the lumbar region) by fixing the spinal cord and provokes mechanical tension and damage to the spinal cord and spinal canal. The clinical picture of a fixed spinal cord with latent spina bifida may appear from birth, but most patients develop symptoms and signs in the first twenty years of life, especially during adolescence. Sometimes, the diagnosis is made when the patient undergoes investigations for other reasons. Diagnosis requires tests such as magnetic resonance imaging (MRI), computed tomography (CT) scans, or X-rays of the spine in the area of fixation. In this study, 50 patients were collected, ages ranging from 3 to 16 years, with mean S.D. 6.2 ± 2.1 . According to the data extracted from the patients, lower back pain was found to be the most common symptom in this study for 13 patients with 26%, numbness in the leg for nine patients with 18%, followed by weakness for 11 patients with

22%. According to a previous study that, urodynamic studies are important in evaluating and understanding the urological abnormalities associated with tethered cord syndrome were found that urodynamic studies can identify neuropathic characteristics and predict the risk of upper urinary tract injury in children with tethered cord syndrome [27]. According to [28], it is reported that adults with tethered cord syndrome may have irreversible urodynamic findings, and surgical release of the tethered cord may not always lead to improvement and as Vassilyadi et al's [29] study focused the high incidence of bladder dysfunction in children with tethered cord syndrome and emphasized the importance of pre-and postoperative urodynamic evaluations [28, 29]. In a study [30] it is suggested that urodynamic studies are useful for diagnosis and follow-up in patients with tethered cord syndrome, and spinal cord untethering can have a positive impact on urological status in most patients. In our study, we provide insights into the shape of tethered cord syndrome, which found that dense adhesions at the lowest laminae and the site of previous

repair were common findings in patients with tethered cord syndrome following myelomeningocele repair, and the most common relevance was round shape for 20 patients with 40%, followed Oval and Tail with same distribute 15 patients with 30% our study provides insights into the pathological lesions of Mother Tether Cord Syndrome (TCS), which we can define TCS is a stretch-induced functional disorder of the spinal cord caused by its caudal portion being anchored by an inelastic structure.

The most common tethering lesions in TCS include Lipomyelomeningocele and Thickened filum terminale, with the same distribute for 13 patients (26%), followed by Dorsal type for 11 patients and 22 % our study provides insights into the complications of Tethered Cord Syndrome (TCS), where it found that surgical management of TCS in adults improved pain and neurological status in the majority of patients, although those who had undergone previous intradural detethering procedures had poorer outcomes and the various causes and clinical manifestations of TCS, including radiographic findings and associated signs and symptoms. Our paper refers to surgical management is effective in improvement symptoms and neurological status in patients with TCS, but outcomes may be influenced by previous procedures, and early intervention is crucial. Finally, our study insights into the relationship between early diagnosis of patients and improved outcomes in different medical conditions. Where focuses highlight the importance of early diagnosis and treatment in improving outcomes for patients. Early diagnosis of patients with Mother Tether Cord Syndrome (TCS) can lead to improved outcomes. We found a direct relationship between early surgical intervention in TCS patients, especially in those with orthopedic manifestations, resulted in satisfactory results. Also emphasized the importance of early operative intervention in TCS patients, which was associated with improved outcomes and pain relief.

Conclusion

This study reinforces the critical role of early diagnosis and laboratory-based pathological evaluation in the management of Tethered Cord Syndrome (TCS), particularly in pediatric patients. TCS, as a progressive neurological disorder rooted in congenital spinal anomalies, presents diagnostic challenges that demand a multidisciplinary approach. The combination of advanced imaging techniques and intraoperative findings remains foundational; however, the integration of histopathological analysis offers additional diagnostic precision that can inform surgical planning and long-term management. Histological examination of tethering structures, such as the filum terminale, reveals key pathological features—fibro collagenous thickening, lipomatous infiltration, gliosis, and vascular congestion—that provide insights into the chronicity and severity of cord tension. These findings not only validate clinical suspicion but also support intraoperative decisions regarding the adequacy of detethering and the risk of recurrence. Moreover, this study highlights the potential for developing a more robust diagnostic protocol that incorporates both radiological measurements and pathological assessment to improve prognostic accuracy. Early surgical intervention, guided by imaging and confirmed through pathology, has shown promising outcomes in preserving motor function and relieving pain, although improvements in urological symptoms remain variable and may require further targeted study. In conclusion, the integration of clinical, radiological, and pathological data enhances the understanding and treatment of TCS. The findings underscore the need for standardized diagnostic workflows that include laboratory pathology in both preoperative evaluation and postoperative confirmation. Such an approach not only supports more accurate diagnosis and improved surgical outcomes but also aligns with the broader goals of laboratory medicine in advancing patient care through evidence-based, multidisciplinary collaboration.

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