FREQUENCY AND CHARACTERISTICS OF TARLOV CYSTS ON MAGNETIC RESONANCE

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Abstract

Background: Tarlov cysts (TCs) are perineural cysts that are most often found at the level of the sacral spine and arise between the covering layers of the perineurium and endoneurium near the dorsal root ganglia.
Aim: The research was aimed at establishing the prevalence, characteristics and visualization of TCs on certain magnetic resonance (MR) sequences of the lumbosacral spine.
Methods*:* The study included 267 patients who underwent an MR of the lumbosacral spine in the period from January 2022 to the end of October 2023 at the radiological diagnostic center of the "S.Tetik" Health Institution in Banja Luka, and in whom MR examination verified one or more TCs.
Results: The prevalence of TCs in the study was 24.2%, with a female predominance 73.4%. Unifocal cyst frequency was 56.18%. The average number of cysts per patient was 1.85±1.32, with a maximum of 8 cysts in a single patient. TCs occurred most often at S2 level (49.7%). The mode of antero-posterior (AP) dimension of TCs was 5 mm, while the cranio-caudal (CC) was 6mm. Visualization was statistically significantly better with the T2 than with the T1 TSE sequence.
Conclusion: The prevalence of TC in our population is slightly higher compared to the results of other studies. They occur more frequently in women. Unifocal TCs occur more often than multifocal. The most common location of TCs is at S2 level and they are predominantly CC-ly oblong in shape. T2 TSE is a significantly more sensitive sequence for detecting TCs compared to T1 TSE.

Key words: Tarlov cyst, sacral perineural cyst, incidence, visualization, magnetic resonance imaging.

Introduction

Tarlov cysts (TCs) are perineural cysts that are most often found at the level of the sacral spine, and arise between the covering layers of the perineurium and endoneurium near the dorsal root ganglia [**Error! Reference source not found.**]. They were first described by the American neurosurgeon Isadore Max Tarlov in 1938[2]. TCs are saccular lesions filled with cerebrospinal fluid (CSF). They have walls of membranous tissue with peripheral nerve fibers and ganglion cells embedded in connective tissue [3].

Most TCs are found incidentally during computerized tomography (CT) or magnetic resonance (MR) examinations performed for other reasons [4]. They are usually benign, asymptomatic lesions, but they can present with a clinical picture that includes: back pain, coccyx pain, low radicular pain, bowel or bladder dysfunction, leg weakness, and sexual dysfunction [5]. They can be seen as single or multiple lesions. According to Nabors classification, spinal cysts are divided into 3 types. TCs are type II lesions that are defined as extradural meningeal cysts with nerve fibers [6]. According to a meta analysis, the most common position of the TC is the sacral canal, especially at S2 level, and they occur significantly more often in female populations [7].

Specific radicular pain may be the result of distortion, compression or stretching of the nerve root due to the space occupied by the TC. When the cysts are large enough to compress the adjacent nerve root, motor deficits occur [8]. Regional complications of TC include: local infection, CSF leakage with possible fistula development [9]. The etiology of these cysts is not well understood; some current theories to explain this phenomenon include: increased CSF pressure, filling of congenital cysts with unidirectional valves, and inflammation in response to trauma and disease [10]. TCs created by expanded sheaths usually have microconnections with the subarachnoid space. However, the pulsating and hydrodynamic forces of the CSF, through a one-way ball valve mechanism cause these perineural cysts to fill and enlarge [11]. Giant TCs are symptomatic with back or leg pain as the most common symptom that is worsened by walking, standing and coughing. Bed rest alleviates the discomfort [12]. The largest TC reported in the literature so far was 20 cm in size [13]. In rare cases, these cysts can extend extensively around the involved nerves and reach the presacral space and can also cause abdominal pain [14].

TCs are often overlooked due to several factors. They are considered clinically irrelevant findings and it is assumed that TCs are clinically difficult to establish as the cause of pain. They are therefore usually underreported by radiologists, and other degenerative conditions of the spine are usually blamed as the cause of the patient's symptoms [15]. In patients with TCs, plain radiographs are usually normal. However, they may reveal characteristic bony erosions of the spinal canal or the anterior or posterior neural foramina [16]. Native CTs scans show them as cystic masses in the area of the sacral foramina, iso-dense with CSF [17]. It is possible to notice the enlargement of the sacral canal and the erosion of the posterior elements of the sacrum as a result of increased pressure in the perineural cyst [18]. The advantages of MR over CT examination in the sacral region include better resolution of tissue density, the absence of bony interference, and superior resolution of the reconstructed images in any plane without exposure to ionizing radiation. Therefore, MR scanning significantly improves the radiological diagnosis of this entity [19]. TCs show a low signal on T1-weighted images and a high signal on T2-weighted images, similar to CSF [4]. They are best observed with a T2-weighted MR sequence [11].

The aim of this study was to establish the prevalence, characteristics and visualization of TCs on certain magnetic resonance (MR) sequences of the lumbosacral spine.

Examinees and methods

This research had the character of a retrospective study, conducted at the radiological diagnostic center of the "S.Tetik" Health Institution in Banja Luka. The study included all patients who underwent an MR examination of the lumbosacral part of the spine in the period from January 2022 to the end of October

2023, and in whom MR examination verified one or more TCs. This study encompassed 1102 patients who underwent MR of the lumbosacral spine, and of these 267 subjects had pathological findings in the form of perineural sacral cysts. Patients whose MR examinations were not adequate for interpretation due to the presence of artifacts, as well as those whose sacrum was not shown in its entirety on diagnostic images, were excluded from the study. For patients who underwent an examination more than once in the given period of 22 months, all examinations performed before the most recent date were excluded from the study, and only the latest examination performed in the given time period was included in the study. Their MR images are stored in the PACS (Picture Archiving and Communication System) system of the Clinic, whilst the written results, interpreted by one of three radiologists, are kept in the Hospital Information System (HIS).

MR examinations were performed on a "Siemens Magnetom Sempra 1.5T" MR device, and the protocol included: the localizer in three planes (sagittal, coronal and transverse plane), T2 TSE sagittal sequence, T1 TSE sagittal sequence, T2 STIR sagittal sequences, T2 TSE coronal sequences and T2 TSE msma transverse sequences. The study analyzed: the age and gender structure of the subjects, the number of individual TCs per patient, and the localization, size and visualization on T1 TSE and T2 TSE sequences. The imaging parameters used for the T2 TSE sequences were: 3130-3750 ms time of repetition (TR); 87 ms time of echo (TE); 120° flip angle (FA); 384x384 matrix size; 320 mm field of view (FOV); with 4mm slice thickness and 0.8 mm (20%) slice gap. The imaging parameters used for the T1 TSE sequences were: 400-700 ms TR; 9.9 ms TE; 120° FA; 256x320 matrix size; 320 mm field of view (FOV); with 4mm slice thickness and 0.8 mm (20%) slice gap. The localization of TC was determined on the basis of the level of the spinal vertebra next to which the cyst was located and on the basis of laterality in terms of the side of the body (left/right) where the lesions were located. The size of the cyst was measured in the antero-posterior (AP) and cranio-caudal (CC) directions and expressed in mm. From the arithmetic mean of these- dimensions, it was established whether the cysts were more often round or oblong in shape. In determining the quality of TC visualization on T1 and T2 sequences, a numerical scale from 1 to 3 was used, as follows: 1 indicates that the cyst is visualized poorly or not visualized at all on the given sequence; 2 indicates that the cyst is well visualized, but that its borders are not clearly visible; 3 indicates that the cyst is visualized with clearly visible borders (Image 1).

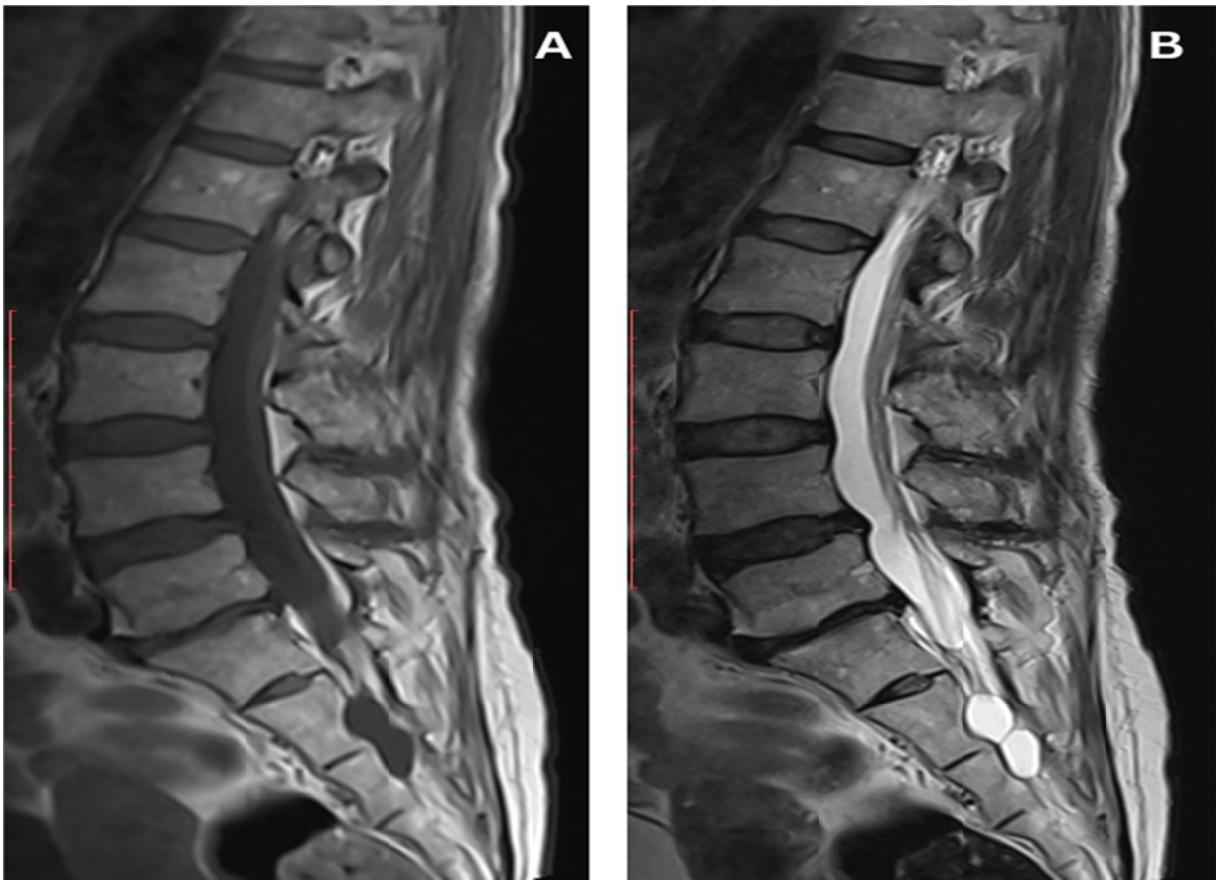

Image 1. MR view of two Tarlov cysts in the sacral canal, which are well visualized on T1 TSE sagittal sequence, but their borders are not clearly visible (A), while on T2 TSE sagittal sequence, the same cysts are visualized with clearly visible borders (B)

Statistical analysis: The collected data were stored in the commercial program Microsoft Excel database. In the standard analysis, standard descriptive statistical methods were used (mean values and standard deviation) and standard statistical parameters. The study tested differences in the frequency of TCs between men and women, and the differences in sensitivity of T1 and T2 TSE sagittal MR sequences in visualization of TCs. The statistical hypotheses were tested on a level of significance of a=0^5; that is, differences on the level of $p<0.05$ were deemed significant.

Results

In this retrospective study, that ran from January 2022 to the end of October 2023, the presence of one or more TC was verified in 267 (24.2%) of 1102 patients who underwent MR of the lumbosacral spine. Of the 267 respondents, 71 (26.6%) were male, and the other 196 (73.4%) were female. The difference between these groups is highly statistically significant at the level of 99.9% ($\chi^2=22.50$; df=1; $p<0.001$), indicating that these cysts occur significantly more frequently in the female population. The study included 431 male patients, of whom 71 (16.47%) had TC present, and 671 female patients, of whom 196 (29.21%) had TCs. This represents a highly statistically significant difference ($\chi^2=22.50$; df=1; $p<0.001$), indicating that TCs occur significantly more frequently in women than in men. The average age of all the subjects with a TC was 56.77±13.57 years (the youngest patient was 16 and the oldest 86 years old); the average age of the male subjects was 54.97±14.94 years, and of female subjects 57.42±13.02 years. Table 1 shows that the largest number of positive subjects, 37.5% (100 respondents), were in the 60 to 74 years age group, while the smallest number, 2.2% (6 respondents), were in the 19 to 29 years age group. Additionally, only one positive subject (0.4%) was in the up to 18 years age group.

Table 1. The distribution of subjects according to age groups

			Age groups						Total
			0-18	19-29	30-44	45-59	60-74	75-90	
Gender	Male	F	0	4	16	23	20	8	71
		%	0.0%	5.6%	22.5%	32.4%	28.2%	11.3%	100.0%
	Female	F	1	2	32	64	80	17	196
		%	0.5%	1.0%	16.3%	32.7%	40.8%	8.7%	100.0%
Total		F	1	6	48	87	100	25	267
		%	0.4%	2.2%	18.0%	32.6%	37.5%	9.4%	100.0%

We can observe that the frequency of unifocal cysts was significantly higher compared to multifocal cysts. Specifically, 56.18% or 150 patients had unifocal cysts, while multifocal cysts were present in 43.82% or 117 patients. The highest number of TCs per patient was 8, in both males and females. When it comes to the frequency of multifocal versus unifocal cysts, there was a statistically significant difference between these two groups (χ^2=4.35; df=1; $p<0.05$), indicating that unifocal cysts occur significantly more often than multifocal TCs. In the sample of male patients (71 subjects), 41 (58%) had unifocal cysts, while 30 (42%) had verified multifocal TCs. In the sample of female patients (196 subjects), 109 (56%) had unifocal cysts, and 87 (44%) had verified multifocal TCs. Regarding the occurrence of multifocal cysts, there were no statistically significant differences by gender (χ^2=0.02; df=1; $p>0.05$), meaning that both men and women were approximately equally likely to have either unifocal or multifocal cysts.

Table 2 shows that out of 267 subjects, 61 subjects (22.8%) had two TCs verified, 29 (10.9%) had three TCs, 14 (5.2%) had four TCs, 4 (1.5%) had five TCs, 5 (1.9%) had six TCs, while 2 subjects each had 7 and 8 TCs verified. Among the 267 patients with the confirmed presence of TCs, a total of 495 individual cysts were found, averaging 1.85±1.32 cysts per patient.

Table 2. Frequency of multifocality of Tarlov cysts according to gender

	Number of Tarlov cysts per subject								
Gender	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Male	41	17	7	4	0	1	0	1	71 (26.6%)
Female	109	44	22	10	4	4	2	1	196 (73.4%)
Total	150 (56.2%)	61 (22.8%)	29 (10.9%)	14 (5.2%)	4 (1.5%)	5 (1.9%)	2 (0.7%)	2 (0.7%)	267 (100%)

TCs occurred from the L5 vertebra to the coccyx, with the highest frequency of TCs found at the level of the second sacral vertebra, where 246 (49.7%) of the 495 cysts were located. They also occurred relatively frequently at the levels of the S1 and S3 vertebrae. The total number of TCs located at S1 level was 88 (17.78%), and at S3 level 49 (9.9%). The distribution of the localization of cysts was statistically different at a highly significant level (χ2=885.16; df=8; $p<0.001$) and we can say with high statistical certainty that their distribution differed from the hypothetical uniform distribution (Figure 1).

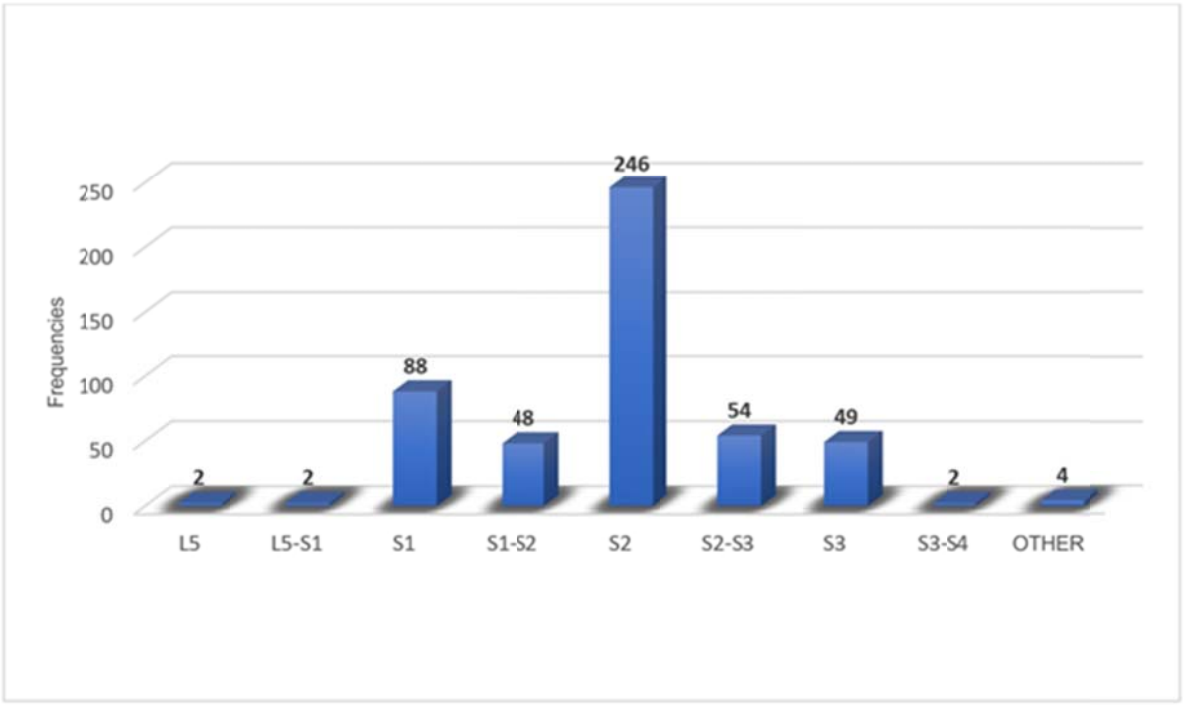

Figure 1. The localization of Tarlov cysts in relation to the vertebral segments. "OTHER" refers to 4 cysts that were much larger and were localized in the following areas: L5-Coccyx; S1-S3; S1-S4; and S4-Coccyx

When it comes to the localization of cysts in terms of side of the body (left/right), 230 (46.5%) TCs were located on the left side of the body, while 236 (47.7%) were located on the right side of the body, with 29 TCs having a central location. From this, we determined that there was no statistically significant difference between the location of cysts in relation to their lateralization ($\chi 2=0.08$; df=1; P>0.05).

When it comes to the dimensions of individual cysts, we observed that the mode of AP dimension was 5 mm, while the arithmetic mean was slightly different at 6.86±4.13 mm. In the CC projection, the situation was similar, with a mode of 6 mm, but the arithmetic mean was higher at 9.71±7.51 mm. This indicates that the TCs were generally elongated in the CC direction. In the AP dimension, there was no statistically significant difference in the size of TCs between genders (t=-0.80; df=492; p>0.05). The smallest TC measured in the AP section was 2 mm in both genders, while the largest was 25 mm in a female patient and 33 mm in a male patient. Similarly, in the CC dimension, there was no statistically significant difference in size between genders (t=0.45; df=142; p>0.05). The smallest cyst measured in the CC section was 2 mm in both genders, while the largest was 54 mm in a female patient and 117 mm in a male patient. The largest TC was found in a male subject, with dimensions of 33 mm in AP diameter and 117 mm in CC diameter (Image 2).

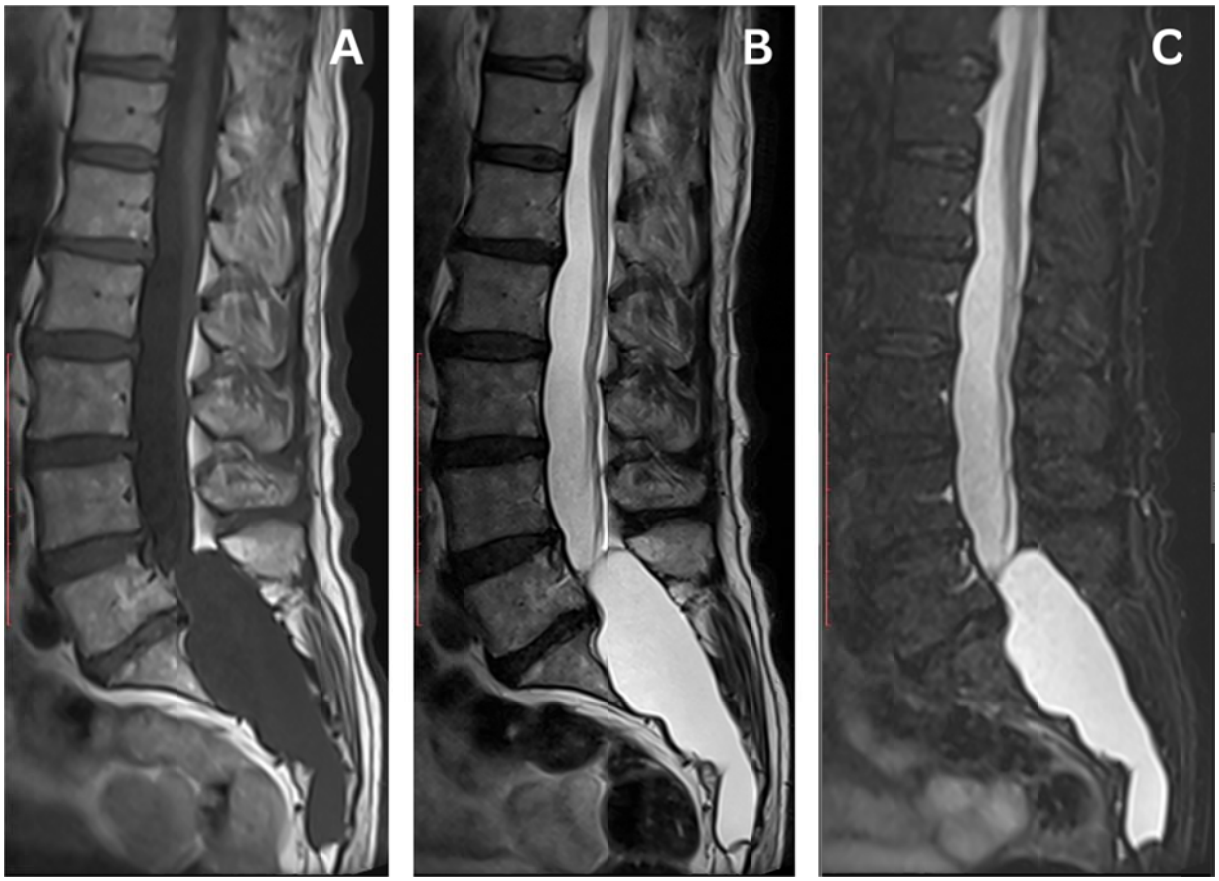

Image 2. The largest Tarlov cyst detected in this study extended from the L5 vertebra to the os coccyges. The lesion was shown on the following sequences: (A) T1 TSE, (B) T2 TSE, and (C) T2 STIR sagittal sequence

The visualization of detected lesions was compared between T1 TSE and T2 TSE sagittal sequences. Out of 267 patients with identified TCs, 63 (23.60%) had TCs poorly or not at all visualized on the T1 TSE sagittal sequence, while none of the cysts were poorly or not visualized on the T2 TSE sagittal sequence. Additionally, 97 (36.33%) patients had TCs with poorly defined boundaries on the T1 TSE sequence, compared to 33 (12.36%) on the T2 TSE sequence. TCs with clearly visible boundaries were found in 107 (40.07%) patients on the T1 TSE sequence and in 234 (87.64%) patients on the T2 TSE sequence (Figure 2). There was a highly significant statistical difference (χ^2=141.81; df=2; p<0.001) in the visualization between T1 and T2 TSE sagittal sequences, showing that T2 TSE is a significantly more sensitive sequence for detecting TCs compared to T1 TSE.

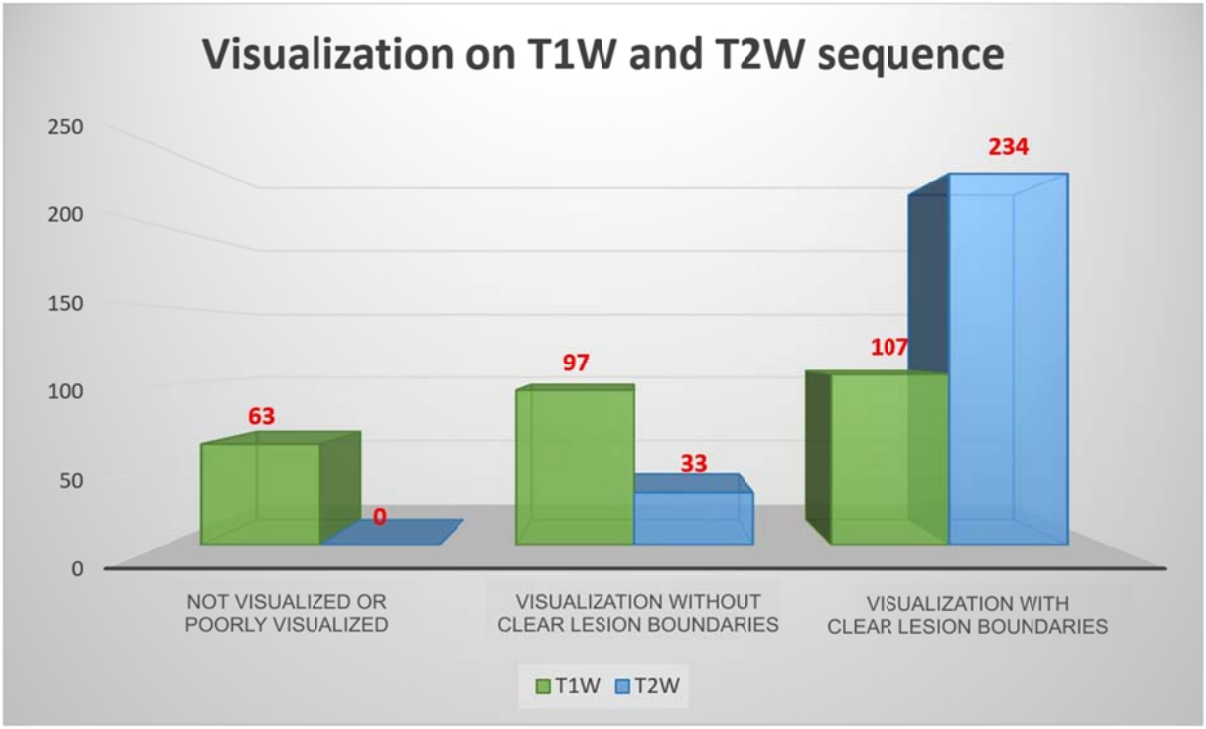

Figure 2. Visualization of Tarlov cysts on T1W and T2W sequences

Discussion

In some cases, because of the anatomic location of TCs near an additional pathology, there may be confusion as to whether the cyst is responsible for symptoms or not [20]. MR imaging studies of the lumbosacral spine often result in the discovery of benign lesions. One of the most common incidental lumbosacral lesions is perineural cysts [21]. A study conducted in France found TCs in 132 (13.2%) of 1,100 patients who underwent MR of the sacral spine, with a female predominance of 67.7%. The average age of subjects was 59 ± 15.8 years, and TC prevalence increased with age; no cysts were found in subjects under 18 [22]. In the study by Shoyab (2021), 384 patients had undergone spinal MR for back pain, and 25 of them (6.51%) had TCs [23]. Similarly, Kozłowski et al. (2021) found TCs in 9% (286) of 3,128 spinal MR examinations, with a higher prevalence in women (218 cases) than in men (68), and a mean age of 54.8 years [24]. Consistent with previous studies, Baig et al. (2023) found a predominance of females (66.67%) among 60 patients with TCs [25]. In contrast to the higher prevalence reported by others, Langdown et al. (2005) reported a notably lower prevalence of TCs, identifying only 54 patients (1.5%) out of 3535 who underwent lumbosacral MR. Of these, 70% were women, with a mean age of 54.4 years [20]. Hulens et al. (2021) presented a study involving a total of 197 patients with fibromyalgia (FM), chronic fatigue syndrome (CFS), or both, who underwent MR. TCs were observed in 77 patients (39%), with an average size of 11.8 mm. Consistent with previous studies, the average age of patients with TCs was 50.3 years. In males, the prevalence was 12%, compared to 42% in females [26]. Aligning with previous studies, in a meta-analysis of 13,266 subjects by Klepinowski et al. (2021), the global pooled prevalence of TCs was 4.18% (95% CI 2.47-6.30). TCs were more common in women than in men (5.84% vs 3.03%) [7]. In contrast to previous studies, Potts et al. (2016) presented a study involving 35 patients with symptomatic sacral TCs, showing the highest female predominance at 83%. [27]. In the present research, we verified the presence of TCs in 24.2% (247) of patients who underwent MR of the lumbosacral spine. This prevalence is significantly higher than the ranges reported in the previous literature, which spans from 1.5% to 13.2% [7, 20, 22, 23, 24]. Notably, only Hulens et al. (2021) reported a higher prevalence, of 39%, likely due to their focused sample of patients with fibromyalgia (FM) or chronic fatigue syndrome (CFS), and the smaller sample size [26]. Our findings not only corroborate previous studies but also suggest that TCs may be more prevalent than previously recognized,

indicating a need for increased awareness in clinical assessments. Of the 267 subjects with TCs, 26.6% were male and 73.4% were female. TCs were present in 16.47% of male patients and 29.21% of female patients. These findings align with previous research, reinforcing the notion that TCs occur significantly more frequently in females [7, 20, 22, 24, 25, 26, 27]. In the current study, the average age of all the subjects with a TC was 56.77±13.57 years (the youngest patient was 16 and the oldest 86). The largest number of positive subjects, 37.5% (100 respondents), were in the 60 to 74 years age group, while only one subject (0.4%) was in the up to 18 years age group. These results are consistent with prior findings, suggesting that TC prevalence increases with age, likely due to cumulative exposure to potential risk factors or age-related anatomical changes [20, 22, 24, 26].

Studies on TCs have consistently identified the sacral canal as the primary location for these cysts, particularly at S2 and S3 levels. Occasionally, they also appear at cervical, thoracic, and lumbar levels [28]. In the study by Shoyab (2021), 60% of subjects showed TCs located at S2/S3 level [23]. Similarly, Feigenbaum and Boone (2015) reported in their study that the most common nerve roots where TCs were found were S2 and S3 [29]. In the research conducted by Caspar et al. (2003), out of 16 symptomatic TCs, nine TCs were located at S2, six at S1 and one at S3 level [12]. Consistent with previous studies, in a meta-analysis Klepinowski et al. (2021) found that the frequency of sacral TCs strongly prevailed over other segments, with the S2 level being the most common (46.7%) [7]. In the present study, we observed that TCs occur from the L5 vertebra to the coccyx, with 49.7% of TCs occurring at the S2 level. Our findings align with prior research, reinforcing the sacral region, especially the S2 vertebra, as the predominant site for TCs [7, 12, 23, 28].

TCs are often multiple and occur in different locations (unilateral, central, bilateral or combined) [20]. In the study by Shoyab (2021), single cysts were found in 72% of cases, while 28% had multiple/bilateral cysts [23]. Similarly, Potts et al. (2016) reported a single TC in 60% of subjects and multiple TCs in the remaining 40% [27]. Lucantoni et al. (2011) also found that TCs were multiple in 32% of cases [5]. A study by Murphy et al. (2016) found that among 213 patients treated for TCs, the number of cysts ranged from 2 to 9, averaging 3 lesions per patient with bilateral cysts [30]. In contrast, the study by Kuhn et al. (2017) showed that the average number of TCs per patient was 2.0±1.2 (95% CI: 1.8-2.2), with a maximum of 6 cysts per patient [22]. In the present study, we observed a significantly higher incidence of unifocal cysts, with 56.18% of patients having unifocal cysts. This finding aligns with previous studies that indicate that unifocal TCs occur statistically significantly more frequently than multifocal ones [5, 23, 27]. However, our study also recorded the highest incidence of multifocal TCs compared to other research. The results obtained are most similar to those of Potts et al. (2016), whose study included a significantly smaller sample of patients with symptomatic TCs [27]. In our study, the average number of TCs per patient was 1.85±1.32, similar to the results of Kuhn et al. (2017) [22]. The highest number of TCs recorded per patient was 8, which is similar to the results published by Murphy et al. (2016) [30]. Regarding cyst localization (left/right), 46.5% were found on the left side, 47.7% on the right, and 29% were central. Previous studies did not provide statistical data on the lateralization of TCs, but our results confirm that TCs can occur in various locations, as noted by Langdown et al. (2005) [20].

TCs can vary significantly in size, with some being as small as a pinhead [2]. Potts et al. (2016) stated that the mean TC size was 3.6 cm (median 3.5 cm, range 1.0–7.9 cm) [27]. In the study by Kozłowski et al. (2021), the average TC CC diameter was noted to be 11.72 mm [24]. Similarly, in the results by Kuhn et al. (2017), the average diameter (long axis) per TC was 12.8 ± 5.6 mm (95% CI: 11.9-13.8mm) [22]. Shoyab (2021) noted that TC diameters were prominently higher in the CC dimension than AP or transverse diameters [23]. In contrast to previous studies, Kuhn et al. (2017) classified the shape of 80.2% of TCs as rounded or oval, while 19.8% were lobular or tubular [22]. Wang et al. (2018) stated that in rare cases TCs can expand extensively around the involved nerves and reach the presacral space, and cause abdominal pain [14]. The largest TC (20 cm) was reported in a case by Paterakis et al. (2019) and was described in a patient with Marfan syndrome [13]. In the present study, we observed found that the mode of AP dimension of TCs was 5 mm (mean 6.86 ± 4.13 mm), while the mode of CC dimension was 6 mm

(mean 9.71 ± 7.51 mm), indicating that the TCs were generally elongated in the CC direction. These results are similar to those published by Kuhn et al. (2017) and Shoyab (2021) [22,23]. In the present study, the largest TC was found in a male subject, measuring 33 mm in the AP diameter and 117 mm in the CC diameter. These results indicate that TCs can develop to significant sizes, as noted by Paterakis et al. (2019) [13].

All patients suspected of having symptomatic TCs should be evaluated with MR, as TCs are best observed using T2-weighted sequences. In these scans, the cysts display CSF intensity signals and appear as expanded, fluid-filled spaces adjacent to the spinal canal [11]. Dimitroulias et al. (2007) reported that perineural cysts were of uniform high signal on T2-weighted images with a thin rim of signal void around them. On T1-weighted images, the masses showed an intermediate signal. After intravenous gadoliniumdiethylene-triamine-penta-acetic acid (Gd-DTPA) there was no evidence of signal intensity enhancement. The signal from the masses mirrored that of CSF, suggesting that they were cysts filled with CSF [31]. Similarly, Burdan et al. (2013) reported that all the perineural spinal cysts observed were visible on the level of the intervertebral foramens or inside the sacral canal as oval or circular uniform structures, hyperintense on T2-weighted and hypointense (or intermediate) on T1-weighted sequences. Their signal corresponded to the CSF in the subarachnoid space surrounding the spinal cord or cauda equina, with a thin rim of signal void around them. In the case of GdDTPA injections, no contrast enhancement of the cyst was found [28]. Paulsen et al. (1994) also noted that cysts showed a low signal on T1-weighted images and a high signal on T2-weighted images, similar to CSF [4]. In the present study, TCs were poorly or not visualized at all in 23.6% of subjects on the T1 TSE sagittal sequence, while all TCs were clearly visualized on the T2 TSE sagittal sequence. TCs with clearly visible borders were observed in 40.07% of participants on the T1 TSE sequence and in 87.64% on the T2 TSE sequence. These results confirm the theory that T2-weighted MR sequences are superior in diagnosing TCs, as noted by Mummaneni et al. (2000) [11].

Conclusion

The prevalence of TCs in our population was slightly higher compared to the results of other studies. TCs occur more often in women than men. The most common location of TCs is at the level of the S2 vertebra, and they are predominantly CC-ly oblong in shape. Unifocal TCs occur more often than multifocal ones. T2 TSE is a significantly more sensitive sequence for detecting TCs compared to T1 TSE.

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