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RESEARCH ARTICLE

Magnetic resonance imaging assessment of the puborectalis muscle and anal sphincter in patients with anismus*

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ABSTRACT

Aim: This study aims to evaluate the significance of puborectalis muscle and anal sphincter thickness in the context of anismus.

Methods: We divided participants into three groups: patients with anismus (n=24), patients with pelvic floor dysfunction (PFD) (n=22), and a control group (n=24). On T2-weighted axial images, the thickness and circumference of both puborectalis muscles were measured at the level of the pubic symphysis, and the mean of these measurements was calculated. Additionally, the thicknesses of the external and internal anal sphincters were measured on T2-weighted axial magnetic resonance images at the level of the mid-anal canal, and the mean of these measurements was also calculated. Comparisons between groups were analyzed using ANOVA with post-hoc Tukey-HSD tests. ROC curve analysis was used to assess the diagnostic performance of key measurements, and interobserver agreement was evaluated using intraclass correlation coefficients (ICC).

Results: A total of 70 participants were included in the study, consisting of 24 patients with anismus (41.6% male), 22 patients with PFD (31.8% male), and 24 controls (45.8% male). Puborectalis muscle thicknesses were significantly higher in the anismus group compared to the PFD group, while the mean puborectalis thickness was significantly greater than that of the PFD group but not significantly different from controls. Additionally, the circumference of the puborectalis muscle was lower in the anismus group compared to the PFD group. ROC curve analysis indicated that puborectalis muscle thickness may potentially serve as a predictive marker for anismus, with an area under the curve of 0.667 (p=0.022). Good to excellent interobserver agreement was noted for the various measurements, with ICC values ranging from 0.762 to 0.970.

Conclusion: Our study suggests that puborectalis muscle and external anal sphincter measurements may aid in diagnosing anismus.

Keywords: Anismus, dyssynergic defecation, MR defecography, puborectalis muscle, sphincter

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INTRODUCTION

Anismus, also referred to as dyssynergic defecation, is a functional disorder characterized by obstructive symptoms and paradoxical contractions of the pelvic floor muscles (1). Anismus may develop due to the inability of the anal sphincter and/or puborectalis muscle to relax, or due to impaired abdominal and rectal pushing forces (2,3). Although innervated by different sources, the puborectalis muscle and external anal sphincter function as a unit (4). Patients with anismus often exhibit symptoms such as incomplete evacuation, the need for manual evacuation of stool, excessive straining, and prolonged evacuation time (5). Physiological tests such as manometry and electromyography are used for evaluating anismus; however, both false-positive and false-negative rates are high in manometry (1,3). In radiological evaluation, failure to observe the physiological 15-20° increase in the anorectal angle during defecation, prolonged evacuation time (greater than 30 seconds), and the presence of incomplete evacuation are assessed. The combination of these criteria allows for a radiological diagnosis of anismus (1,6-9). Magnetic resonance (MR) defecography also provides valuable information about accompanying pelvic floor abnormalities (2). However, there is no established reference standard for diagnosing anismus (3). Measuring static parameters, such as the thickness of the puborectalis muscle and anal sphincters at rest, may complement dynamic MR imaging by providing baseline structural insights that could refine the understanding of muscle abnormalities and their role in anismus pathophysiology.

The purpose of this study is to assess the role of the puborectalis muscle and anal sphincter thickness in anismus.

METHODS

This study protocol was approved by the Bolu Abant İzzet Baysal University Clinical Research Ethics Committee (approval date:26.06.2024, number:154). Due to the retrospective design of the study, the requirement for written informed consent was waived. This study was conducted in accordance with the principles outlined in the Declaration of Helsinki and reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (10).

Study design and participants

The anismus patient group was identified by searching MR defecography reports in the medical records of Bolu Abant İzzet Baysal University Training and Research Hospital from January 2014 to May 2024 using the keywords 'anismus' and 'dyssynergic defecation', resulting in the enrollment of 24 patients. A gender- and age-matched group of 22 patients with pelvic floor dysfunction (PFD) who had undergone MR defecography during the same period was also included. Additionally, 24 controls who underwent pelvic MR imaging for other reasons were recruited. Patients with inadequate imaging, a history of pelvic surgery or chemoradiotherapy, those under 18 years of age, and those with inflammatory bowel disease were excluded from the study.

Magnetic resonance imaging technique

MR images were obtained using a 1.5 Tesla MR imaging scanner (General Electric, Signa Explorer) with a phased-array body coil. After the instillation of 120-180 mL intrarectal sonographic gel in the decubitus position, sagittal, axial, and coronal T2-weighted images of the entire pelvis were acquired, along with mid-sagittal cine balanced/T2-weighted sequence images during squeezing, straining, and defecation, as recommended by the Society of Abdominal Radiology (7). The defecation phase was repeated at least three times to empty the rectum.

The routine pelvic MR protocol comprises sagittal, axial, and coronal T2-weighted images; axial T1-weighted images; diffusion-weighted images; and liver acquisition with volume acceleration (LAVA) sequences. Typical parameters of an axial T2 PROPELLER sequence include for MR defecography: TR 6000 ms, TE 120 ms, slice thickness/spacing of 4/1 mm, field of view 35 cm, acquisition matrix 320 × 320, and 4 excitations. For pelvic MR imaging: TR 4000 ms, TE 100 ms, slice thickness/spacing of 5/1 mm, field of view 32 cm, acquisition matrix 300 × 300, and 4 excitations.

Image interpretation

MR images were retrospectively evaluated by an experienced abdominal radiologist (ABY), and measurements were performed by two additional radiologists (AES, ST) who were blinded to the clinical data. On T2-weighted axial images, the thickness and circumference of both puborectalis muscles were measured at the level of the pubic symphysis, and the mean of these measurements was calculated (Figure 1). The thicknesses of the external and internal anal sphincters were measured on T2-weighted axial MR images at the level of the mid-anal canal, and the mean of these measurements was calculated (Figure 2).

Statistical analysis

Data analysis was conducted using the Statistical Package for the Social Sciences 24.0 software (IBM Corp., Armonk, NY, USA). Data distribution was assessed using the Shapiro-Wilk test. Descriptive statistics were reported as means with standard deviations for normally distributed variables and as medians with interquartile range (IQR) for others. Comparisons between the three groups were analyzed using one-way analysis of variance (ANOVA) test, followed by post-hoc test (Tukey-HSD). Since homogeneity of variances was violated, the Kruskal-Wallis test was used to compare right internal sphincter thickness and mean internal sphincter thickness. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the ability of mean puborectalis muscle thickness, puborectalis muscle circumference, and mean external sphincter thickness to distinguish anismus. Interobserver agreement between the measurements of the two radiologists was quantified using the intraclass correlation coefficient (ICC). ICC values were classified as follows: less than 0.49 indicated poor reliability, values from 0.50 to 0.75

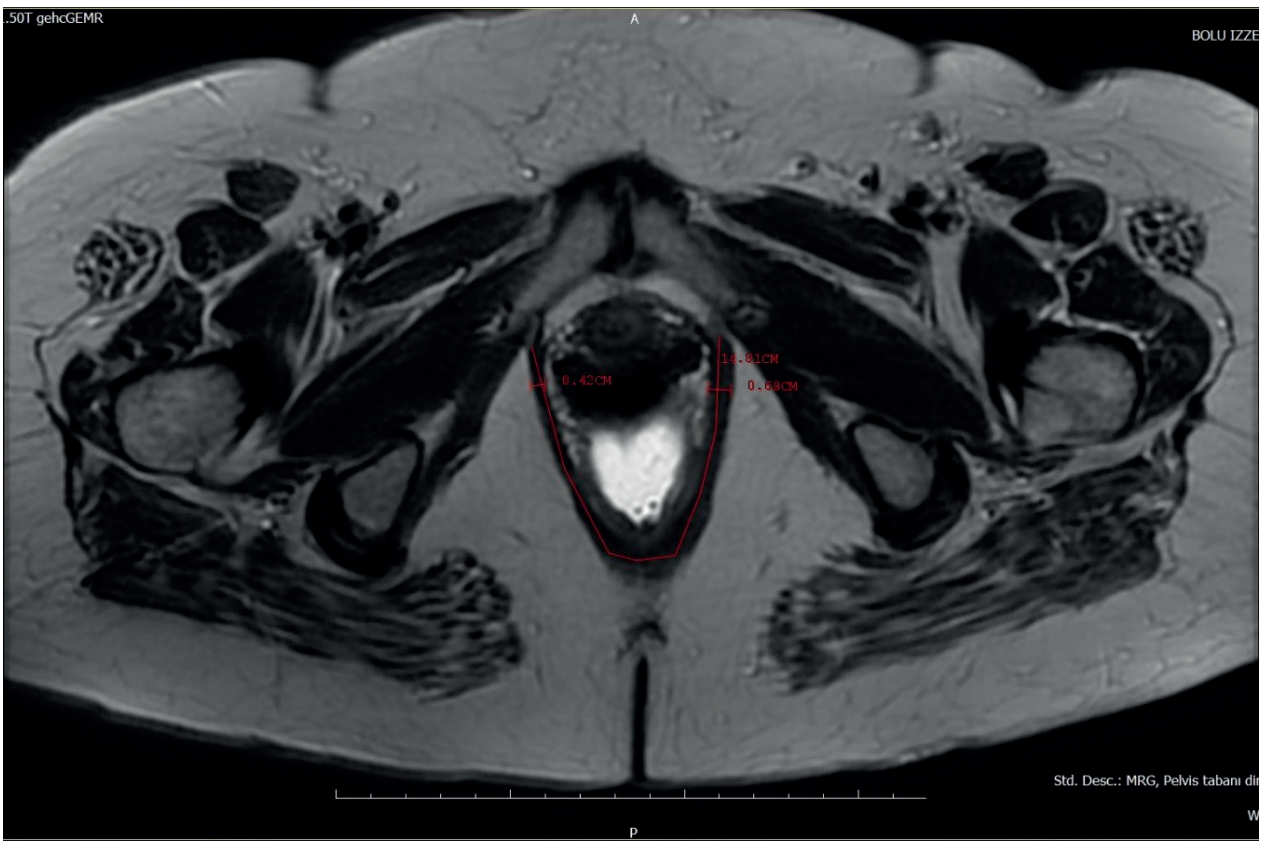

Figure 1. An example of measurements for puborectalis muscle thickness and circumference.

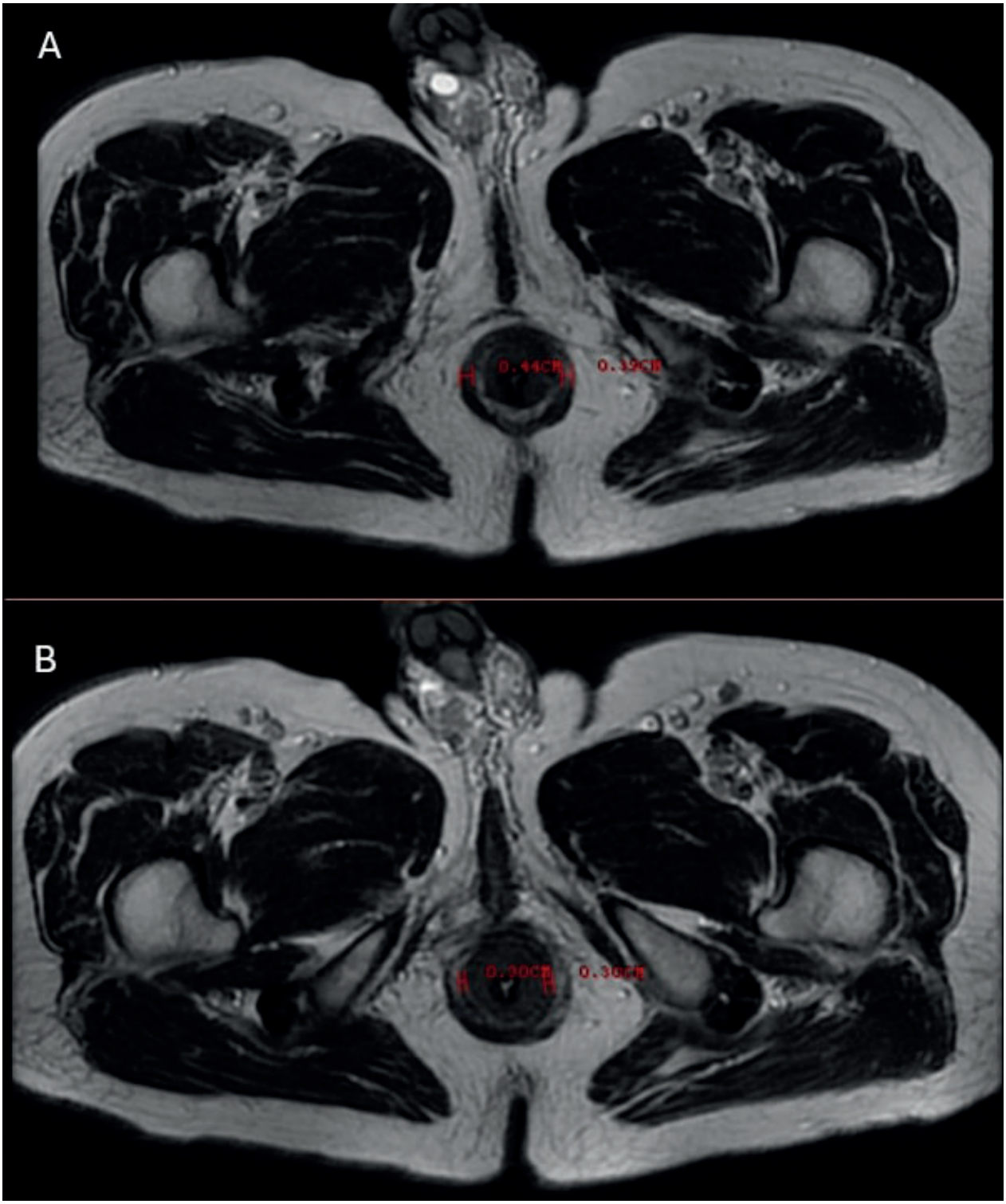

Figure 2. An example of measurements for external(A) and internal anal sphincter (B) thickness.

suggested moderate reliability, 0.75 to 0.89 reflected good reliability, and values between 0.90 and 1.00 indicated excellent reliability (11). The significance level was set to $p<0.05$ for all analyses.

RESULTS

The study included a total of 70 individuals, comprising 28 men and 42 women. The mean ages of the anismus, PFD, and control groups were 48.17 ± 13.8, 48.5 ± 14.4, and 48.21 ± 13.8 years, respectively, with no significant differences in mean age between the groups ($p=0.996$). The right puborectalis muscle thickness was significantly higher in the anismus group (6.04 ± 1.4 mm) compared to the PFD group (3.09 ± 1.3 mm, $p<0.0001$). However, it was significantly lower compared to the control group (7.04 ± 1.2 mm, $p=0.031$). The left puborectalis muscle thickness followed a similar pattern, as it was significantly higher in the anismus group (6.95 ± 1.7 mm) compared to the PFD group (3.23 ± 1.5 mm, $p<0.0001$), but not significantly different from the control group (7.17 ± 1.6 mm, $p=0.876$). The mean puborectalis muscle thickness in the anismus group (6.49 ± 1.5 mm) was significantly higher than in the PFD group (3.16 ± 1.3 mm, $p<0.0001$), but not significantly different from the control group (7.10 ± 1.3 mm, $p=0.274$). The puborectalis muscle circumference in the anismus group (104.90 ± 21.6 mm) was significantly lower than in the PFD group (126.55 ± 27.1 mm, $p=0.003$) but not significantly different from the control group (110.38 ± 14.5 mm, $p=0.654$).

Table 1. One-way analysis of variance (ANOVA) results

Parameter	Anismus group (n=24) Mean ± SD	Pelvic floor dysfunction group (n=22) Mean ± SD	Control group (n=24) Mean ± SD	Homogenity of variance test		One way ANOVA	
				Levene's statistic	p-value	F statistic	p-value
Age (years)	48.17 ± 13.8	48.5 ± 14.4	48.21 ± 13.8	0.107	0.899	0.004	0.996
Right puborectal muscle thickness (mm)	6.04 ± 1.4	3.09 ± 1.3	7.04 ± 1.2	0.580	0.563	53.817	<0.0001
Left puborectal muscle thickness (mm)	6.95 ± 1.7	3.23 ± 1.5	7.17 ± 1.6	0.026	0.974	43.651	<0.0001
Mean puborectal muscle thickness (mm)	6.49 ± 1.5	3.16 ± 1.3	7.10 ± 1.3	0.378	0.687	54.779	<0.0001
Puborectal mucle circumference (mm)	104.90 ± 21.6	126.55 ± 27.1	110.38 ± 14.5	2.627	0.080	6.211	0.003
Right internal sphincter thickness (mm)	1.76 ± 0.4	1,58 ± 0.2	1.78 ± 0.5	5.477	0.006*	1.999	0.144
Left internal sphincter thickness (mm)	1.75 ± 0.4	1.62 ± 0.4	1.73 ± 0.5	2.904	0.062	0.706	0.497
Mean internal sphincter thickness (mm)	1.76 ± 0.3	1.60 ± 0.3	1.75 ± 0.4	6.274	0.003*	1.482	0.235
Right external sphincter thickness (mm)	2.29 ± 0.6	2.46 ± 0.6	2.98 ± 0.8	1.249	0.293	6.716	0.002
Left external sphincter thickness (mm)	2.21 ± 0.5	2.28 ± 0.6	2.78 ± 0.8	3.059	0.054	4.477	0.015
Mean external sphinter thickness (mm)	2.25 ± 0.5	2.37 ± 0.6	2.84 ± 0.8	3.086	0.052	6.356	0.003

No statistically significant differences were detected among the three groups in terms of right, left, and mean internal anal sphincter thickness (p-values: 0.240, 0.497, and 0.235, respectively). Right and mean external sphincter thicknesses were statistically significantly lower in the anismus group (2.29 ± 0.6 mm and 2.25 ± 0.5 mm, respectively) compared to the control group (2.98 ± 0.8 mm, p=0.002; and 2.84 ± 0.8 mm, p=0.003, respectively). However, there were no statistically significant differences between the anismus group and the PFD group (p=0.685 and p=0.789, respectively). The number of cases participating in the study groups, their mean ages, and puborectalis muscle and anal sphincter thicknesses are summarized in Table 1 and Table 2.

Table 2. Post hoc test (Tukey HSD) results

Post-hoc test (Tukey HSD)				
	Group comparison	**Mean difference**	**p-value**	**95% Confidence interval (Lower and upper)**
Right puborectal muscle thickness (mm)	Anismus vs Control	-0.9958	0.031	-1.918 & -0.073
	Anismus vs Pelvic floor dysfunction	2.9508	<0.0001	2.008 & 3.894
	Control vs Pelvic floor dysfunction	3.9466	<0.0001	3.003 & 4.890
Left puborectal muscle thickness (mm)	Anismus vs Control	-0.2258	0.876	-1.328 & 0.876
	Anismus vs Pelvic floor dysfunction	3.7132	<0.0001	2.586 & 4.840
	Control vs Pelvic floor dysfunction	3.9390	<0.0001	2.812 & 5.066
Mean puborectal muscle thickness (mm)	Anismus vs Control	-0.61083	0.274	-1.5552 & 0.3335
	Anismus vs Pelvic floor dysfunction	3.33197	<0.0001	2.3664 & 4.2975
	Control vs Pelvic floor dysfunction	3.94280	<0.0001	2.9772 & 4.9084
Puborectal mucle circumference (mm)	Anismus vs Control	-5.4792	0.654	-20.373 & 9.414
	Anismus vs Pelvic floor dysfunction	-21.6504	0.003	-36.878 & -6.422
	Control vs Pelvic floor dysfunction	-16.1712	0.035	-31.399 & -0.943
Left internal sphincter thickness (mm)	Anismus vs Control	0.0208	0.983	-0.266 & 0.308
	Anismus vs Pelvic floor dysfunction	0.1360	0.511	-0.157 & 0.429
	Control vs Pelvic floor dysfunction	0.1152	0.617	-0.178 & 0.409
Right external sphincter thickness (mm)	Anismus vs Control	-0.6917	0.002	-1.163 & 0.221
	Anismus vs Pelvic floor dysfunction	-0.1671	0.685	-0.649 & 0.315
	Control vs Pelvic floor dysfunction	0.5246	0.03	0.043 & 1.006
Left external sphincter thickness (mm)	Anismus vs Control	-0.4958	0.019	-0.924 & -0.068
	Anismus vs Pelvic floor dysfunction	-0.0693	0.924	-0.507 & 0.369
	Control vs Pelvic floor dysfunction	0.4265	0.058	-0.012 & 0.865
Mean external sphincter thickness (mm)	Anismus vs Control	-0.5938	0.003	-1.012 & -0.173
	Anismus vs Pelvic floor dysfunction	-0.1182	0.789	-0.549 & 0.313
	Control vs Pelvic floor dysfunction	0.4756	0.027	0.045 & 0.906

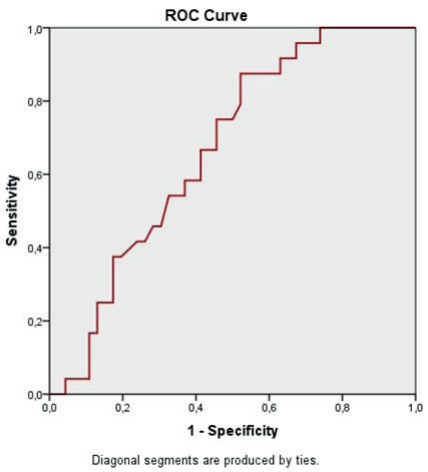

Figure 3. Receiver operating characteristic (ROC) curve analysis of the ability of puborectalis muscle thickness to predict anismus (area under the curve [AUC]: 0.667, cut-off value 6.125 mm with a sensitivity of 0.625 and specificity of 0.587).

Receiver operating characteristic (ROC) curve analysis was conducted to evaluate the capacity of puborectalis muscle thickness to differentiate anismus. The analysis revealed that the area under the curve was 0.667, p-value was 0.022 (Figure 3). These findings highlight the potential of puborectalis muscle thickness as a predictive marker for anismus.

Good interobserver agreement was observed for measurements of the puborectalis muscle circumference, with an ICC value of 0.762. Excellent agreement was found for the thickness of the right and left puborectalis muscles, as well as for the mean internal and external sphincter thicknesses, with ICC values of 0.960, 0.938, 0.920, and 0.970, respectively.

DISCUSSION

In this retrospective comparative study, our primary objective was to investigate the relationship between puborectalis muscle and anal sphincter thickness and to evaluate their potential contribution to the MR defecography assessment of anismus. As we hypothesized, our results confirmed that puborectalis muscle thickness is significantly greater in patients with anismus compared to those with PFD, while not significantly different from that of healthy controls. These findings suggest that static measurements, particularly puborectalis muscle thickness, may serve as supportive imaging markers in the diagnosis of anismus, especially in cases where dynamic sequences are inconclusive or technically limited.

Anismus is considered a significant cause of chronic constipation; however, its diagnosis can be challenging due to the lack of specific findings and objective criteria (1-3,12). It is characterized by paradoxical contraction or failure of relaxation of the pelvic floor muscles (puborectalis muscle and external anal sphincter) during defecation (1). Though, in some cases, incomplete rectal evacuation results from low intrarectal pressure (2,3). Therefore, anismus encompasses a group of functional disorders with obstructive symptoms, and some authors prefer the term 'pelvic floor incoordination' instead of 'anismus' to broaden its scope (13).

The diagnosis of dyssynergic defecation is based on physiological and radiological tests, including digital rectal examination, anorectal manometry, electromyography, balloon expulsion test, evacuation proctography (X-ray defecography), MR defecography, and colonic transit studies (5). While anorectal manometry measures the pressure activity of anorectal muscles, balloon expulsion test helps estimate fecal transit time (14). The superiority of radiological methods over physiological tests is their ability to assess anatomical and structural problems (e.g., accompanying rectocele) at the same time (2,3). Conventional X-ray defecography provides valuable real-time information about the posterior compartment during defecation. However, due to radiation exposure and the need for contrast media, MR defecography has replaced X-ray defecography in modern practice (15). MR defecography enables the evaluation of all three pelvic compartments (14,15).

The major disadvantage of MR defecography is the non-physiological supine position during defecation (15). Static MR measurements may be helpful in cases where dynamic sequences are suboptimal or inconclusive. Specifically, static images can still provide important anatomical information that may support the diagnosis of anismus, such as the thickness and

symmetry of the puborectalis muscle, the anorectal angle at rest, and structural changes. These findings can complement dynamic imaging and offer additional diagnostic insight, especially in patients who are unable to perform adequate straining during dynamic sequences (16).

In this study, we hypothesized that there is a positive correlation between the thickness of the puborectalis muscle and the thickness of the external anal sphincter in patients with anismus. Previous studies are primarily focused on dynamic anorectal angle measurement, M-line measurement (distance between pubococcygeal line and anorectal junction), anal canal length measurement, sphincteric thickness measurement, and rectal emptying ratios (2,3). Few studies have investigated the relationship between the puborectalis muscle and anismus (17,18).

A recent study conducted by Çamur et al. identified cut-off values for puborectalis muscle thickness and abdominal subcutaneous adipose tissue thickness in diagnosing anismus (17). Our study demonstrated significant differences in puborectalis muscle thickness and circumference, as well as external anal sphincter thickness, among the three groups. In their study, the cut-off value for mean puborectalis muscle thickness was slightly lower than our results (17). These findings support the role of the puborectalis muscle and external anal sphincter in functional disorders. The high interobserver agreement in our measurements indicates that MR defecography is a reliable method for evaluating anismus and PFD.

Another study conducted by Chu et al. reported that children with anismus exhibit a smaller anorectal angle and paradoxical contraction of the puborectalis muscle. However, it is not yet fully understood whether these findings are due to the pathophysiology of the condition or its consequences (18). Paradoxical puborectalis muscle contraction is a form of chronic constipation and is associated with prolonged and repeated straining, as well as incomplete evacuation of the rectum (19,20). A deep impression of the puborectalis sling on the posterior rectal wall at rest, as seen on MR defecography, has been identified as a finding indicative of paradoxical puborectalis muscle contraction (21). An important point to keep in mind is that paradoxical sphincter contraction during digital rectal examination or anorectal manometry can also occur in healthy individuals, potentially leading to the overdiagnosis of anismus (21,22).

In the article published by Haliloğlu et al. in 2022, patients with anismus and perineal descent were compared, and no significant differences were found in the thickness of the internal and external anal sphincters (2). In our study, while no significant differences were observed in internal sphincter thickness, the mean external sphincter thickness was found to be higher in the control group compared to the anismus and PFD groups, with no notable difference between the anismus and PFD groups. The internal anal sphincter thickness values in our study were abnormally low across all groups, in clear contrast to the values commonly observed and reported in clinical practice worldwide, which typically range from 4.9 to 5.5 mm (23). The choice of axial imaging plane may have influenced our interpretation, and caused this discrepancy. Future studies may benefit from utilizing oblique planes perpendicular to the anal canal's long axis to enhance the accuracy of sphincter thickness measurements and minimize the risk of anatomical misidentification.

The main limitation of this study is that the patient diagnoses were not confirmed through anorectal manometry or balloon expulsion testing but were based solely on clinical and radiological data. The retrospective design and the small sample size also represent notable limitations. The lack of data on parity and menopausal status, both of which may influence pelvic floor muscle morphology, is an additional constraint. Due to the retrospective design of the study and incomplete clinical documentation, we were unable to control for or analyze the potential effects of these variables.

Since there are no specific findings to establish a diagnosis of anismus in MR defecography, diagnosing anismus can be challenging. In non-cooperative patients, MR defecography findings may be confused with anismus. Our study suggests that changes in puborectalis muscle thickness and circumference, as well as external anal sphincter thickness, may provide important insights for diagnosing anismus and PFD.

Ethical approval

This study has been approved by the Bolu Abant İzzet Baysal University Clinical Research Ethics Committee (approval date 26/06/2024, number 154). Written informed consent was obtained from the participants.

Author contribution

Surgical and Medical Practices: ABY, AES, ST; Concept: ABY, AES, ST; Design: ABY, AES, ST; Data Collection or Processing: ABY, AES, ST; Analysis or Interpretation: ABY, AES, ST; Literature Search: ABY, AES, ST; Writing: ABY, AES, ST. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

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