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The association of anal sphincter morphology and somatotype characteristics with the pathogenesis of hemorrhoidal disease

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Abstract

Aim: This study aims to evaluate the changes that may occur in the morphology of the anal sphincter muscles in hemorrhoidal disease. The relationship between the somatotype features of individuals and the disease was also evaluated.

Materials and Methods: The study was conducted with 76 stage IV hemorrhoidal disease patients and 75 controls. Internal (IAS) and external (EAS) anal sphincter muscle thicknesses were measured at the middle anal canal level, and in four quadrants (anterior, posterior, right, left), puborectalis muscle thicknesses were measured at the upper anal canal level and in two quadrants (right, left) by using 3D-endoanal ultrasonography (3D-EAUSG). Anal triangle dimensions were measured with a digital caliper and the area was calculated with the relevant formula. The somatotype features were determined using the Heath-Carter formula.

Results: It was observed that the external anal sphincter muscle thicknesses were higher in the right and posterior quadrants of the patients compared to the control group. The internal anal sphincter muscle thicknesses were thicker in the right and anterior quadrants in the patient group. Somatotype features of individuals in the patient and control groups were similar.

Conclusion: The thickening in some quadrants of the anal sphincter muscles in the patient group can be considered a result of hemorrhoidal disease. However, the fact that there is no difference the mean value cannot confirm its relationship with the disease. Therefore, it can be concluded that individual somatotype differences do not affect pathogenesis of hemorrhoidal disease.

Introduction

The anal canal is approximately 2.5-4 cm long and surrounded by the anal sphincter complex [1]. The anal canal, the shortest section of the gastrointestinal tract, starts from the lower section of the ampulla recti (*linea anorectalis*) and ends at the line known as the anal verge (*linea anocutanea*) [2, 3]. Two sphincter muscles surround the anal canal, one of which is the internal anal sphincter muscle (IAS), a thickening of the distal section of the circular smooth muscle structure in the rectum that extends towards the anal canal. It is continuously and involuntarily contracted except during defecation. The other muscle is the external anal sphincter (EAS) which surrounds almost the entire anal canal and operates voluntarily. In addition, the main structure of the pelvic floor, which is also important in the function of the anal sphincter, includes the levator ani muscle complex. The puborectalis muscle is a part of this complex and the most important formation for the solid continence of the anus [4].

Hemorrhoids, included in the normal anatomical structure of the human body, consist of mucosa, submucosal connective tissue, smooth muscles, and blood vessels. These structures, defined as vascular pillows, are separate thickened masses in the submucosal tissue and slide down during defecation [5, 6]. Hemorrhoidal pads, which play a role in the sustenance of continence, attach to the IAS and longitudinal muscle fibers via collagen connective tissue fibers. Following the third decade in life, these connective tissue fibers begin to loosen and break in certain locations. Thus, the hemorrhoidal pads slide and prolapse outwards. These pads, when pressured by the feces, induce

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vascular occlusions and bleeding. Hemorrhoidal disease is observed with the involvement of inflammation [7]. The theory that focuses on the sphincters in the development of hemorrhoidal disease suggested that the increased pressure in the anal sphincters triggers hemorrhoidal disease through compression. Increased activity has been identified in the internal anal sphincters in hemorrhoid patients, leading to obstruction and congestion in the venous flow, followed by hemorrhoidal symptoms [8, 9]. The vascular pathology that develops in hemorrhoidal disease is well-defined, however, the morphological changes that occur in the anal sphincter are still unknown [10].

Although it is known that hemorrhoidal disease occurs as a result of changes in the vascular mechanism, it is thought that excessive obesity may also contribute to the disease due to increased intra-abdominal pressure [11]. Somatotype analysis provides a more detailed evaluation of the body composition according to anthropometric measurements [12]. Somatotype analysis, which classifies the human body type according to muscularity, fat mass and weakness based on the external features of the body composition, can also provide more detailed information about the susceptibility of individuals to hemorrhoidal disease.

The presented study aimed to investigate and compare the possible morphological changes in the puborectalis muscle, IAS, and EAS muscle thicknesses of patients diagnosed with stage IV hemorrhoidal disease and healthy individuals. Also, it was aimed to evaluate the susceptibility to the disease by determining the somatotype characteristics of individuals.

Materials and Methods

The study population

This study was conducted with the approval of the Clinical Research Ethics Committee, Inonu University (No: 2018/172). The study was case series analysis and conducted with 76 (8 women, 68 men) 21-65 years old patients who presented to General Surgery Department, Proctology Outpatient Clinic, Turgut Özal Medical Center, Inonu University and 75 18-65 years old healthy individuals (16 women, 59 men) who presented to the same outpatient clinic between December 2018 and January 2020. The control group comprised patients that presented for other reasons such as diarrhea or constipation and did not have any proctological diseases. The numbers of individuals in the study groups were determined utilizing power analysis. While the number of individuals in the groups was Type I error (alpha) 0.05, test power (1-beta) 0.8, effect size 0.46, and alternative hypothesis (H1) two-sided, the minimum sample size required to find a significant difference using this test was in each group was calculated as 75, which corresponded to a total of 151 individuals. Age, gender, height, weight data, and information on prior surgical procedures associated with the anal canal were collected from all participants. Furthermore, the number of vaginal deliveries and episiotomies during delivery were recorded for the women participants. Individuals who had undergone a surgical procedure associated with the anal region for any reason, individuals with impaired anal canal sphincter muscle integrity, and women with episiotomy anamnesis during normal delivery were excluded. This study was reported in accordance with the STROBE guidelines. No randomization or blinding methods were employed. The primary outcome variables were the thickness measurements of the IAS, EAS, and puborectalis muscles.

Patient selection and measurement of anal triangle dimensions

Patients who presented to Turgut Ozal Medical Center Proctology Outpatient Clinic with rectal bleeding and pain complaints were accepted for routine examination. Visual and manual examinations were performed on the patients in the knee-elbow position. After the examination, the anal triangle dimensions of the individuals diagnosed with stage IV hemorrhoidal disease were measured. To determine the anal triangle boundaries, first, the tuber ischiadicum (right-left) and the coccyx apex were marked with manual palpation. This procedure was performed in the knee-elbow position on the routine examination table, and no problems were experienced in the determination of the points, independent of the weight of the patient. Then, the distances between the marked points were measured with a digital caliper (Astor) (Figure 1). The anal triangle area was calculated by substituting the measurements in the relevant formulas.

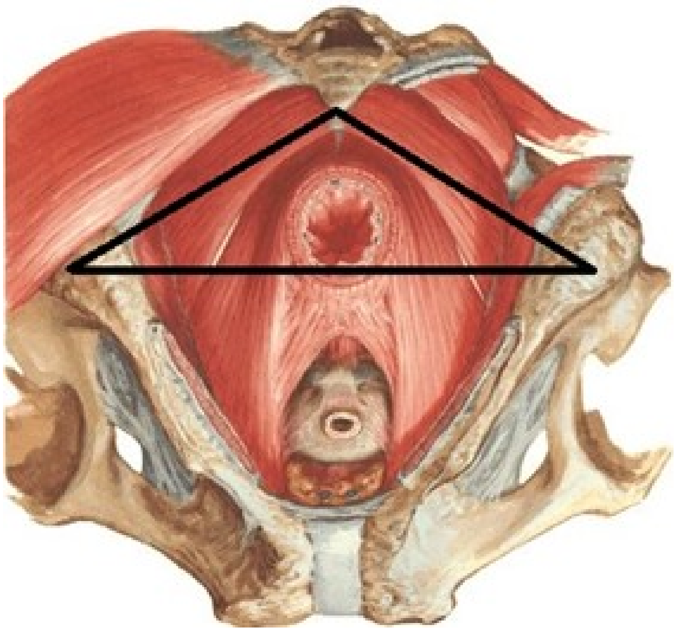

Figure 1. Measurement of anal triangle sizes.

Measurement of muscle thickness by three-dimensional endoanal ultrasonography

The muscle thicknesses of the participants were measured with the Flex Focus 400 3D-EAUSG device (BK Medical, Herlev, Denmark). Before the procedure, participants were asked to conduct a simple enema in the morning of the day of the procedure. When the participants arrived, detailed information was provided about the procedure, and it was initiated after they signed the "Informed Consent Form." The procedure did not require anesthesia. Participants were laid down on their left arm on a stretcher. They were asked to pull their right leg towards

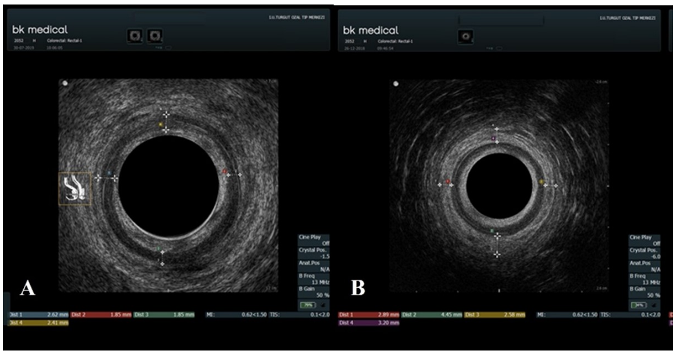

Figure 2. Measurement of IAS and EAS (A: Measurement of IAS muscle thickness; B: Measurement of EAS muscle thickness).

Figure 3. Measurement of IAS and EAS (A: Measurement of IAS muscle thickness; B: Measurement of EAS muscle thickness).

themselves and to extend their left leg. Then, the ultrasound probe, fitted with a condom, was lubricated with ultrasound gel and inserted into the anal canal. At this position, minimal muscle thickness changes and compression on the sphincter muscles surrounding the canal were ignored. Measurements from each participant were taken by the specialist. The section between the opening of the anal canal and the anorectal ring was divided into three parts: lower, middle, and upper. Muscle thicknesses (EAS and IAS) were measured from the middle of the anal canal. Since the puborectalis muscle thickness could be observed in the upper part of the anal canal, measurements were taken at this location. IAS and EAS muscle thicknesses were measured separately in four quadrants: right, left, anterior and posterior, and the average distances were calculated (Figures 2A and 2B). Puborectalis muscle thicknesses were measured in two quadrants, right and left (Figure 3). The average of the values was taken into account.

Determination of the somatotype

To determine the somatotypes of participants, height, weight, body mass index (BMI), knee width, elbow width, muscular arm circumference, calf circumference, subscapular, triceps, suprailiac and calf skinfold thicknesses were taken according to the technique recommended by the International Biological Program (IBP). The somatotype features were determined by using the Heath-Carter method [13].

Statistical analysis

Data are presented as median (min-max) and frequency. The normal distribution of the data was determined with the Shapiro-Wilk test. Statistical analyses were performed using the Mann-Whitney U test and the Kruskal Wallis test. The Conover test was employed after the Kruskal Wallis test for multivariate comparisons. The relationship between somatotype characteristics and disease was evaluated with the chi-square test. A p value of <0.05 was accepted as statistically significant. All analyses were performed on the IBM SPSS Statistics 22.0 software.

Results

The patients and the controls had no complications related to endoanal ultrasonography. There were no statistical differences between the groups regarding age, gender, height, weight, and body mass index (BMI) (Table 1).

Table 1. Patient and control group demographics.

Variable	Group		p
	Patient (n=76)	Control (n=75)	
Age	42 (21-65)	39 (18-65)	0.112
Gender (M/F)	68/8	59/16	0.055
Height	1.74 (1.50-1.98)	1.74 (1.50-1.93)	0.597
Weight	79 (47-117)	81 (43-137)	0.701
Body Mass Index (BMI)	26.17 (16.65-36.85)	25.78 (15.42-35.12)	0.460

The Mann-Whitney U test was employed to compare the variables. Data are presented as median (min.-max.) and frequency. p<0.05 is considered significant.

Comparison of muscle thickness and anal triangle dimensions between the patient and control groups

External anal sphincter (EAS) and internal anal sphincter (IAS) muscle thicknesses were measured in the right, left, anterior and posterior quadrants of the individuals. It was observed that the EAS muscle thickness was higher in the right (p=0.046) and posterior (p=0.017) quadrants in the patients when compared to the controls, and the difference was statistically significant. In addition, the difference between the two groups in terms of mean value was close to the level of significance (p=0.058) The IAS muscles were thicker in the right (p=0.041) and anterior (p=0.006) quadrants in the patient group, and the difference was statistically significant (Table 2). Puborectalis muscle thicknesses were measured around the right and left quadrants of the anal canal. The mean values of the right and left quadrant measurements were calculated, and the two quadrant measurements and mean values were compared between the patient and the control groups. Moreover, the anal triangle areas were calculated in both patients and controls. There was no statistically significant difference in terms of puborectalis muscle thickness and anal triangle area between the groups (Table 2).

Table 2. Comparison of muscle thickness and anal trigonum area between the groups.

Variable	Group		p*
	Patient (n=76)	Control (n=75)	
EAS muscle thickness-Right	3.45 (1.85-7.96)	3.16 (1.17-6.19)	**0.046**
EAS muscle thickness-Left	3.64 (1.64-7.27)	3.40 (1.75-7.27)	0.252
EAS muscle thickness-Anterior	2.86 (1.43-5.84)	2.63 (1.07-5.70)	0.289
EAS muscle thickness-Posterior	3.42 (1.64-5.78)	3.06 (1.29-5.60)	**0.017**
EAS muscle thickness-Mean	3.30 (1.87-5.99)	3.04 (1.64-5.90)	**0.058**
IAS muscle thickness-Right	2.34 (0.95-5.94)	1.97 (0.81-5.46)	**0.041**
IAS muscle thickness-Left	2.35 (0.81-6.50)	2.25 (1.16-5.46)	0.647
IAS muscle thickness -Anterior	2.17 (0.81-4.75)	1.83 (0.47-4.06)	**0.006**
IAS muscle thickness-Posterior	2.17 (1.17-6.39)	2.26 (1.04-4.32)	0.714
IAS muscle thickness-Mean	2.21 (1.29-4.87)	2.13 (1.08-4.49)	0.124
Puborectalis muscle thickness-Right	6.94 (4.07-10.90)	6.57 (3.36-10.30)	0.346
Puborectalis muscle thickness-Left	7.11 (4.23-11.20)	7.27 (3.67-10.10)	0.733
Puborectalis muscle thickness-Mean	6.98 (4.48-11.05)	7.03 (3.87-9.93)	0.805
Area of anal triangle	42.01 (11.70-66.69)	43.77 (20.43-83.07)	0.161

* The variables were compared with the Mann-Whitney U test. Data are presented as median (min.-max.). Muscle thickness was measured in mm, and trigonum anal area was measured in cm^2. p<0.05 was considered significant.

Table 3. Comparison of somatotype features and hemorrhoidal disease.

Somatotype	Group		p
	Patient (76)	Control (75)	
Mesomorph	50 (65.8%)	44 (58.7%)	**0.829**
Endomorph	10 (13.2%)	13 (17.3%)	
Ectomorph	8 (10.5%)	9 (12%)	
Central	8 (10.5%)	9 (12%)	
Total	**76 (100%)**	**75 (100%)**	

The variables were compared with the Pearson's Chi-square test. Data are presented as number (%). p<0.05 was considered significant.

Somatotype features and hemorrhoidal disease All participants were evaluated according to their somatotype characteristics and four groups were determined: endomorph, ectomorph, mesomorph and central. While endomorphy is characterized by excessive fat mass, ectomorph people are lean and not muscular; mesomorphy is characterized by muscularity and athletic body; central is the body type in which all components are in balance. It was observed that there was no significant difference between the groups in terms of somatotype characteristics and somatotype differences were not effective in the pathogenesis of hemorrhoidal disease (Table 3).

Discussion

Anal sphincter thickness may vary depending on various pathological conditions. In a study, it was determined by endoanal ultrasonography that the anal sphincter muscle structure was quite thin and weak even in nulliparous women with accidental anal bowel leakage [14]. Hemorrhoidal disease is a common pathological condition that affects the anorectal region. Several theories have been suggested on the development of the disease. The theory that focuses on the sphincters argues that the increase in the pressure on the anal sphincters induces hemorrhoidal disease. Increased activity was reported in the IAS muscles of hemorrhoid patients. This increased pressure may lead to obstruction and congestion in the venous flow, which is followed by hemorrhoidal symptoms [8, 9]. In addition to anal sphincter muscles, the levator ani muscle also contributes to fecal continence. The puborectalis muscle which branches from the levator ani muscle, surrounds the anal canal circularly. The anorectal angle created by this muscle around the anal canal is considered a significant anatomical barrier that ensures anal continence [15, 16]. Moreover, it is known that disorders in the collagen tissue cause a decrease in the stability of the connective tissue and lead to the development of hemorrhoidal disease. It is known that in hemorrhoidal disease, the muscle and elastic connective tissue break down, resulting in the distal shift of the anal cushions and increased blood flow in the terminal branches of the superior rectal artery. The rate of collagen in hemorrhoid tissues taken from individuals with hemorrhoidal disease and healthy individuals were compared, and it was observed that this rate was significantly reduced in patients with hemorrhoidal disease [10]. Currently, various techniques are employed to image the anatomical structures in and around the anal canal. The three-dimensional endoanal ultrasonography (3D-EAUSG) is the most preferred method to identify the problems in the anal sphincter complex in daily clinical practice. Although the anal sphincter complex could be successfully visualized with trans-perineal and transvaginal approaches, high-resolution scanning using the endoprobes inserted into the anus remains the gold standard in ultrasonic examination to detect sphincter damages [17, 18].

In our study, a significant thickening was detected in the external anal sphincter muscle thickness of individuals with stage 4 hemorrhoidal disease, especially in the right and posterior quadrants. The internal anal sphincter muscle showed much thicker thickness in the right and anterior quadrants. It was also observed that this thickening in the muscles was not related to the body composition of the individuals (such as muscularity and fatness).

It was reported in the literature that hemorrhoidal disease is more common among men and although it affects all age groups, it is more prevalent in individuals over 50 years of age [19, 20]. In the present study, similar to the literature, the number of male patients was higher than the female. However, it was also demonstrated that individuals in every age group could be diagnosed with hemorrhoidal disease.

The closure of the anal canal at rest is mainly provided by contraction of the internal anal sphincter muscle. In addition, external anal sphincter contraction and soft tissues in the anal canal, such as hemorrhoids, contribute to the closure of the anal canal and maintain anal continence. It is known that the puborectalis muscle, which is closely related to the external anal sphincter, also plays a role in maintaining anal continence [21]. It is known that important pathological changes in anal cushions such as deterioration in the structure of hemorrhoids and cavernous vessels and hypertrophy of Treitz muscle and fibroelastic tissues are the main causes of the development and pathogenesis of hemorrhoidal disease [22]. It was noted that the submucosa layer was thickened in the anterior part of the anal canal in patients with hemorrhoids, and the hemorrhoids in this region had a hypoechoic appearance in endosonographic evaluation. The researchers also stated that the mean value of IAS, EAS, and submucosal tissue thicknesses in patients were significantly higher than in the control groups, and that the increased submucosa thicknesses were correlated with the stage of hemorrhoidal disease [23]. Furthermore, another study showed that although hemorrhoids affect multiple sites in the anal canal, the most common anatomical region is in the right-posterior quadrant [20]. In our study, it was observed that the EAS and IAS muscle thicknesses in different quadrants were higher in patients than in controls. It is thought that morphological changes in the muscle structure in some quadrants may be related to the disease, but the small study population affects the level of significance of the difference. In a previous study, it was determined that the thickness of the muscle was highest around the anal canal. Similar to our findings, they reported that there was no statistically significant difference between the IAS thickness of the individuals with hemorrhoidal disease and healthy controls. Although their study population was much smaller (n=20) [23], our study population can also be considered small, which may have affected the results of the study. Therefore, further studies on larger populations may reveal different and more powerful results.

In the present study, the association between the anal triangle area and stage IV hemorrhoidal disease was analyzed, and it was determined that the anal triangle area was not associated with the disease. There are no other studies in the literature, to the best of our knowledge regarding the association between the anal triangle area and hemorrhoidal disease, which makes the presented findings the first on the topic.

Studies have shown that in obesity-related cancers, especially colon cancer, the measurement of waist circumference and hip size increases the risk of cancer, independent of the BMI parameter. It is thought that major anatomical structures and morphological characteristics of individuals may cause the emergence of many diseases [24, 25]. Furthermore, different somatotypes reflecting the body's characteristics such as muscularity and excessive body fat may contribute to the development of hemorrhoidal disease. However, in our study, it was determined that somatotype differences between the groups were not associated with the disease. It has been stated in a recent study that waist and hip circumference determined by traditional anthropometric measurements are affected by strong relationships between body mass index and diseases [24]. Therefore, since the somatotype characteristics of individuals are determined by using anthropometric measurements and body mass indexes, they may have misguided us about their relationship with the disease. Evaluating the relationship between the groups in terms of waist and hip circumferences and the relationship between hemorrhoidal disease may reveal stronger results.

Conclusion

It can be concluded that thickening of the anal sphincter muscles in different quadrants may be associated with hemorrhoidal disease. The fact that these thickenings are significantly increased, especially in areas where hemorrhoidal cushions are dense, also supports this view. However, determining whether changes in muscle morphology influence muscle function would be a more accurate approach to analyze its' relationship with hemorrhoidal disease. It is understood from the results that somatotype differences between individuals do not play a role in the pathogenesis of the disease.

Informed consent

All participants signed the informed consent documents before the operation.

Conflict of interest

The authors declare that they have no conflict of interest.

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Ethical approval

Ethical approval was given by Clinical Research Ethics Committee, Inonu University, Malatya, approval number 2018/172.

Author contribution

Conceptualization: Nesibe Yilmaz, Mustafa Ates; Methodology: Nesibe Yilmaz, Mustafa Ates,; Formal analysis: Nesibe Yilmaz, Evren Kose, Ahmet Kavakli; Investigation: Nesibe Yilmaz, Mustafa Ates, Evren Kose, Ahmet Kavakli, Davut Ozbag; Writing-Original draft preparation: Nesibe Yilmaz, Mustafa Ates, Evren Kose; Writing review and editing: Nesibe Yilmaz, Mustafa Ates, Evren Kose,; Resources: Nesibe Yilmaz, Mustafa Ates. All the authors read, critically evaluated, gave their feedback, and edited the manuscript.

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