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Configuration, geometry, and presence of defect in the pelvic floor muscles of women with apical pelvic organ prolapse

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ABSTRACT

Objectives: This study aimed to assess the presence of defects in the pelvic muscles, muscle configuration, and the relationship of pelvic organs using magnetic resonance imaging (MRI) in women with apical pelvic organ prolapse (POP), and compare these findings with measurements from women without POP.

Materials and Methods: The study analyzed computer-based medical records of patients diagnosed with POP prolapse at İzmir Bakırçay University Çiğli Training and Research Hospital between March 2022 and May 2023. Forty-five patients diagnosed with apical POP were matched with 45 patients of the same age group without prolapse. Pelvic MRI images of all patients were examined, and the pubococcygeal line, H line, and M line were marked. Additionally, measurements of the uterocervical angle, genital hiatus width, obturator internus muscle area, and levator ani defect were assessed.

Results: The demographic characteristics of patients with POP were similar to those in the control group. There were no statistical differences in the POP group regarding pubococcygeal distance, genital hiatus length, vaginal length, uterocervical length, and puborectal distance (H). The presence of unilateral and bilateral levator ani muscle defects was more common in the POP group (p=0.02 and p=0.03). The obturator internus muscle area was lower in the POP group compared to the control group (1770±293.4 mm^2 vs. 2104±303.5 mm^2, p=0.02). M length was higher in women with POP (27.3±5.8 mm vs. 15±4.2 mm, p=0.02).

Conclusion: MR images revealed defects in pelvic floor muscles and descent of pelvic organs in patients with POP. MRI has the potential to become a standard preoperative examination for pelvic floor abnormalities, assisting in surgical planning.

Keywords: Cystocele; levator ani defects; magnetic resonance imaging; pelvic floor; rectocele

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INTRODUCTION

Pelvic organ prolapse (POP) encompasses a range of clinical conditions leading to genitourinary, gastrointestinal, and sexual dysfunctions. These conditions arise due to insufficiency in the pelvic floor.[1] The support of pelvic organs in females relies on the interplay between pelvic floor muscles and the connective tissue that anchors to the bony pelvis.[2]

The levator ani muscle complex, comprised of the pubococcygeus, puborectalis, and iliococcygeus muscles, furnishes primary support to the pelvic organs by providing a stable and flexible foundation upon which these organs repose.[3] Fibrous thickening of the endopelvic fascia, referred to as uterosacral and cardinal ligaments, play a role in stabilizing the pelvic organs in their optimal positions. Another muscle implicated in pelvic floor insufficiency is the obturator internus.[4] Diagnosis and classification of pelvic floor dysfunction hinge on physical assessment, encompassing a multifaceted array of measurements. Given that one-third of individuals undergoing prolapse surgery necessitate subsequent procedures, a thorough preoperative evaluation becomes indispensable for accurately identifying structural weaknesses leading to the descent of supportive structures.[5] Recently, magnetic resonance (MR) imaging has emerged as a valuable tool in the preoperative assessment of POP, aiding in the identification of various anatomical anomalies in patients. This proactive approach holds the potential to enhance postoperative outcomes and consequently lower the risk of recurrence.[6] MR imaging (MRI) facilitates an in-depth morphological assessment of the pelvic floor structure.Through high-resolution static MRI, it becomes possible to offer unbiased and quantitative evaluations of deficiencies in pivotal pelvic floor support muscles, like the levator ani, as well as alterations in the positioning and orientation of the uterus and vagina.[7,8] The utilization of MR imaging is projected to experience growth, particularly in scenarios involving pelvic floor disorders where surgical intervention is anticipated.

This study was planned to examine the presence of pelvic muscle defects, muscle configuration, relationships of pelvic organs with MRI in women with apical POP and compare them with measurements of women without POP.

MATERIALS AND METHODS

This study was carried out by examining the computer-based medical records of patients diagnosed with POP at İzmir Bakırçay University Çiğli Training and Research Hospital between March 2022 and May 2023. Utilizing pelvic MRI scans acquired from all participants using the Siemens Avanto T1.5 system, a comprehensive analysis was conducted. Key parameters studied included the pubococcygeal line (PCL), denoting the line extending from the base of the pubic bone to the sacrococcygeal joint; the H line, drawn from the lower end of the pubic bone to the posterior rectal wall at the point of the anorectal junction where the puborectalis muscle becomes visible; and the M line, which runs perpendicular from the posterior extremity of the H line to the PCL (Figure 1). Furthermore, assessments encompassed the angle formed by the uterus and cervix, the width of the genital hiatus, the area of the obturator internus muscle, and the identification of any levator ani defects (Figure 2). The G Power software aided in determining the appropriate number of participants for the study. With the line length M as the primary determinant, a sample size of 45 patients was established, aiming for 80% statistical power and a significance level (α) of 0.05. The study encompassed 45 patients diagnosed with apical POP and a matched group of 45 individuals without prolapse, all within the same age range (control). Exclusion criteria encompassed patients with pelvic masses in the uterine

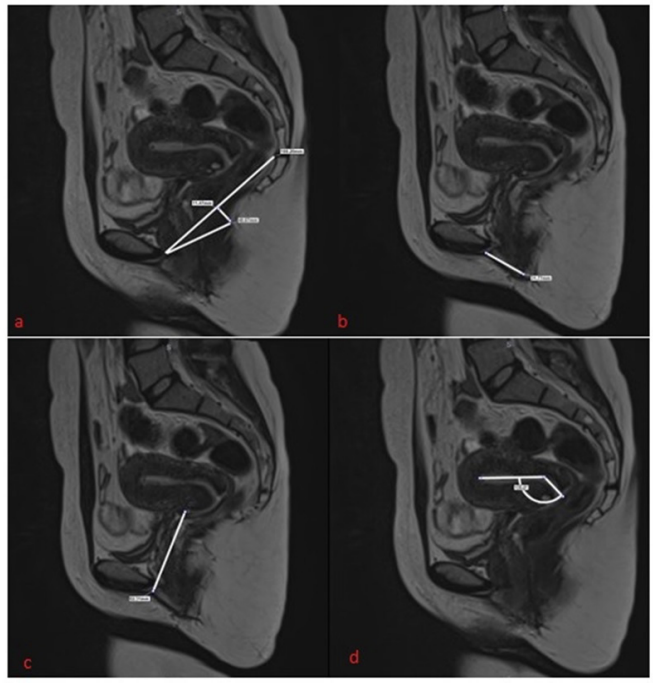

Figure 1. a) Pubococcygeal line, H line, M line, H line; **b**) Genital hiatus distance; **c**) Vaginal length; **d**) Uterocervical angle

Figure 2. MR images of levator ani muscle, thin arrow shows damaged muscle and thick arrow shows intact muscle
MR: magnetic resonance

and adnexal regions, a history of pelvic surgery, and those who had undergone radiotherapy.

The study was performed in accordance with the principles of the Declaration of Helsinki and was approved by the İzmir Bakırçay Ethical Committee (approval number: 1074/1054-23).

MRI Measurements

The PCL is defined as the measurement from the lower extremity of the pubic bone to the sacrococcygeal joint. Referred to as Line H, this measurement represents the distance between the lower edge of the pubic bone and the posterior wall of the rectum at the point of the anorectal junction where the puborectalis muscle becomes visible. Line M is determined by the length drawn perpendicular to the PCL from the posterior terminus of Line H (Figure 1). Alterations in the structure of the levator ani muscle were assessed utilizing the grading system introduced by DeLancey.[9] Axial planes were used to evaluate both the bilateral levator ani and obturator internus muscles. Muscle defects were categorized as either unilateral or bilateral. The area of the obturator internus muscle was quantified, encompassing the area between the anterior pubic bone, the posterior sacrum, and the sacrospinous ligament. Measurements in the sagittal plane included the urogenital hiatus, defined as the distance from the urethra to the perineal body, and vaginal length, which was determined as the distance from the urethral meatus to the anterior fornix along the midsagittal line. To gauge the uterocervical angle (Figure 1), the clockwise angle between the axis connecting the internal and external openings of the cervix and the axis traversing the uterine cavity was measured.

Statistical Analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS), version 23.0 (SPSS Inc., Chicago, IL), as well as R statistical calculation software (version 3.6.1, https://www.r-project.org/). A significance level of $p<0.05$ was adopted to determine statistical significance. For continuous variables, mean and standard deviation values were computed. Parametric tests were employed when both compared groups demonstrated normal distribution; conversely, non-parametric tests were utilized for groups with non-normally distributed data. In cases of independent group comparisons, an independent sample t-test was employed as the parametric test, while the Mann-Whitney U test served as the non-parametric alternative

RESULTS

During the study period, MR images of 45 women diagnosed with POP and MR images of 45 patients without POP were compared. Both groups had similar demographic characteristics (Table 1). There was no statistical difference between the two groups in terms of the pubococcygeal distance (PC), genital hiatus length, vaginal length, uterocervical angle, and puborectal distance (H). However, both unilateral (58% vs. 26%) and bilateral (38% vs. 18%) levator ani muscle defects were more common in the POP group than in the control group ($p=0.02$ and $p=0.03$, respectively). The obturator internus muscle area was found to be smaller in the POP group compared to the control group (1770±293.4 mm^2 vs. 2104±303.5 mm^2, $p=0.02$). The M length, which is the distance between the PC and H line, was greater in POP patients (27.3±5.8 mm vs. 15±4.2 mm, $p=0.04$) (Table 2).

DISCUSSION

The consequences of pelvic floor insufficiency can extend beyond a single organ or specific region. Failure to comprehensively identify all sites of prolapse may result in incomplete surgical correction and subsequent recurrences.[10] Earlier investigations have indicated that around one-third of individuals undergoing surgical intervention for pelvic prolapse require subsequent reoperations.[11] Clinical assessment often underestimates the degree of descent or might even overlook it altogether.[12] MRI can serve as a valuable tool for preoperative planning, particularly in intricate cases involving multiple compartments. Our study identified both unilateral and bilateral levator ani defects in the

Table 1. Demographic characteristics of the patients

	POP with patients n=45	Control patients n=45	*p*-value
Age, years	55.6±6	54.6±5.8	0.75
BMI, kg/m^2	29.1±5.1	28.8±5	0.65
Gravity	3 [2; 5]	3 [2; 5]	0.66
Parity	2 [1; 3]	2 [1; 3]	0.71
Smoking	8 (18%)	9 (20%)	0.61
Maximum birth weight, g	3340±450	3410±514	0.62

BMI: body mass index; POP: pelvic organ prolapse

Table 2. Comparison of MRI measurements of patients with pelvic organ prolapse with patients without genital prolapse

	POP with patients n=45	Control patients n=45	*p*-value
Pubococcygeal distance (PC), mm	121.1±17.3	119.3±16.2	0.33
Genital hiatus length, mm	47.5±6.7	46.8±6.6	0.37
Vaginal length, mm	65.2±9.4	68.5±10	0.46
Uterocervical angle	167.2±32.2	172±35.3	0.55
Presence of bilateral levator ani muscle defect, n (%)	17 (38)	8 (18)	**0.03**
Presence of unilateral levator ani muscle defect, n (%)	26 (58)	12 (26)	**0.02**
Obturator internus muscle area (mm^2)	1770±293.4	2104±303.5	**0.02**
M line distance, mm	27.3±5.8	15±4.2	**0.02**
Puborectal distance (H), mm	53.3±6.7	52.5±6.1	0.38

POP: pelvic organ prolapse; MRI: magnetic resonance imaging

MR images of patients diagnosed with apical prolapse. However, the area measurement of the obturator internus muscle was smaller in prolapse patients.

Even among women without pelvic issues, a slight shift in pelvic organ position can manifest due to heightened intra-abdominal pressure.[13] In cases of patients with symptoms, an organ descent of 1 cm above the PCL signifies pelvic floor laxity, while an organ descent exceeding 2 cm frequently necessitates surgical treatment.[14] Our findings showed that the distance between the PCL and the puborectal line was an average of 27 mm for POP patients. However, this descent distance was on average 15 mm in patients in the control group without clinical prolapse. Although we demonstrated partial pelvic floor insufficiency in these patients based on MR images, these patients had no signs of prolapse in their gynecological examination and did not experience POP-related symptoms. We believe that the possible cause of pelvic organ failure in patients in the control group, even if they were asymptomatic, was due to levator ani muscle damage. This is because unilateral levator ani muscle damage was observed in 26% of these patients.

Another risk factor associated with POP and detectable by MRI is injury to the levator ani muscle.[15] The term "levator avulsion" denotes the detachment of the puborectalis muscle from the pelvic sidewall.[16] This injury often arises as a consequence of vaginal childbirth and can manifest as either a unilateral or bilateral condition.[16] Nevertheless, evidence suggests that levator ani avulsion constitutes a risk factor for post-prolapse surgery recurrence.[17] The count of births and the maximum infant birth weights for the patients within both study groups were comparable. Although both groups were similar in terms of demographic characteristics, levator muscle damage was more common in POP patients, both unilaterally and bilaterally.

Another important muscle that causes pelvic floor disorders is the obturator internus.[18] The arcus tendineus is formed by the connection of the levator ani muscle to the obturator fascia along the pelvis' lateral wall. Consequently, elongation of the obturator internus muscle amplifies tension in the fascial attachments, thereby bolstering the mechanical support provided by the levator ani. Research focusing on the rehabilitation of the obturator internus has demonstrated its potential to shield patients against pelvic floor dysfunction, alleviate symptomatic urinary incontinence, and enhance pelvic floor strength among young women. These benefits are attributed to the same underlying mechanism.[19] Our study showed that the obturator internus muscle area was lower in POP patients. Exercises for the obturator internus muscle, which have been reported to increase levator ani muscle function by 40%, can be offered to patients to reduce recurrences after surgery.

Study Limitations

The sample size utilized in the study was relatively small .Studies with a larger sample could have offered a more robust representation, allowing for a broader generalization of the results. The study employed a retrospective design. A prospective design would have enabled better data control and more precise outcomes. The study did not assess patients' clinical outcomes or include factors such as postoperative recovery or symptomatic relief. Given these limitations, it is essential to interpret the results and findings of the study with caution.

CONCLUSION

Our study underscores the profound impact of pelvic floor insufficiency on various dimensions of pelvic organ health. The ramifications of not identifying all prolapse sites extend

to incomplete surgical repair and the potential for recurring issues, underscoring the critical necessity of precise preoperative planning. In this context, MRI emerges as an invaluable asset, particularly in intricate cases encompassing multiple compartments. It effectively revealed levator ani defects and diminished obturator internus muscle areas among patients with apical prolapse. Additionally, our findings underscore the significance of even minor shifts in pelvic organ positioning, signaling pelvic floor laxity and the potential requirement for surgical intervention. The measurement between the PCL and puborectal line demonstrated its relevance in assessing pelvic organ descent, thereby indicating its potential importance in gauging prolapse risk. Notwithstanding certain limitations -such as our study's modest sample size and retrospective design- it furnishes meaningful insights into the roles of levator ani muscle impairment and levator avulsion as risk factors in POP. Furthermore, the notable influence of the obturator internus muscle in pelvic floor disorders suggests the potential efficacy of targeted exercises in diminishing recurrences post-surgery.

In clinical practice, a comprehensive evaluation of pelvic floor function, incorporating MRI assessments and clinical examination, is crucial for accurate diagnosis and treatment planning for POP patients. Future research with larger prospective cohorts will further elucidate the relationships between pelvic floor muscle function, surgical outcomes, and patient satisfaction, contributing to improved management strategies for this challenging condition.

ETHICS

Ethics Committee Approval: The study was performed in accordance with the principles of the Declaration of Helsinki and was approved by the İzmir Bakırçay Ethical Committee (approval number: 1074/1054-23).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Contributions

Medical Practises: İ.K.; Concept: İ.K.; Design: İ.K., M.B.; Data Collection or Processing: M.B.; Analysis or Interpretation: M.B.; Literature Search: İ.K., M.B.; Writing: İ.K., M.B.

DISCLOSURES

Conflict of Interest: No conflict of interest was declared by the authors.

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