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How does the type of delivery affect pelvic floor structure? Magnetic resonance imaging parameter-based anatomical study

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ABSTRACT

Objectives: The aim of this study is to examine the effects of delivery type and birth weight on pelvic floor structure using muscle defects, uterus-vagina angles and landmarks in pelvic magnetic resonance imaging (MRI).

Material and methods: This is a retrospective study. Pelvic MR images of 38 vaginal deliveries and 62 cesarean section patients who met the study criteria were analyzed. Pubococcygeal line, H line, M line were marked on MR images, uterus cervix, cervix upper vagina, upper and middle vagina, middle and lower vagina angles, urogenital hiatus width, levator hiatus width, obturator internus muscle area, levator ani defect was measured. The urinary incontinence and pelvic organ prolapse examination findings were recorded. The patients' age, body mass index (BMI), parity, delivery type, maximum birth weight questions were asked. The data of both groups were compared.

Results: Uterocervical angle and levator ani muscle defect was significantly higher in the vaginal delivery group ($p < 0.001$). In the vaginal delivery group, a significant positive correlation was found between the parity and the levator ani muscle defect ($r = 0.552$), ($p = 0.000$). A significant negative correlation was found between the parity and the uterocervical angle ($r = -0.337$), ($p = 0.039$). A significant negative correlation was found between maximum birth weight and cervix upper vagina angle ($r = -0.365$) ($p = 0.024$). In the vaginal delivery group, a negative significant correlation was found between birth weight and obturator internus muscle area ($r = -0.378$), ($p = 0.019$).

Conclusions: These results show that cesarean section exposes the pelvic floor to less trauma and suggest that cesarean section may protect the pelvic floor.

Key words: birth weight; cesarean section; parity; pelvic floor; vaginal delivery

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INTRODUCTION

Childbirth is associated with pelvic floor overload and may disrupt pelvic floor structures [1]. It is accepted that pelvic floor dysfunction may develop due to direct trauma to the pelvic floor during birth, and this may occur as muscle injury, connective tissue damage, nerve damage, or all three [2, 3]. The levator ani muscle, which consists of puborectalis, iliocoxygeus and puboviseralis parts, has a key role in pelvic organ support and pelvic functions [4]. A common muscle injury that has received increasing scientific and clinical attention in the last decade is the avulsion of the puborectal muscle, which is part of the levator ani muscle, seen in 13–36% of primiparous women. Avulsion is defined as the separation of the muscle from its attachment to the pubic bone [5]. It has been shown that levator ani muscle injury is especially associated with pelvic organ prolapse, and prolapse symptoms increase as the size of the defect increases [6]. In pelvic floor disorders, it is closely related to the axial and mechanical balance disorders of the uterus and vagina; therefore, the axis, position, and shape of the uterus and vagina have been hypothesized to play an important role in maintaining the function of the pelvic floor organs. There are few studies reporting the anatomical axes and positions of the uterus and vagina. Barnhart et al. [7]

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used magnetic resonance imaging (MRI) to measure the initial dimensions of the unenlarged vagina in 28 women. Luo et al. [8] proposed a technique to measure the individual variability of vaginal shape, axis, and size in healthy women. However, comparative studies on the axes, shapes and positions of the uterus and vagina in women with and without prolapse are scarce.

There are studies in the literature showing that the obturator internus muscle (OIM) area is also closely related in pelvic organ damage [9, 10]. It is thought that different types of delivery have different effects on the pelvic floor structure, the incidence of pelvic floor injury varies according to the type of delivery [11, 12]. Epidemiological studies have shown that vaginal delivery causes more pelvic floor damage than cesarean section, and that this is related to the parity and that cesarean section protects the pelvic floor structure [13, 14]. Magnetic resonance imaging (MRI) provides detailed morphological evaluation of the pelvic floor structure. High-resolution static MRI can provide objective and quantitative assessments of changes in position and angle of the uterus and vagina, as well as defect of key support muscles of the pelvic floor, such as the levator ani muscle.

Objectives

The aim of this study is to examine the effects of different birth types and different birth weights on pelvic floor structure using muscle defects, uterus-vagina angles and landmarks in pelvic MRI.

MATERIAL AND METHODS

Study design and sample size

Our study was designed as a retrospective case-control study. Patients who applied to our hospital between January 2018 and April 2022 and underwent pelvic MRI for any indication were analyzed. Inclusion criteria were being premenopausal and over 18 years of age, having had at least one vaginal delivery or only elective cesarean section. It is not known exactly at what stage of delivery the pelvic trauma occurs, so patients with emergency cesarean section were not included in the study. Exclusion criteria were a pelvic mass in the uterus or adnexal areas that disrupted the uterine axis, a history of pelvic surgery, a history of pelvic radiotherapy, and a diagnosis of gynecological malignancy. Pubococcygeal line, H line, M line were marked on pelvic MR images. Uterine cervix angle, cervix upper vagina angle, upper and middle vagina angle, middle vagina lower vagina angle, urogenital hiatus width, levator hiatus width, obturator internus muscle area were measured. Levator ani muscle defect was evaluated. The urinary incontinence and pelvic organ prolapse examination findings of the patients were recorded from the patient data. The patients' age, body mass index (BMI), parity, delivery type, maximum infant birth weight questions were asked from the phone records of the patients in the hospital system.

The sample size of the study was the G Power 3.1.9.4 program. With an effect size of 0.5, power of 80%, and an alpha error of 0.05, at least 38 patients were calculated for vaginal delivery and cesarean section. In our study, 62 patients in the vaginal delivery group and 38 cesarean section group were included and the power increased to 88%.

Pelvic magnetic resonance measurements

Pelvic MR images taken in the supine position with the Siemens Avanto T1.5 MR device in our hospital were examined. Imaging parameters were as follows: repetition time 5331 ms, 375 phase coding, 24 cm field of view and 2 mm slice thickness, no gap between slices in axial, coronal or sagittal projections. Resting MRI sequences were taken in sagittal, coronal and axial planes.

Identification of landmarks

Pubococcygeal line (PCL) was measured as the line drawn from the lower end of the pubic bone to the sacrococcygeal joint. The H line was the line drawn from the lower end of the pubic bone to the posterior rectal wall at the level of the anorectal junction, where the puborectalis muscle was visible. The M line was the line drawn perpendicular to the PCL from the posterior end of the H line (Fig. 1).

Levator ani muscle measurements

Birth-related levator ani muscle injury, morphological or functional changes in the muscle are evaluated quantitatively. Morphological changes were evaluated with the LAM scoring system proposed by DeLancey et al. [15]. Bilateral muscles were scored separately in the axial planes. "0" points, invisible damage; "1" if less than half of the muscle is lost, "2" if more than half of the muscle is gone; and it was scored as "3" if the origin of the muscle was distorted. Bilateral muscles were categorized from 0 to 6: a score of 0 indicated no defect, a score of 1–3 indicated a minor defect, and a score of 4–6 a major defect. Three points unilaterally and 4–6 points bilaterally showed major defects (Fig. 2A, B). The levator hiatus was measured in the sagittal plane up to the anorectal junction where the lower end of the pubis anteriorly and the puborectalis muscle posteriorly are visible.

Obturator internus muscle measurements

Evaluated on axial images. The obturator internus muscle area was measured in the section where the pubic bone anteriorly, the sacrum posteriorly, and the sacrospinous ligaments posteriorly were visible (Fig. 2C).

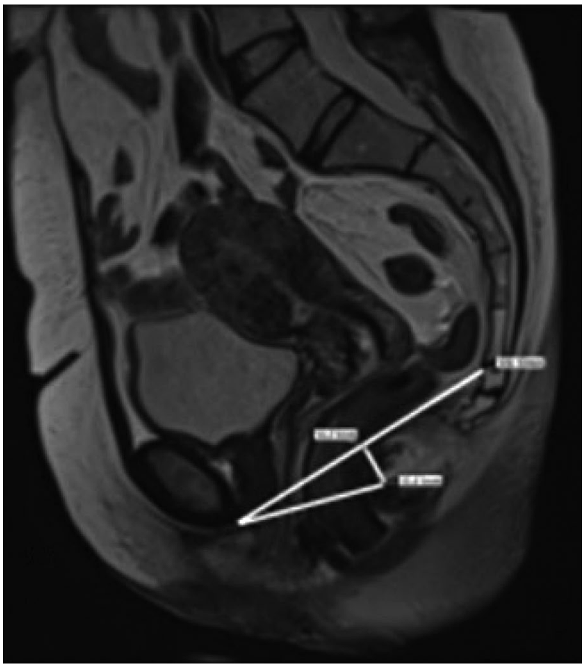

Figure 1. Pubococcygeal line, H line, M line

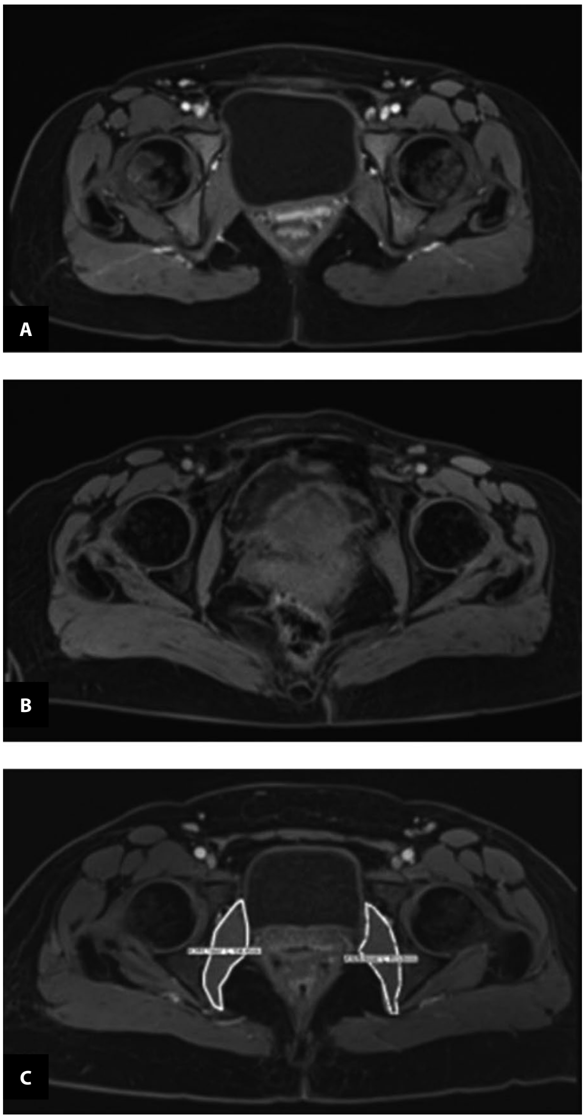

Figure 2. A. Normal levator ani muscle; **B.** Score 6 levator ani defect; **C.** Obturator internus muscle area

Urogenital hiatus and vagina length measurement

The urogenital hiatus defines the distance from the urethra to the perineal body in the sagittal plane. Vaginal length defines the distance in the midsagittal line from the urethral meatus to the anterior fornix (Fig. 3A, 3B).

Angle measurements

The uterus was divided into uterus body and cervix to measure the uterus vaginal axis. The vagina is divided into upper, middle and lower sections. The upper vagina was analyzed using a line connecting the apex of the anterior and posterior fornix. The middle vagina was the area of the vagina above the pelvic septum and the lower vagina was the area of the vagina below the pelvic septum. The cervical axis was defined as the cervical canal connecting the inner orifice of the cervix with the outer orifice of the cervix. The uterine body axis was defined as the line between the inner opening of the cervix and the furthest point of the uterine floor passing through the uterine cavity. The uterocervical angle was defined as the clockwise angle between the uterine body axis and the cervical axis. All measurements were taken clockwise (Fig. 4). Data were recorded and compared between vaginal and cesarean delivery patients.

Statistical analysis

In the statistical analysis phase, frequency tables for categorical variables and descriptive statistics for continuous variables were calculated. Pearson chi-square test was used to analyze categorical data in terms of groups. Shapiro-Wilk test of normality was used to examine whether continuous variables were normally distributed. If the data were normally distributed, the t-test was used in the independent groups to compare the variables in the normal and cesarean delivery groups, and the Mann-Whitney U test was used if they were not normally distributed. The Spearman Correlation coefficient was calculated to examine the correlation between the data. The significance level was taken as 0.05 in all hypothesis tests. IBM SPSS Version 25.0 statistical package program was used for statistical analysis.

Ethics committee approval

Local ethics committee approval was obtained for the study in accordance with the Declaration of Helsinki. Decision number and date 613/01.06.2022.

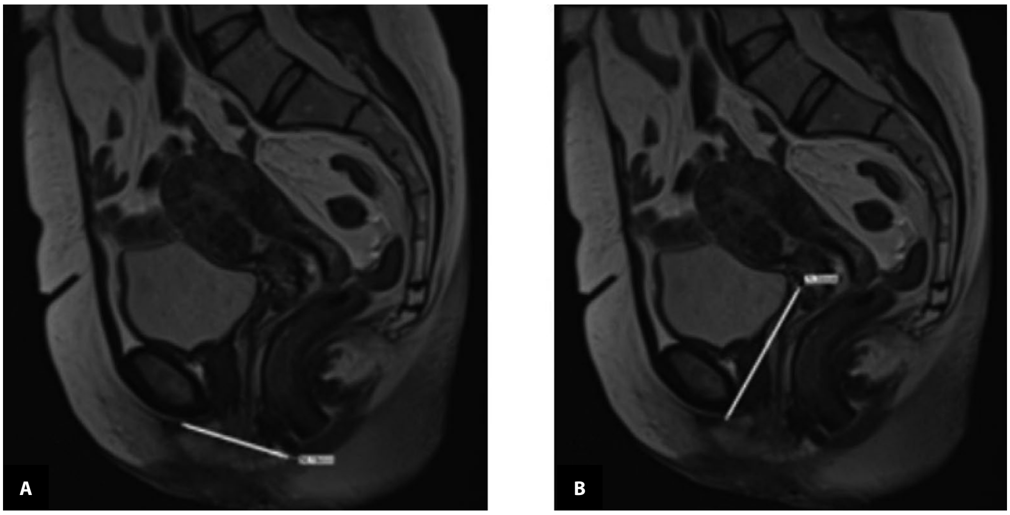

Figure 3. A. Genital hiatus; **B.** Total

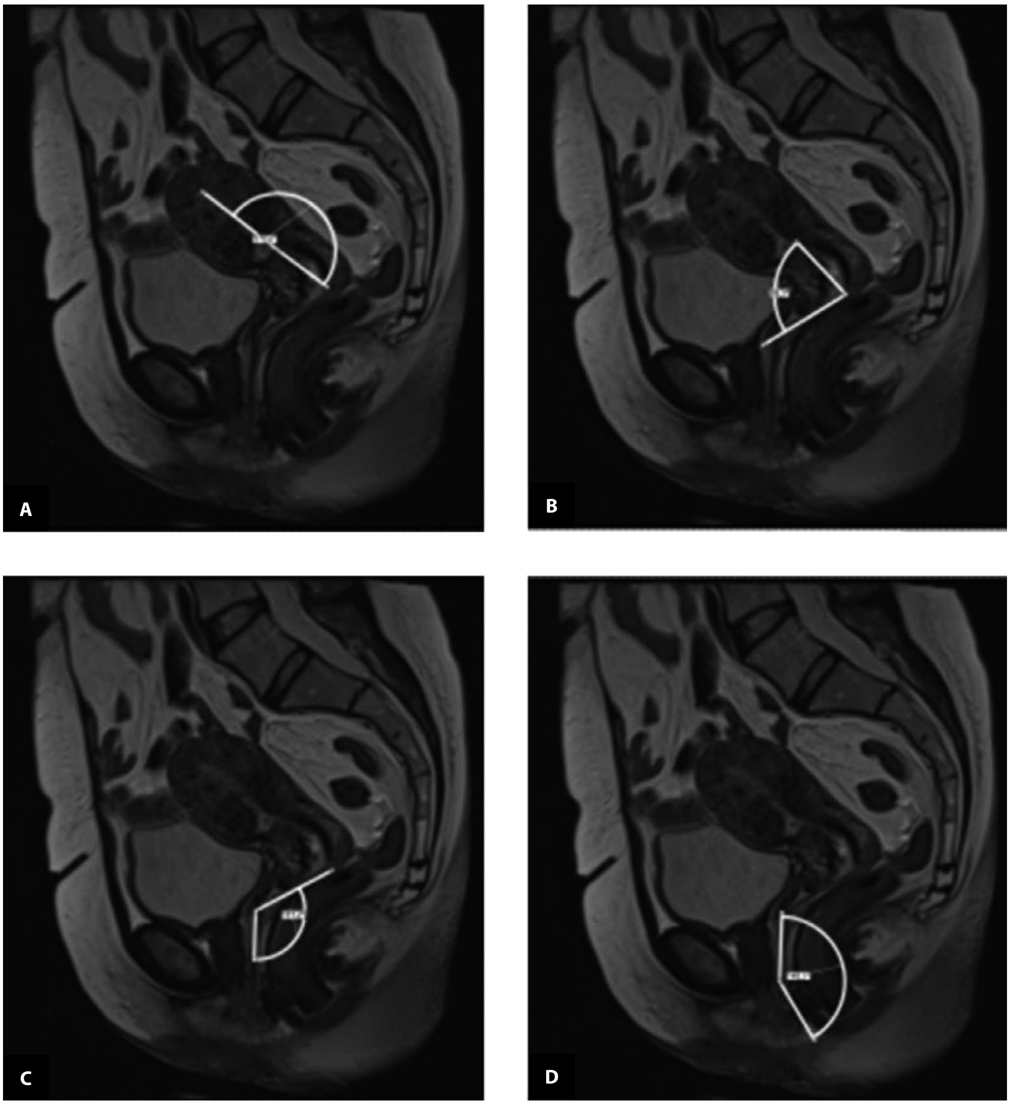

Figure 4. A. Uterocervical angle; **B.** Cervix upper vagina angle; **C.** Upper middle vagina angle; **D.** Middle lower vagina angle

RESULTS

Of the 100 patients included in the study, 38 (38%) had vaginal delivery and 62 (62%) had cesarean section. In the cesarean section group, 59 patients had cesarean section due to cephalopelvic disproportion and 3 patients due to fetal macrosomia. The mean age of the patients was 36.63 years for vaginal delivery and 37.5 years for cesarean section, and there was no statistically significant difference (p = 0.542). There was no significant difference between the two groups in terms of BMI (p = 0.244). The height of the group who had vaginal delivery was statistically significantly higher (p = 0.042). The parity was less in the cesarean section group and it was statistically significant (p < 0.001). The maternal age at first birth in the vaginal delivery group was significantly lower than the cesarean section group (p < 0.001). There was no significant difference between the two groups in terms of maximum birth weight, incontinence, and presence of pelvic organ prolapse (p = 0.232; 0.139; 0.133, respectively). In terms of radiological MR measurements, there was no significant difference in terms of H line, M line, cervix upper vagina angle, upper middle vagina angle, middle lower vagina angle, obturator internus muscle areas, genital hiatus diameter and total vagina length (p = 0.324; 0.173; 0.890; 0.699; 0.341; 0.324; 0.097; 0.055, respectively). Uterocervical angle was significantly higher in the vaginal delivery group (p < 0.001). Levator ani muscle defect was significantly higher in the vaginal delivery group (p < 0.001). Details are shown in Table 1.

When the correlation between the number of births, maximum birth weight and MR measurement parameters of both groups was evaluated, a significant positive correlation was found between the parity in the vaginal delivery group and the anterior posterior diameter of the levator hiatus (r = 0.334) and levator ani muscle defect (r = 0.552), (p = 0.041, p = 0.000). In addition, a significant negative correlation was found between the parity and the uterocervical angle (r = –0.337) (p = 0.039). A significant negative correlation was found between maximum birth weight and cervix upper vagina angle (r = –0.365), (p = 0.024). A negative significant correlation was found between maximum birth weight and right obturator internus muscle area (r = –0.325), left obturator internus muscle area (r = –0.375) and total obturator internus muscle area (r = –0.378), (p = 0.046; 0.020; 0.019, respectively). The correlation in the vaginal delivery group is shown in Table 2. In the cesarean section group, only the parity and the uterocervical angle (r = –0.259) were negatively correlated (p = 0.042).

Table 1. Comparison of demographic, clinical and radiological characteristics of patients

	Vaginal delivery (n = 38, 38%)	Cesarean section (n = 62, 62%)	p
Age [year][a]	36.63 (7.00)	37.50 (6.00)	0.542[d]
Height[b]	1.64 ± 0.05B	1.61 ± 0.06	**0.042**[e]
Weight[a]	70.00 (16.00)	65.00 (15.00)	0.066[d]
BMI (kg/m^2)[a]	25.89 (6.28)	24.85 (6.26)	0.244[d]
Parity[a]	2.00 (1.00)	2.00 (1.00)	**< 0.001**[d]
Maternal age at first delivery [year][b]	20.00 (4.00)	24.00 (5.00)	**< 0.001**[e]
Max birth weight [kg][a]	3625.00 (713.00)	3500.00 (825.00)	0.232[d]
Incontinence[c]			0.139[f]
None	26 (68.50)	52 (83.90)	
Stres incontinence	11 (28.90)	8 (12.90)	
Urge incontinence	1 (2.60)	2 (3.20)	
Pelvic organ prolapse[c]			0,133[f]
None	35 (92.10)	61 (98.40)	
Cystocele	2 (5.30)	–	
Rectocele	1 (2.60)	–	
Cystorectocele	–	1 (1.60)	
PCL[b]	115.09 ± 8.44	115.11 ± 9.07	0.993[e]
H line[a]	53.25 (10.83)	51.59 (10.08)	0.324[d]
M line[b]	16.96 ± 4.47	15.55 ± 5.30	0.173 [e]
Uterocervical angle[b]	192.79 ± 35.32	163.88 ± 40.06	**< 0.001**[e]
Cervix upper vagina angle[a]	275.80 (36.80)	276.95 (46.20)	0.890[d]
Upper middle vagina angle[a]	138.10 (16.70)	138.70 (21.70)	0.699[d]
Middle lower vagina angle[a]	169.10 (17.00)	168.35 (23.70)	0.341[d]
OIM area right[b]	947.82 ± 190.08	927.32 ± 192.03	0.604[e]
OIM area left[b]	913.35 ± 176.79	880.28 ± 191.49	0.391[e]
OIM area total[a]	1915.35 (384.40)	1913.25 (467.30)	0.324[d]
Levator ani defect[a]	2.50 (3.00)	0.00 (1.00)	**< 0.001**[d]
Score 0 [n (%)]	8 (21)	41 (66.1)	
Score 1 [n (%)]	6 (15.8)	13 (21)	
Score 2 [n (%)]	5 (13.2)	7 (11.3)	
Score 3 [n (%)]	8 (21)	1 (1.6)	
Score 4 [n (%)]	6 (15.8)	0	
Score 5 [n (%)]	3 (7.9)	0	
Score 6 [n (%)]	2 (5.3)	0	
Genital hiatus size[b]	45.70 ± 7.28	43.11 ± 7.63	0.097[e]
Total vagina lenght[b]	66.51 ± 11.43	62.07 ± 10.87	0.055[e]

[a] — Median (IQR); [b] — mean ± standard deviation; [c] — n (%); [d] — Mann-Whitney U test; [e] — t-test on independent groups; [f] — chi-square test; BMI — body mass index, PCL — pubococcygeal line, OIM — obturator internus muscle

DISCUSSION

Vaginal delivery traumatizes the pelvic floor structure and has been shown to be directly related to pelvic floor damage [11, 16]. Although there are studies in the

Table 2. Correlations between parity, maximum birth weight and magnetic resonance imaging parameters in the vaginal delivery group

	Parity		Maximum birth weight	
	r	p	r	p
Uterocervical angle	**–0.337**	**0.039**	0.033	0.842
Cervix upper vagina angle	–0.302	0.066	**–0.365**	**0.024**
Levator hiatus size	**0.334**	**0.041**	0.166	0.319
Levator ani defect	**0.552**	**0.000**	0.178	0.285
OIM area right	–0.115	0.492	**–0.325**	**0.046**
OIM area left	–0.122	0.465	**–0.375**	**0.020**
OIM area total	–0.103	0.538	**–0.378**	**0.019**

OIM — obturator internus muscle

literature showing that elective cesarean section protects the pelvic floor structure, there are also studies claiming the opposite [11, 17, 18]. The main question to be answered is whether pregnancy or childbirth has an effect on pelvic floor dysfunction.

The pelvic floor has two main functions: to provide structural support to the pelvic organs and to provide urinary and fecal continence [19]. The most important muscle providing this function is the levator ani muscle. The pelvic floor structure is disrupted in its defect [20]. According to a study by Li et al. [21], it was concluded that the length and axis of the uterus and vagina are also important in pelvic floor support.

Our aim in this study was to examine the pelvic MRI parameters and to reveal whether vaginal delivery and cesarean section have an effect on the pelvic floor. Therefore, we used pelvic MR images, which are a good indicator of the pelvic floor. When we compared both groups in terms of MRI parameters, we found more levator ani muscle defect in the vaginal delivery group. Also, the uterocervical angle was higher in patients who had vaginal delivery compared to patients with cesarean section. This suggested that mechanical forces have an effect on the levator ani, which is the biggest support factor of the pelvic floor during the delivery process. In support of our results, various studies have shown that vaginal delivery creates a defect on the levator ani muscle, especially in the puborectalis muscle [22, 23].

In our study, the correlation between MR parameters and the parity and maximum birth weight in the cesarean and vaginal delivery groups was also important. In both groups, as parity increased, uterocervical angle decreased. This suggested that, regardless of the delivery type, pregnancy alone decreased the uterocervical angle, making the uterus more vertical. In our study, although we did not find a significant difference between the two groups in terms of pelvic floor dysfunction clinically, there are studies showing that the uterocervical angle is larger in patients with prolapse [21].

Significant correlations were observed in the vaginal delivery group. As the number of vaginal deliveries increased, the levator ani muscle defect and accordingly the anterior posterior diameter of the levator hiatus increased significantly. Although no clinically increased pelvic floor dysfunction was found in this group in our study, it was shown in a review that the levator hiatus was larger in patients with prolapse compared to the normal patient group [24].

It was determined that as the maximum birth weight increased in the vaginal delivery group, the cervix upper vagina angle and obturator internus muscle areas on both sides decreased significantly. This result suggested that the larger a fetus passed through the pelvis, the more traumatized the OIM was. In addition, the decrease in the cervix-upper-vaginal angle indicates that the uterus has become more vertical. In their study, Sammarco et al. [10] showed the relationship between decreased OIM area and prolapse. In our study, our patients were in the premenopausal period. These patients, whose OIM area we measure as small, may constitute a risky population for prolapse in later ages.

Our study has advantages. It is known that pelvic floor dysfunction increases in the postmenopausal period. All of our study patients consisted of women in the premenopausal period and the mean age of both groups was similar. Thus, we excluded advanced age, which is one of the most important risk factors for pelvic floor dysfunction. Previous studies have indicated that pelvic floor dysfunction increases with high BMI [25, 26]. In our study, the BMI of the vaginal delivery and cesarean section groups was similar. In addition, there was no significant difference between the two groups in terms of the M line, which is a good indicator of pelvic organ prolapse in MRI [27].

Our study is a retrospective study, patients were not undergone MRI at a standard time after delivery, both groups are not homogeneous in terms of height, parity and age at first birth. This is the limitations of our study.

CONCLUSIONS

As a result, although there are studies in the literature showing that cesarean section has a protective effect on the pelvic floor, a complete consensus has not been reached. Results of our study show that cesarean section exposes the pelvic floor to less trauma and suggest that cesarean section may protect the pelvic floor. Prospective case-control studies are needed to demonstrate the long-term effects of delivery type on the pelvic floor.

Ethics approval

Local ethics committee approval was obtained for the study in accordance with the Declaration of Helsinki. Decision number and date 613/01.06.2022.

Authors' contributions

Conceptualization — Ayşe Rabia Şenkaya, İbrahim Karaca; Methodology: Ayşe Rabia Şenkaya, Sabahattin Anıl Arı; Formal analysis and investigation — Eren İsmailoğlu; Writing — original draft preparation: Ayşe Rabia Şenkaya; Writing — review and editing: Ayşe Rabia Şenkaya, İbrahim Karaca; Funding acquisition — not applicable; Resources — Sabahattin Anıl Arı, Eren İsmailoğlu; Supervision — İbrahim Karaca.

Conflicts of interest

All authors declare no conflict of interest.

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