

## Accurate Differentiation of Dyssynergic Defecation Patients from Normal Subjects Based on Abnormal Anorectal Angle in MR Defecography

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### Abstract

**Objective:** We aimed to study the kinematic indices of the pelvic floor, anorectal angle and the descent of perineum, and the differing movement, in dyssynergic defecation patients in comparison with healthy controls, based on MR defecography.

**Methods:** Twenty-two individuals involved with dyssynergic defecation constipation and fourteen healthy asymptomatic subjects fell into this study. In four dynamic pelvic floor MRI indices, namely paradox (unusual change of anorectal angle), perineal descent during straining, perineal ascent, and narrowing of anorectal angle at squeeze, were measured in patients and healthy subjects.

**Results:** Paradox Index had the highest sensitivity (95.45%) and specificity (92.86%) for detection of dyssynergic defecation, with an  $R^2$  value of near 1 (0.902). The sensitivity and specificity of other indices were not high; therefore, no significant improvement could be achieved using other indices along with Paradox Index. Negative Predictive Value (92.85%) and Positive Predictive Value (95.45%) were only high in Paradox Index.

**Conclusion:** Paradox Index was indicated to be the best finding of MR defecography for identifying dyssynergic defecation patients from healthy controls. Hence, MR defecography could be exploited as an authentic tool to manifest the patients the paradoxical function and the relevant muscles of pelvic floor, which could enhance their imagination of the correct defecation pattern during their treatment.

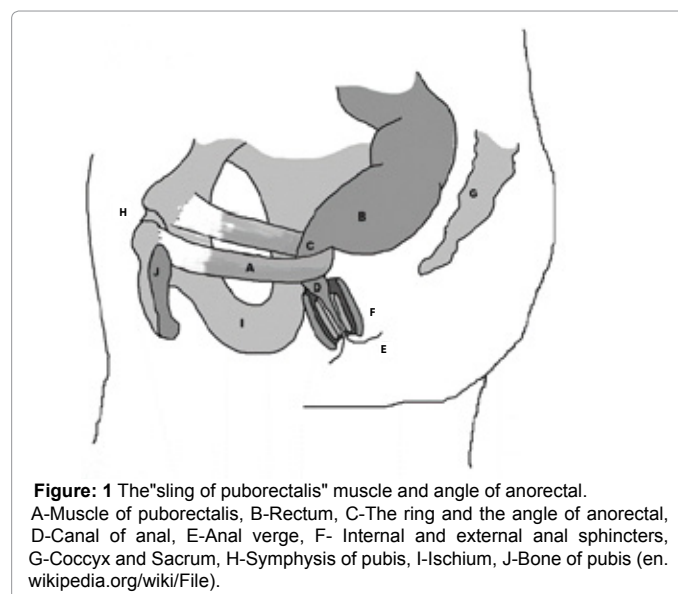
**Keywords:** MR defecography; Functional constipation; Dyssynergic defecation

### Introduction

Disordered defecation can result as a consequence of many structural and functional causes in the pelvic floor region. "Dyssynergic Defecation" (DD) or contraction syndrome of paradoxical puborectalis, as the most common disorders of defecation, recognized as a fundamental cause of functional "chronic constipation". Almost 50% of "chronic constipation" patients have been considered to be in this category [1].

Muscle of puborectalis is a section of the sphincter of anal, originates from the trunk of pubic bone and shapes a ring just round the rectum [2]. With contraction of puborectalis the joining point of the rectum is pulled and the canal of anal comes forward. So, it forms the angle of anorectum "ARA". As it is an angle formed from posterior edge of the lower end section of rectum and the axis of the center of anal canal. The joining point of anorectal (ARJ) is the lower end of the rectum as reaching down to the canal of anal (Figure 1). The "ARA" normally closes between rest and squeeze conditions, and the ARJ can raise 1-2 cm from the rest position. While straining the "ARA" gets more widen (15-20°), in accordance with the relaxation of the puborectalis muscle [2].

In "dyssynergic defecation" individuals coordinating the abdominal, pelvic floor and anorectal muscles function gets disabled during defecation phase. By the way the external sphincter of anal and puborectalis muscles cannot get relaxed and paradoxical contraction occurs. The pattern of the dyssynergic defecation is not obvious etiologically. But the abnormal activity of this muscles is related to dysfunction of the brain-bowel axis, an impaired defecation pattern learned, or because the mechanisms of coordination for defecation never learnt during childhood [3].



**Figure 1** The "sling of puborectalis" muscle and angle of anorectal. A-Muscle of puborectalis, B-Rectum, C-The ring and the angle of anorectal, D-Canal of anal, E-Anal verge, F- Internal and external anal sphincters, G-Coccyx and Sacrum, H-Symphysis of pubis, I-Ischium, J-Bone of pubis (en.wikipedia.org/wiki/File).

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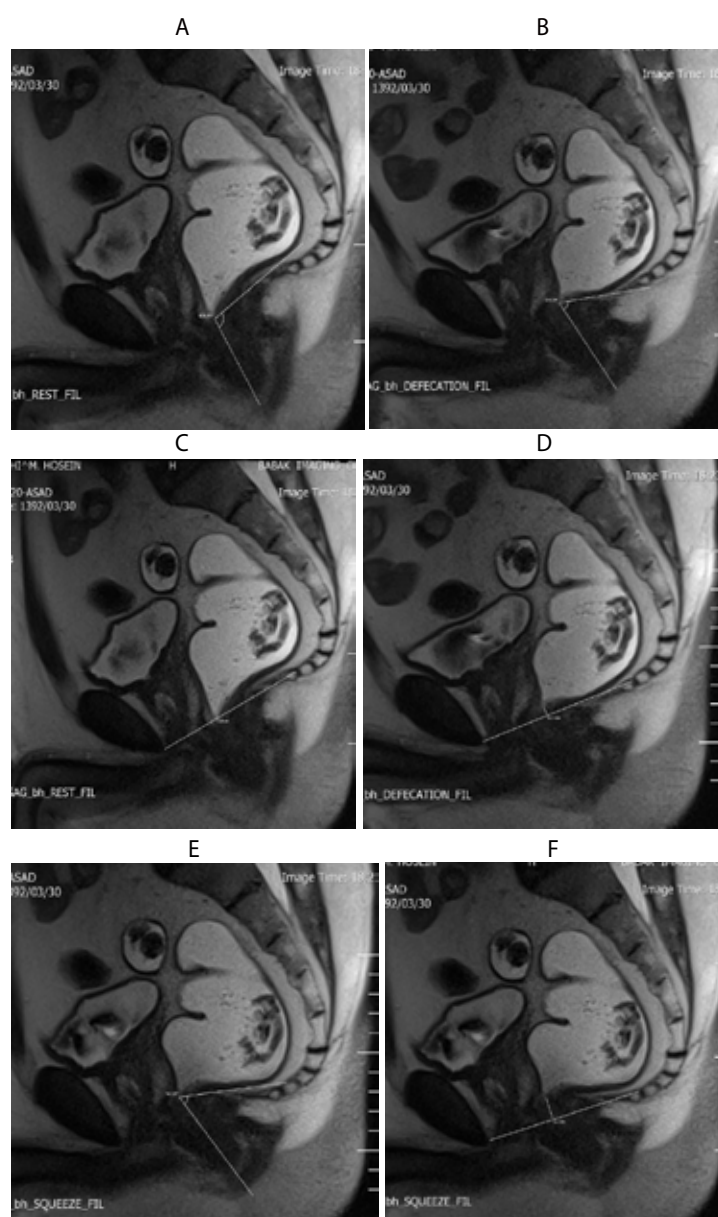
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In many authors' opinions, this learned misresponse (paradoxical contraction) may be due to sexual, physical or emotional abuse, or resulting from a history of painful defecation during childhood [4,5]. The pathophysiology of chronic constipation is heterogeneous; so, different physiological tests, such as "balloon expulsion test", "conventional defecography", electromyography (EMG) of the muscles of anal and pelvic floor can be used to identify the DD patients [6]. Each of these tests has its own limitations, thus, none can be used separately. Therefore, it is recommended to use a combination of diagnostic tests. The needle pain may cause a false positive on EMG. For defecography the limitations are; "Radiation exposure", "inter-observer bias", "inconsistent methodology" and lack of visualization of the necessary bony landmarks for measuring the motion of

anorectal [2]. To overcome these limitations, the MR defecography or "Dynamic Pelvic MRI (DPMRI)" with a crucial role in recognizing "the paradoxical function" of puborectalis muscle and few disadvantages, can be recommended. MR defecography is a valuable approach that can assess the movement and the anatomy of pelvic floor both at the same time [2,7]. It also reveals multiplanar information of impairments of the pelvic floor along with defecation imaging "real-time". Furthermore, "high temporal resolution", "Soft-tissue contrast" and absence of "radiation exposure" make this modality suitable in evaluating the dysfunction of pelvic floor that can help to manage a more precise treating program [2,5,8-10]. In patient with dyssynergic pattern, MR defecography can show "ARA" get closed and absence of the pelvic floor descending in defecation as illustrated in (Figure 2).



**Figure: 2** The figure shows a 43 year man with dyssynergic defecation in (a) rest and (b) during defecation. As shown in part (b) the angle of anorectal (ARA) paradoxically closes and the sphincter of anal does not widen because of unsuitable puborectalis muscle contraction. Part (d) shows the absence of the pelvic floor descent because for unsuitable puborectalis muscle contraction of the patient during defecation compare with when resting. Parts (e) and (f) respectively indicate decreased anorectal angle and increased anorectal junction during squeeze.

There are rare studies on assessing the value of MR defecography in diagnosing of differentiating "dyssynergic defecation" pattern in patients vice versa healthy subjects [11]. This study aimed at investigating sensitive and specific parameters of MR defecography for identifying patients from healthy subjects.

## Materials and Methods

### Subjects

Those patients suffering from chronic constipation, who were referred to our medical center, were selected in this study if fulfilled "Rome Diagnostic Criteria" for "functional constipation" at least for 3 months [12]. The study of clinical history and digital examination of the rectum, by a proctologist confirmed the diagnosis of "dyssynergic defecation" in the subjects. The patients having had anorectal surgery, tumors of anorectal, structural disorders of anorectal needed any kind of surgical intervention, were excluded. The healthy subjects voluntarily agreed to take part in the study. They were selected if did not have any complaints of constipation with no previous anorectal disorders. The local institution Ethics Committee approved the study. The patients providing written informed consent were included.

### Measures

The changes of pelvic floor movements, the angle of anorectal and the descent of perineum (M-line) which is the shortcut between the line of pubococcygeus (PCL) and the joining point of the anorectum (ARJ) measured at rest, squeezing and straining to defecation with doing MR defecography [13].

### MR defecography procedures

MRI was performed on a 1.5 Tesla MR scanner "MAGNETOM Avanto, Siemens, Erlangen, Germany", a closed MRI with a coil of 4 element phased array, which adjusted round the pelvis. With patients in supine position and knees and hips flexed, a physiologic defecation position simulated. Although MRI in sitting position with pelvic floor muscle more relaxed and "ARA" more widen could facilitate defecation, but not superior to MRI in supine position [14]. The patients' preparation not necessary for MR defecography [9].

Before the MRI, with patient in lying lateral position, 120 ml gel of ultrasound into the rectum instilled [10]. In supine position, the anatomical abnormalities of pelvic floor were assessed by "coronal and axial fast spin-echo, T2-weighted" images. Then a "single-shot fast spin echo, T2-weighted" imaging technique in the sagittal plane at rest, and squeezing with maximal contraction of the puborectalis muscle and sphincter of anal, also at straining each 1.5-2 s was obtained [15]. The maneuver accuracy could be monitored by "real-time" imaging [10]. The specifications of the images obtained, were; "field of view (FOV)=25 mm", "matrix size=256 × 256", "repetition time (TR)=896 ms", "echo time (TE)=83 ms", "rectangular FOV=84.4-100 cm (according to each patient's size)", "section thickness=6 mm", "inter-slice gap=20%", "bandwidth=416 kHz", "flip angle=150".

Asking the patients contracting the pelvic floor muscles for 12 s. Then have a rest for 12 s. Finally strain, till the occurrence of defecation [11].

### Analysis of images

The images were analyzed independently by two different radiologists. The angle of anorectal and the joining point of anorectal to PCL or "M-Line" at rest and squeezing and during defecation were

assessed. The changes from rest to straining were measured as "(ARA at straining)-(ARA at rest)" [13]. In this measurement, the decline of "ARA" defined as "Paradox Index" [11].

Up and down movement of the ARJ to the PCL while squeezing and defecation were calculated by measuring the "ascending or descending" of ARJ from PCL. Perineal descent between rest and straining were measured as "[M-Line at defecation)-(M-Line at rest)". Descent below the PCL was represented as negative value. ARJ goes down far from PCL from rest to defecation; with this we can diagnose a normal perineal descent. Decreased or lack of perineal descent while straining resulted from "the paradoxical function" of puborectalis and sphincter of anal muscles, defined as "abnormal perineal descent" [13]. Normally, during squeezing, perineal ascent must be observed. Ascent of perineum from rest to squeeze was measured as "(M-Line at squeeze)-(M-Line at rest)". Narrowing of ARA as well as Perineal ascent during squeeze indicates a normal pelvic floor and anal sphincter muscle strength. Narrowing of ARA during squeeze was calculated as [(ARA during squeezing)-(ARA at rest)]. In this study we measured 4 MR defecography dynamic indices in healthy subjects and patients, including, "Paradox Index", "Perineal Descent Index", Perineal Ascent at Squeeze Index, and Narrowing of ARA at Squeeze Index. Impaired evacuation, as an MRI finding, was not the purpose of this work for discrimination of patients with DD; owing to if the subject has a pattern of "dyssynergic defecation" as soon as he/she tended to defecate the striated muscle of pelvic floor muscle, that is puborectalis and sphincters of anal would soon contract unwillingly and paradoxically [14]. In fact, in these cases, the clinical symptom is a difficulty in initiating evacuation [15].

## Results

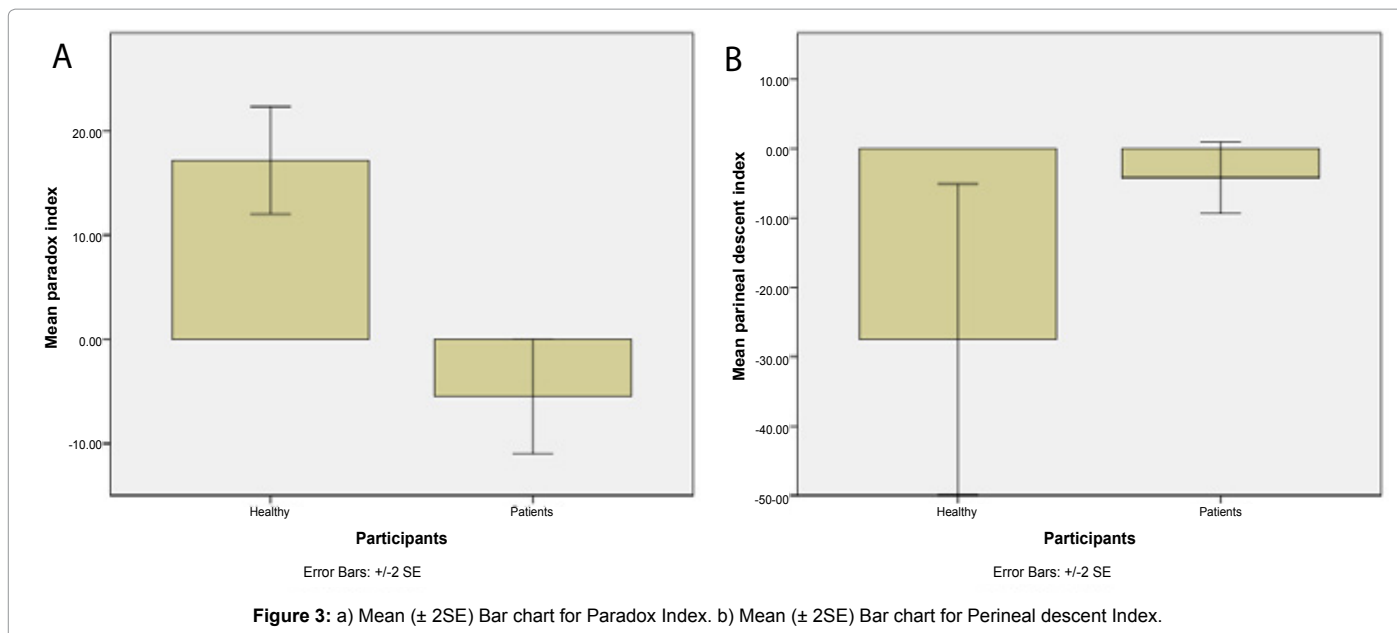
From 2012 to 2014, 22 constipated subjects with "dyssynergic defecation", [5 males and 17 females, age=37 ± 13.6 (mean ± SD), age range=19-63] and 14 asymptomatic subjects, [7 males and 7 females, age=37.86 ± 12.62 (mean ± SD), age range=20-65], participated in this study. The differences between the two groups relating to the age (p=0.77) were not significant. Statistical analysis was performed using Statistical Package for Social Science (SPSS) software. The statistically significant difference grade was 0.05 or less (p-value ≤ 0.05). "The inter-observer agreement" between the two separate observers by measuring intra-class correlation coefficient (ICC) and 95% of confidence intervals (CI).

MRI measures of anorectal movement in healthy controls vs. "dyssynergic defecation" subjects.

In healthy control subjects, defecation was along with pelvic floor muscles relaxation, detected by increase of angle of anorectal and descent of perineum. In the 14 controls, "Perineal Descent Index" was not correlated with "Paradox Index", (r=0.15, p=0.61).

Using t-test, "Paradox Index" and "Perineal Descent Index" of the patients were put to comparison with the healthy ones. Mean (± standard deviations) for "Paradox Index" of healthy subjects and patients were respectively 17.19 (± 9.69) and -5.47 (± 12.9) with p-value < 0.0001. For "Perineal Descent Index" mean (± standard deviations) for patient and healthy groups were -4.18 (± 12.1) and -27.49 (± 41.89), respectively. However, due to high variance of "Perineal Descent" in healthy ones, t-test did not detect any significant in the two groups (p-value=0.061), as indicated in (Figure 3 and Table 1).

We used four MRI findings individually to classify subjects into healthy and patient groups, by binary logistic regression (BLD) method. As it can be observed in (Table 1), only "Paradox Index" has an



MRI findings indices (pelvic floor motion indices)	Sensitivity	Specificity	PPV	NPV	Nagelkerke R <sup>2</sup>
Paradox Index (abnormal ARA changes)	95.45	92.86	95.45	92.86	0.902
Perineal Descent Index	95.45	42.86	72.41	85.71	0.231
Perineal Ascent at Squeeze Index	100.00	0.00	61.11	N/A	0.004
Narrowing of ARA at Squeeze Index	86.36	35.71	67.86	62.50	0.113

**Table 1:** Diagnostics test characteristics MR defecography indices using binary logistic regression analysis.

R2 (Nagelkerke) value of near 1 and can discriminate the patients from the healthy group. The other indices showed poor R2. "Perineal Descent Index" has R2=0.231 and Index of Narrowing ARA at Squeezehas R2=0.113.

The worst parameter was Index of Perineal Ascent at Squeeze with R2=0.004, as healthy persons and patients behave similarly in this respect. Therefore, this parameter has no predictive value for discriminating the patients from the healthy subjects.

Highest sensitivity and specificity for "dyssynergic defecation" detection were shown with "Paradox Index". But, the sensitivity and specificity of other indices were not high, so that, even in combination with "Paradox Index", no change in the sensitivity of these findings was observed.

Negative and Positive predictive value (NPV and PPV) were only high in "Paradox Index". So, the "Paradox Index" parameter was proved as the best index for discrimination of the patients from the healthy subjects.

### Inter-observer agreement

The six parameters of MRI used to construct our basic calculation of indices as being, M-line and angle of anorectal; while resting, squeezing and defecation were calculated by two deferent radiologists. All measured ICC values showed higher than 0.9, which means existence of similarity of the two observers.

### Discussion

In "dyssynergic defecation" the diagnostic achievements on dynamic MR imaging encompasses a distinct impression of puborectalis muscle,

and narrowing of canal of anal. The levator plate bulge up, "ARA" does not increase, and pelvic floor does not descend [14]. The sagittal images show that during defecation, the angle of anorectal gets more widen proves the fact that the muscle of puborectalis does not relax, in the process of defecation [15].

In this study, our main goal was to specify the accuracy of "ARA" in discriminating patients with "dyssynergic defecation" from healthy persons, using MRI defecography.

In ascertaining the use of MR defecography for recognizing pelvic floor movement in subjects with "dyssynergic defecation" (DD). There are not enough controlled studies (including healthy and asymptomatic subjects). To overcome this limitation, we studied both healthy and involved subjects. We aimed to design a study on detecting the sensitivity and specificity of MRI dynamic findings in pelvic floor motion, i.e., ARA changes and the perineal vertical movement. According to the outcome of a study by Chu et al. on dynamic MRI in pediatric subjects with DD, which suggested significant difference of abnormal ARA changes "Paradox Index" during straining, comparing the patients and the healthy subjects [16]. We also found that our primary outcome measure, i.e., "Paradox Index", is the best indicator for identifying patients from healthy controls, which resulted in high values of specificity (92.86), sensitivity (95.45), PPV (95.45) and NPV (92.85). In a study by Reiner et al., it was indicated that the decrease in ARA during defecation is a very important sign of DD [13]. However, no abnormal ARA changes, which could be helpful for identifying patients with DD, was observed when ARA was interpreted as an independent parameter. Rather, they found ARA to be highly predictive for DD patients when interpreting it along with paradoxical sphincter contraction parameter or "Abnormal Perineal Descent" [13]. This relates to the fact that in their study, the

control group was consisted of "functional constipation" patients and without DD, who could have other symptoms similar to the DD patients. To be able to use ARA-changes (here called Paradox Index) as an independent and strong predictor of DD, in our study, the patients with DD were compared with asymptomatic healthy subjects, who did not have obstructed defecation. Meanwhile, we could not find the abnormal Perineal Descent Index as a helpful parameter to differentiate these patients from the control group, although this abnormal index was present in 95.5% of the patients, it was also seen in the healthy subjects. This index had a low specificity (42.86), PPV (72.41) and NPV (85.71) for diagnosis of DD. This could be justified because we could not separate patients with paradoxical contraction of puborectalis and sphincter muscles from non-relaxed patients (inability to relax or no sufficient relaxation of their muscles during straining, which would result in not enough descending of perineum). Whilst, normally perineal descent during defecation is from zero (meaning ARJ is located just on the PCL and perineal descent has not occurred) to 2.5 cm below PCL in asymptomatic subjects, this finding could be seen in both the healthy and the non-relaxed patients. However, Reiner et al. reported that "Abnormal Perineal Descent" presented a sensitivity of 83%, which could be increased to 94% when it was interpreted along with abnormal "ARA" changes [13,16,17]. In contrast to the work by Reiner et al., we did not choose impaired evacuation as an MRI finding for discrimination of patients with DD; because, this finding can be observed in other subjects with "functional constipation" [13]. In a study by Shink et al., it was concluded that the decrease of anorectal angle in MR defecography during squeeze indicated the probability of improvement of muscle function after biofeedback therapy. Also, they presented that increase of ARA during squeeze predicts weak answer to treatment by biofeedback for persons with DD [18]. In contrary, our results suggest that decreasing ARA from rest to squeeze cannot differentiate the patients from healthy subjects, because this finding was also observed in the patients group (Figure 2). Normally, dynamic MRI reveals contraction of puborectalis muscle and anal sphincter during squeeze as perineal ascending and also narrowing of ARA. In contrast to the study by Shink et al., we did not observe increased ARA during squeeze in any of our subjects [18]. The relatively less number of study groups, is one of the restrictions in this study because, there are structural rectal disorders such as "rectocell", "rectal intussusceptions" and "solitary rectal ulcer syndrome" in most of the patients with "dyssynergic defecation" [19]. These patients attending the clinic only if they need surgery for their disorder. So it was hard to find DD patients need not surgery (the exclusion criteria of our study).

Another limitation of this study was MR defecography in supine position. Supine is not a physiological defecation position. ARA doesn't increase in normal situation either in patients or healthy subjects during defecation. Maglente et al. suggested that evacuation in supine position with patients' legs extended and in protocols with just rest and strain sequences, does not precipitate the symptoms [20]. But in this study, with laying the patients in supine position and placing a pillow beneath the knees, a relative physiologic defecation position was created [21]. Also placing the hips in as much flexion as possible caused a relative relaxed position to make more perpendicular rectoanal canal. Hence, the strain could occur more easily and forcefully [21]. In addition if the procedures of MR defecography had been imposed a true sitting position with unusual circumstances that bothers the patients, so this imaging is not taken in a real physiologic defecation condition [22]. For as much as the aim in evaluation of the dysfunction of pelvic floor is getting right diagnosis to plan a suitable treatment [23]. So with our proposed procedure, we could recognize the correct defecation pattern.

There laxation of the pelvic floor muscles and opening up of the "ARA" in defecation is a learned response which occurs unconsciously and cannot be influenced by gravity (sitting position) [6,22]. Besides, while the exam was done completely in the same position and condition for all subjects (healthy or patient), MRI could significantly detect healthy from patient subjects by ARA index.

Opposite of the current belief that "fluoroscopic examination" should get a better result as it is down in sitting position, shown that there is no significant difference between the outcomes of MR defecography and fluoroscopic tests, although MR imaging taken in supine position [14]. Gufler et al., have suggested that; in pelvic straining, data measured from "dynamic MRI" don't differ from "colpocystoproctography" in both supine and sitting positions [20]. Little differences found in pelvic floor movement detection between MRI taken in supine and sitting position by Bertschinger et al. [23-27]. According to the outcomes of previous studies in our study "inter-observer agreement" for anorectal movement indices, which build up the principle component of assessment, was high (ICC>0.9).

## Conclusion

This study, as a "Confirming an Assessment Tool", demonstrated that MR defecography (Dynamic pelvic MRI), could represent a useful diagnostic approach in differentiating DD patients from healthy subjects.

DD is a behavioral disorder, thus, we can simply use dynamic images of MR defecography to make the patients conscious about their dysfunction and enhance the result of their treatment. Furthermore, it is desirable for the imaging modality to be less invasive and harmful (radiation exposure) and more available. Open-configuration magnets (sitting position) are not widely available and are expensive and scarce [20].

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