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Rectal sensory-motor alterations: a clinical perspective on anorectal disorders. The correlation between rectal sensation and motility in different anorectal diseases

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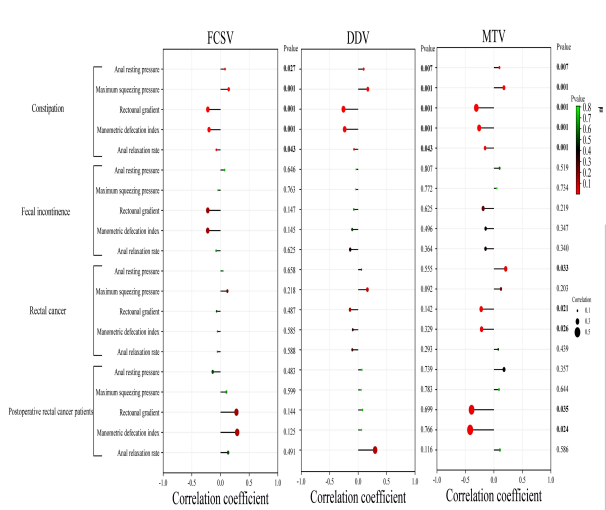
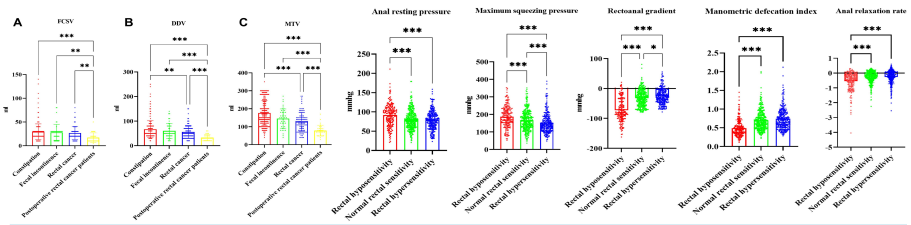
[Rectal Sensory-Motor Alterations: A Clinical Perspective on Anorectal Disorders]





Significant differences in rectal sensation are observed across various types of anorectal diseases. Particularly among patients with constipation, there are marked differences in rectal motility between groups with different levels of rectal sensitivity. Variations in rectal sensation may have a significant impact on rectal motility. (A) Comparison of FCSV in different diseases. (B) Comparison of DDV in different diseases. (C) Comparison of MTV in different diseases. *p<0.05 **p<0.01 ***p<0.001

Association between Rectal Sensation and Motility in Different Anorectal Diseases: In constipated patients, FCSV, DDV, and MTV are positively correlated with anal resting and maximum squeeze pressures, and negatively with rectoanal gradient, manometric defecation index, and anal relaxation rate. In rectal cancer patients, MTV is positively correlated with anal resting pressure, and negatively correlated with rectoanal gradient and manometric defecation index. In postoperative rectal cancer patients, MTV is negatively correlated with rectoanal gradient and manometric defecation index

[Different diseases affect rectal sensory function in their unique ways]

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Rectal sensory-motor alterations: a clinical perspective on anorectal disorders. The correlation between rectal sensation and motility in different anorectal diseases

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Inclusion and Diversity Declaration： We support inclusive, diverse, and equitable research.

Artificial intelligence: the authors declare that they did not use artificial intelligence (AI) or any AI-assisted technologies in the elaboration of the article.

Data availability statement： Data supporting the study findings are available from the corresponding author upon request.

Ethics approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the ethics review committee of Xinhua Hospital Affiliated to Dalian University (No.2023-93-01).

Consent to participate: Informed consent was obtained from all individual participants

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included in the study.

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Abbreviations list:

1. FI: fecal incontinence

2. FCSV: first constant sensation volume

3. DDV: defecatory desire volume

4. MTV: maximum tolerable volume

5. ANOVA: analysis of Variance

6. ARM: Anorectal manometry

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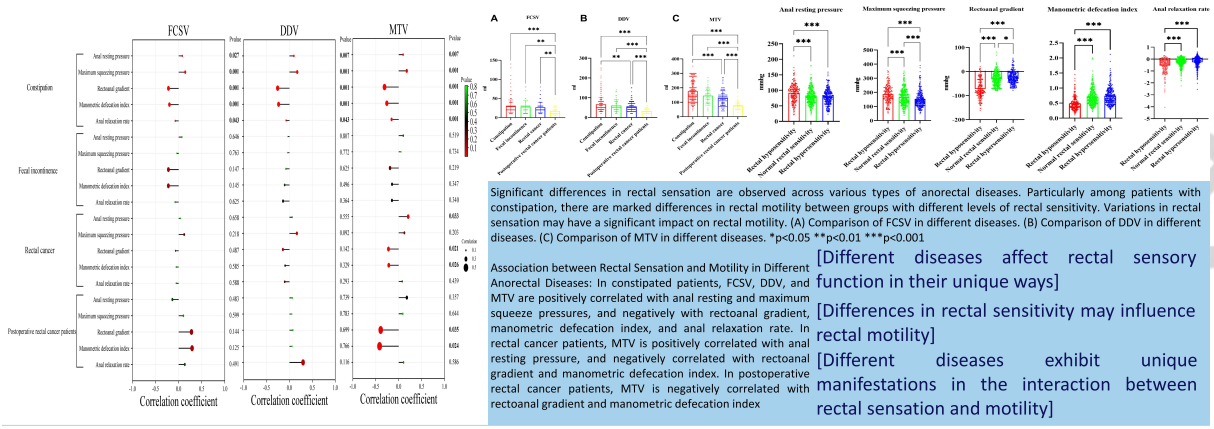

Significant differences in rectal sensation are observed across various types of anorectal diseases. Particularly among patients with constipation, there are marked differences in rectal motility between groups with different levels of rectal sensitivity. Variations in rectal sensation may have a significant impact on rectal motility. (A) Comparison of FCSV in different diseases. (B) Comparison of DDV in different diseases. (C) Comparison of MTV in different diseases. *p<0.05 **p<0.01 ***p<0.001

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Lay summary

Anorectal disorders are frequently associated with rectal sensory and motor dysfunction, which are key factors leading to severe defecation problems in patients. Throughout the course of the disease and after treatment, alterations in rectal sensation and/or motility may be observed. However, the direct relationship between rectal sensation and motility is not yet understood. This study aims to investigate this potential association and to refine treatment approaches for enhancing patients' defecation function. This study utilized anorectal manometry to assess rectal sensation and motility in patients with various anorectal diseases. The study found significant differences in rectal sensation among patients with constipation, fecal incontinence, rectal cancer, and postoperative patients. Particularly in patients with constipation, there were marked differences in rectal motility under varying sensory presentations. Additionally, we observed specific correlations between rectal sensation and motility in patients with constipation, rectal cancer, and postoperative patients. Further analysis indicated that in constipated patients, this correlation was influenced by the synergistic interaction of age and gender. In anorectal diseases, changes in rectal sensation may directly lead to alterations in rectal motility, and this sensory-motor correlation may be influenced by physiological factors. Therefore, enhancing rectal sensation and employing personalized treatment strategies to improve

rectal motility and alleviate related symptoms may offer a new approach to the treatment of anorectal diseases.

ABSTRACT

Background: Patients with anorectal diseases commonly exhibit abnormalities in rectal sensation and/or rectal motility. However, the relationship between rectal sensation and motility in these pathological processes is unclear. We aim to explore this association.

Methods: We conducted a retrospective review of clinical data from 954 patients with anorectal disorders and defecation problems who had undergone anorectal functional testing. We investigated the correlation between rectal sensation and motility across various conditions and assessed the impact of physiological factors.

Results: Significant rectal sensation differences were seen across constipation, fecal incontinence, rectal cancer, and postoperative patients, with the highest sensitivity in postoperative patients ($P<0.05$). Stratified analysis showed constipated patients with rectal hyposensitivity had higher anal resting and maximum squeeze pressures, lower rectoanal gradients, manometric defecation index, and anal relaxation rate ($P<0.05$). Further analysis revealed that rectal sensory parameters in constipated patients positively correlated with anal resting and maximum squeeze pressures, and negatively correlated with rectoanal gradients, manometric defecation index, and anal relaxation rate ($P<0.05$), with the influence of age and gender being synergistic ($P<0.05$). In rectal cancer, the maximum tolerable volume positively correlates with anal resting pressure and negatively with the rectoanal gradient and manometric defecation index ($P<0.05$). This negative correlation is also observed in postoperative patients ($P<0.05$).

Conclusions: In patients with anorectal disorders and defecation problems, there is a significant correlation between rectal sensory abnormalities and dynamic changes induced by varying levels of rectal sensitivity, with these changes being modulated by physiological factors.

Keywords: Rectal sensation. Rectal motility. Anorectal disorders. High-resolution anorectal manometry.

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INTRODUCTION

Anorectal disorders, impacting roughly 25% of individuals (1,2), often lead to defecation problems, which significantly impact quality of life despite not being life-threatening. Defecatory difficulty is commonly related to impaired neuroregulation during defecation, frequently accompanied by abnormalities in rectal sensation and motility (3,4). As key diagnostic indicators for defecatory disorders, rectal sensation and motility have been extensively investigated. Accumulating evidence indicates their pivotal contributions to the pathogenesis and progression of anorectal diseases (5). Patients with functional constipation typically exhibit reduced rectal sensitivity, increased bowel wall compliance, and elevated rectal capacity, alongside impaired rectal motility and recto-anal reflexes (6). Individuals with fecal incontinence (FI) often experience acute defecation urgency, stemming from diminished rectal volume or prolonged stool retention. These conditions diminish rectal sensation and alter bowel wall tone, usually with lower resting and squeeze pressures (2). Symptoms alone inadequately differentiate defecation issues from anorectal disorders. Evaluating the rectal sensory and motility characteristics of each disease, and comparing these features, may enhance diagnostic precision and facilitate disease identification.

Furthermore, rectal sensory and motility alterations in anorectal disease patients correlate with symptom severity (7-9). These alterations may impact therapeutic efficacy. In patients with decreased bowel movements but normal colonic transit, abnormal rectal sensation may significantly diminish the efficacy of biofeedback therapy (10). Currently, sacral nerve stimulation effectively tunes rectal afferent nerves, improving evacuation in chronic constipation with reduced rectal sensation (11). However, the role of rectal sensation changes in mediating motility regulation and affecting evacuation function is not yet understood. We will embark on initial research to investigate several clinically prevalent anorectal disorders.

PATIENTS AND METHODS

Participants

We retrospectively examined the records of patients who received anorectal functional tests for defecation problems from January 2018 to April 2023. This study cohort comprised 954 patients who presented with chief complaints of defecation disorder, including: 774 cases of functional constipation meeting Rome IV diagnostic criteria, 44 cases of FI, 107 cases of rectal cancer, and 29 cases of postoperative rectal cancer patients. The study excluded individuals with implanted devices, pregnant women, severe psychiatric disorders, under 18, or those with a history of other cancers. Participants were categorized into elderly (≥60 years) and young and middle-aged (<60 years) groups based on age (12). The research plan was approved by the ethics review committee of Xinhua Hospital Affiliated to Dalian University (2023-93-01).

High-resolution anorectal manometry

The rectal motility was evaluated utilizing a high-resolution anorectal manometry with a 24-channel water-perfused catheter (Ningbo Maida Medical Device, Ningbo, China). The absolute parameters were assessed as: anal resting pressure, and maximum squeezing pressure. In addition, a range of comprehensive parameters was analyzed, including manometric defecation index, rectoanal gradient, and anal relaxation rate (13). Rectal sensation was assessed by incrementally distending the rectal balloon by 10 mL from 0 to 400 mL, identifying three established sensory thresholds: first constant sensation volume (FCSV), defecatory desire volume (DDV), and maximum tolerable volume (MTV).

Classification of rectal sensitivity: Elevation of one of the three sensory parameters above the normal range suggests borderline rectal hyposensitivity; if two or more parameters are elevated, the diagnosis is rectal hyposensitivity. Given the small patient population with borderline rectal hyposensitivity, we have grouped them together with patients having rectal hyposensitivity under the broader category of rectal hyposensitivity. Any single sensory threshold parameters falling below the normal standard is indicative of rectal hypersensitivity (14). The Pelvic Floor Center's reference standards for healthy individuals are: FCSV 20-90 ml, DDV 50-170 ml, MTV 120-280 ml (15).

Statistical analysis

Statistical analyses were conducted with SPSS 23.0 and the graphics were made by GraphPad Prism 9. Continuous variables are presented as mean ± SD. Categorical variables are expressed as counts and percentages, analyzed by chi-square test. Multiple comparisons applied the Bonferroni correction. To compare the measurement data, a normality test was conducted first. Data following a normal distribution were analyzed using one-way analysis of variance (ANOVA) and t-tests. For non-normally distributed data, the Kruskal-Wallis H test and Mann-Whitney U test were applied. Spearman's coefficient assessed rectal sensation-motility correlation and a multiple linear regression model examined age and gender effects. $P < 0.05$ was considered statistically significant.

RESULTS

Demographics

Of the 954 patients with various anorectal diseases, 774 were diagnosed with constipation, 44 with fecal incontinence, 107 with rectal cancer, and 29 were postoperative patients. Their demographic and clinical characteristics are presented in Table 1. The constipation group had a significantly higher proportion of females compared to the rectal cancer and postoperative groups ($p<0.001$). Elderly patients were more prevalent in the rectal cancer and postoperative groups than in the constipation group ($p=0.004$). Table 1 further details the distribution of rectal sensitivity categories and anorectal manometry parameters across these groups.

Different diseases affect rectal sensory function in their unique ways.

Postoperative rectal cancer patients exhibited significantly lower FCSV compared to constipation ($P<0.001$), FI ($P=0.002$), and rectal cancer groups ($P=0.001$), and had significantly lower DDV and MTV than all other groups (all $P<0.001$). Rectal cancer patients exhibited decreased DDV ($P=0.004$) and MTV ($P<0.001$) compared to constipation patients (Fig. 1), reflecting differences in sensory function among these anorectal disorders.

Differences in rectal sensation may influence rectal motility.

In the constipated cohort, anorectal manometric parameters varied significantly according to rectal sensitivity status. The hyposensitivity group showed elevated anal resting

pressure and maximum squeeze pressure compared to both normal and hypersensitivity groups (all P<0.001), but reduced rectoanal gradient, manometric defecation index, and anal relaxation rate (all P<0.001). Differences were also observed between normal and hypersensitivity groups, with the former exhibiting higher maximum squeeze pressure (P<0.001) yet lower rectoanal gradient (P=0.049) (Fig. 2). Similar manifestations have not been observed in other anorectal disorders.

Different diseases exhibit unique manifestations in the interaction between rectal sensation and motility.

In constipated patients, FCSV demonstrated significant positive correlations with anal resting pressure (r=0.079, P=0.027) and maximum squeeze pressure (r=0.143, P<0.001), while showing negative correlations with rectoanal gradient (r=-0.221, P<0.001), manometric defecation index (r=-0.200, P<0.001), and anal relaxation rate (r=-0.073, P=0.043). DDV and MTV show similar correlation patterns (DDV: r=0.097, P=0.007, r=0.170, P<0.001, r=-0.258, P<0.001, r=-0.237, P<0.001, r=-0.073, P=0.043, respectively; MTV: r=0.097, P=0.007, r=0.176, P<0.001, r=-0.309, P<0.001, r=-0.259, P<0.001, r=-0.155, P<0.001, respectively) (Fig. 3). The sensation-motility relationships remained consistent across various anorectal disorders. In rectal cancer patients, MTV correlates positively with anal resting pressure (r=0.207, P=0.033) and correlates negatively with rectoanal gradient (r=-0.223, P=0.021) and manometric defecation index (r=-0.216, P=0.026). In postoperative rectal cancer patients, MTV correlates negatively with rectoanal gradient (r=-0.392, P=0.035) and correlates negatively with manometric defecation index (r=-0.417, P=0.024).

Age and gender significantly influence the association between rectal sensation and motility.

Age and gender synergistically modulate rectal sensation-motility associations, specifically in constipated patients. Elderly patients show significantly lower anal resting pressure, maximum squeeze pressure, and anal relaxation rate (all p<0.05) but higher rectoanal gradient and manometric defecation index (both p<0.001) compared to younger patients. Gender further modifies these effects: females exhibit lower maximum squeeze pressure yet higher rectoanal gradient and manometric defecation index than males (all

p<0.001), while males demonstrate reduced anal relaxation rate (p<0.001) (Table 2).

DISCUSSION

Rectal sensation depends on the functionality of afferent nerves and the intestinal wall to perceive the defecation urge (16). Sensory dysfunction or absence may indicate the presence of anorectal disease. Especially in individuals with FI and constipation, unique rectal sensory alterations are commonly observed and are increasingly recognized clinically (17). However, studies on rectal sensation and motility in rectal cancer and postoperative patients are limited. Ihnat et al. found that postoperative rectal cancer patients frequently suffer from defecation problems with lower anal pressure, volume, and compliance (18). These issues cause defecation urges with minimal content, frequent bowel movements, compromising quality of life and increasing rectal sensitivity (19). This is consistent with our findings. Additionally, rectal sensitivity may be significantly increased in patients with rectal cancer due to tumor occupation, surpassing that in constipation cases, and this should be taken into consideration.

Anorectal disease patients often suffer from abnormal defecation propulsion and elevated resistance, compounded by a long-standing negative rectoanal gradient and smooth muscle dyssynergia, leading to defecation problems (9). After analyzing patients grouped by sensitivity, we observed that in patients with constipation, as rectal sensitivity increased, the anal resting and maximum squeeze pressure associated with fecal control gradually decreased. Concurrently, the rectoanal gradient and the rate of anal relaxation during rectal evacuation correspondingly increased. This echoes the known characteristics of rectal hyposensitivity in constipation (20,21). Furthermore, training to improve pelvic floor muscle coordination and anal sphincter relaxation can modulate rectal sensation (20,22). Investigating the link between rectal sensation regulation and motility in fecal control and evacuation is crucial for understanding and treating anorectal diseases.

A study shows that a rectal balloon can enhance the rectoanal gradient and facilitate defecation, but it fails in those with diminished rectal sensitivity (23). Our research suggests that rectal sensation continuously influences rectal motility in patients. FCSV, DDV, and MTV are correlated with motility in constipation, suggesting that varying rectal sensations may be associated with specific pathophysiological processes (7). We propose

that alterations in sensory function may be a potential underlying cause of defecation problems. Jiang et al. found that patients with constipation and reduced rectal sensation commonly exhibited elevated levels of DDV, which may serve as an effective indicator for diagnosing rectal sensory impairment (24). Our correlation analysis identified the MTV as most associated with motility changes in constipation, with a higher correlation coefficient than FCSV and DDV. Therefore, we infer that MTV is likely the optimal parameter for assessing rectal sensory impairment, predicting rectal motility alterations, and diagnosing defecation problems. MTV also significantly correlates with rectal evacuation motility in rectal cancer and postoperative patients, underscoring its predictive value in these groups. For patients whose defecation problems are not fully resolved by improving rectal motility alone, we aim to improve efficacy by adjusting rectal sensation to optimize motility.

Age and gender also play significant roles in the alterations of rectal sensation and motility. Rectal sensation often increases with age, especially in males (25). Rectal motility typically decreases with age, more so in females (26). This trend is seen in both patients with anorectal diseases and healthy individuals (27). Our study shows that age and gender interact synergistically with rectal sensation, affecting motility in constipation. Aging leads to decreased anal pressures for fecal control, while rectal evacuation parameters rise, especially in females. Meanwhile, the anal relaxation rate decreases with age, particularly in male patients. Additionally, rectal cancer and postoperative patients may be more prone to rectal structure and function changes, distinct from age/gender-related physiological changes. These differences yield unique profiles compared to constipated patients. Therefore, a multifaceted approach is required in the treatment and management of various anorectal diseases, to accommodate the individual physiological variations of patients.

This study offers a novel view on rectal sensation and motility in anorectal diseases, indicating a link between sensory changes and motility alterations. However, result generalizability may be limited by disease variety and sample size constraints. In addition, the sensation of defecation arises not only from the rectum but also involves the anal canal, with each having distinct functions (28). Some patients may experience abnormal anal canal sensation despite normal rectal sensation (29). Further investigation of rectal and anal canal sensory functions and their motility correlation is urgently needed.

In patients with anorectal diseases presenting with defecation problems, abnormal

rectal sensation is closely associated with dynamic differences under varying rectal sensitivities. It is further observed that changes in rectal sensation in different anorectal diseases may directly mediate alterations in rectal motility, potentially being a primary cause of motility discrepancies. Additionally, this association may be influenced by a synergistic effect of physiological and other factors. Enhancing rectal sensation and personalizing treatment approaches may represent an innovative method for improving rectal motility and alleviating symptoms.

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Table 1. The characteristics of patients with various anorectal diseases.

Characteristics	Value			
	Constipation	**Fecal incontinence**	**Rectal cancer**	**Postoperative rectal cancer patients**
Total patients (n)	774	44	107	29
Gender				
Male (n, %)	240, 31.0%	20, 45.4%	69, 64.5%	17, 58.6%
Female (n, %)	534, 69.0%	24, 54.6%	38, 35.5%	12, 41.4%
Age (years, $\bar{x}\pm s$)	57.48±13.79	59.64±13.92	64.39±12.41	63.55±11.01
Age group				
Young and middle-aged group	372, 48.1%	18, 40.9%	35, 32.7%	8, 27.6%
Elderly group	402, 51.9%	26, 59.1%	72, 67.3%	21, 72.4%
Rectal sensation				
FCSV (mL, $\bar{x}\pm s$)	29.46±16.53	28.18±16.6	26.63±13.59	17.07±10.14
DDV (mL, $\bar{x}\pm s$)	66.94±34.49	60.34±30.39	55.79±26.21	33.1±11.98
MTV (mL, $\bar{x}\pm s$)	176.77±68.5	145.46±53.63	127.34±52.03	78.45±30.21
Rectal hyposensitivity (n, %)	191, 24.7%	0	0	0
Normal rectal sensitivity (n, %)	259, 33.5%	15, 34.1%	36, 33.6%	2, 6.9%
Rectal hypersensitivity (n, %)	324, 41.9%	29, 65.9%	71, 66.4%	27, 93.1%
ARM				

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Anal resting pressure (mmHg, $\bar{x}$±s)	82.61±26.32	59.81±25.92	71.91±27.25	71.45±29.14
Maximum squeezing pressure (mmHg, $\bar{x}$±s)	167.52±59.76	114.85±61.88	170.31±62.99	163.87±61.44
Rectoanal gradient (mmHg, $\bar{x}$±s)	-40.33±35.27	-33.42±30.46	-33.29±37.15	-12.05±40.13
Manometric defecation index ($\bar{x}$±s)	0.66±0.28	0.64±0.32	0.68±0.27	0.89±0.52
Anal relaxation rate (%, $\bar{x}$±s)	-33.7%±49.6%	-54.2%±87.0%	-33.5%±55.7%	-10.7%±32.2%

ARM, Anorectal manometry; FCSV, first constant sensation volume; DDV, defecatory desire volume; MTV, maximum tolerable volume.

Table 2. Multiple linear regression analysis of rectal motility data in chronic constipation patients with varying degrees of rectal sensitivity

Independent variables	β	Std Error	Standardizedβ	p-value
Constipation		**Dependent variable: Anal resting pressure**		
FCSV	0.100	0.056	0.063	0.077
Age	-13.812	1.896	-0.262	<0.001***
Gender	-2.569	2.063	-0.045	0.213

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DDV	0.068	0.027	0.088	0.013*
Age	-13.817	1.889	-0.262	<0.001***
Gender	-2.242	2.066	-0.039	0.278
MTV	0.045	0.013	0.116	0.001***
Age	-13.887	1.883	-0.264	<0.001***
Gender	-2.299	2.045	-0.040	0.261
		Dependent variable: Maximum squeezing pressure		
FCSV	0.179	0.125	0.050	0.151
Age	-26.630	4.191	-0.223	<0.001***
Gender	-39.366	4.560	-0.305	<0.001***
DDV	0.136	0.060	0.079	0.023*
Age	-26.698	4.176	-0.223	<0.001***
Gender	-38.591	4.567	-0.299	<0.001***
MTV	0.112	0.030	0.128	<0.001***
Age	-26.999	4.152	-0.226	<0.001***
Gender	-38.321	4.509	-0.297	<0.001***
		Dependent variable: Rectoanal gradient		
FCSV	-0.352	0.074	-0.165	<0.001***
Age	12.369	2.487	0.175	<0.001***
Gender	18.723	2.707	0.246	<0.001***
DDV	-0.224	0.035	-0.219	<0.001***
Age	12.333	2.456	0.175	<0.001***
Gender	17.744	2.685	0.233	<0.001***
MTV	-0.170	0.017	-0.330	<0.001***
Age	12.724	2.369	0.180	<0.001***
Gender	17.548	2.573	0.230	<0.001***
		Dependent variable: Manometric defecation index		
FCSV	-0.003	0.001	-0.159	<0.001***
Age	0.099	0.020	0.179	<0.001***
Gender	0.125	0.022	0.208	<0.001***
DDV	-0.002	0.000	-0.198	<0.001***
Age	0.099	0.020	0.178	<0.001***

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Gender	0.119	0.021	0.198	<0.001***
MTV	-0.001	0.000	-0.248	<0.001***
Age	0.100	0.019	0.180	<0.001***
Gender	0.121	0.021	0.202	<0.001***
		Dependent variable: Anal relaxation rate		
FCSV	-0.001	0.001	-0.040	0.268
Age	-0.078	0.036	-0.078	0.032*
Gender	0.169	0.039	0.158	<0.001***
DDV	-0.000	0.001	-0.027	0.455
Age	-0.079	0.036	-0.080	0.028*
Gender	0.170	0.040	0.159	<0.001***
MTV	-0.001	0.000	-0.147	<0.001***
Age	-0.073	0.036	-0.074	0.042*
Gender	0.156	0.039	0.146	<0.001***
Rectal cancer		**Dependent variable: Anal resting pressure**		
MTV	0.116	0.050	0.221	0.024*
Age	-10.948	9.072	-0.168	0.230
Gender	6.414	7.910	0.113	0.419
		Dependent variable: Rectoanal gradient		
MTV	-0.090	0.070	-0.127	0.197
Age	5.298	12.540	0.060	0.674
Gender	5.425	10.934	0.070	0.621
		Dependent variable: Manometric defecation index		
MTV	-0.001	0.000	-0.188	0.051
Age	0.182	0.088	0.284	0.041*
Gender	-0.043	0.077	-0.077	0.575
Postoperative rectal cancer patients		**Dependent variable: Rectoanal gradient**		
MTV	-0.456	0.272	-0.344	0.106
Age	8.065	26.057	0.091	0.760
Gender	1.204	22.464	0.015	0.958
		Dependent variable: Manometric defecation index		
MTV	-0.006	0.003	-0.374	0.078
Age	0.195	0.333	0.171	0.564
Gender	-0.055	0.287	-0.053	0.850

FCSV, first constant sensation volume; DDV, defecatory desire volume; MTV, maximum tolerable volume;

*p<0.05 **p<0.01 ***p<0.001

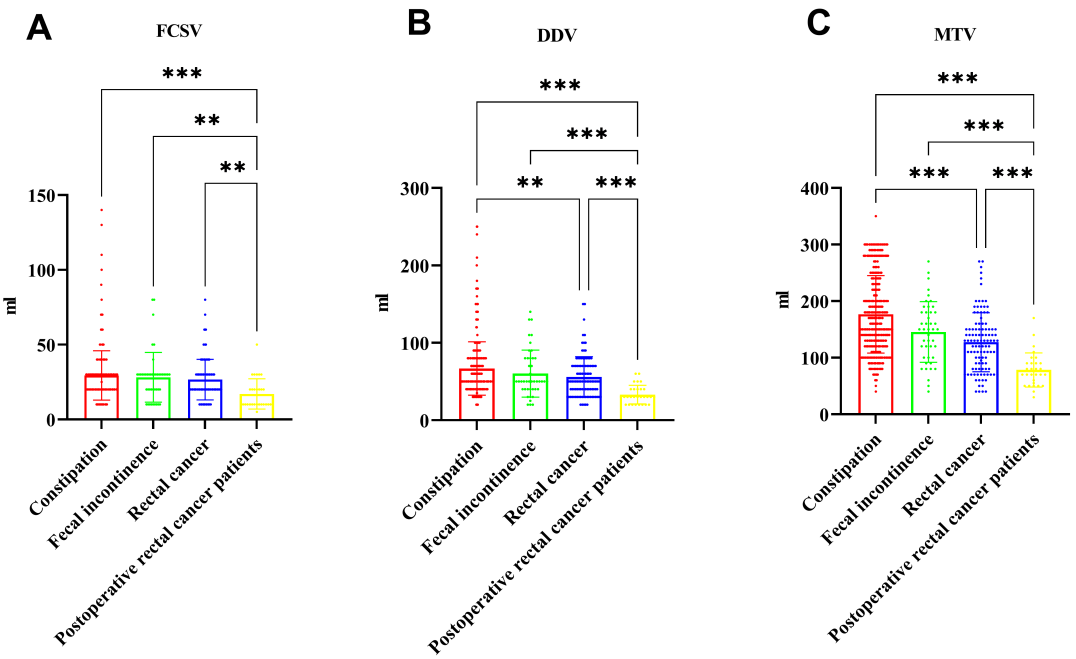

Fig. 1. Differential rectal sensation in patients with various types of anorectal diseases.

(A) Comparison of FCSV in different diseases. (B) Comparison of DDV in different diseases. (C) Comparison of MTV in different diseases. *p<0.05 **p<0.01 ***p<0.001

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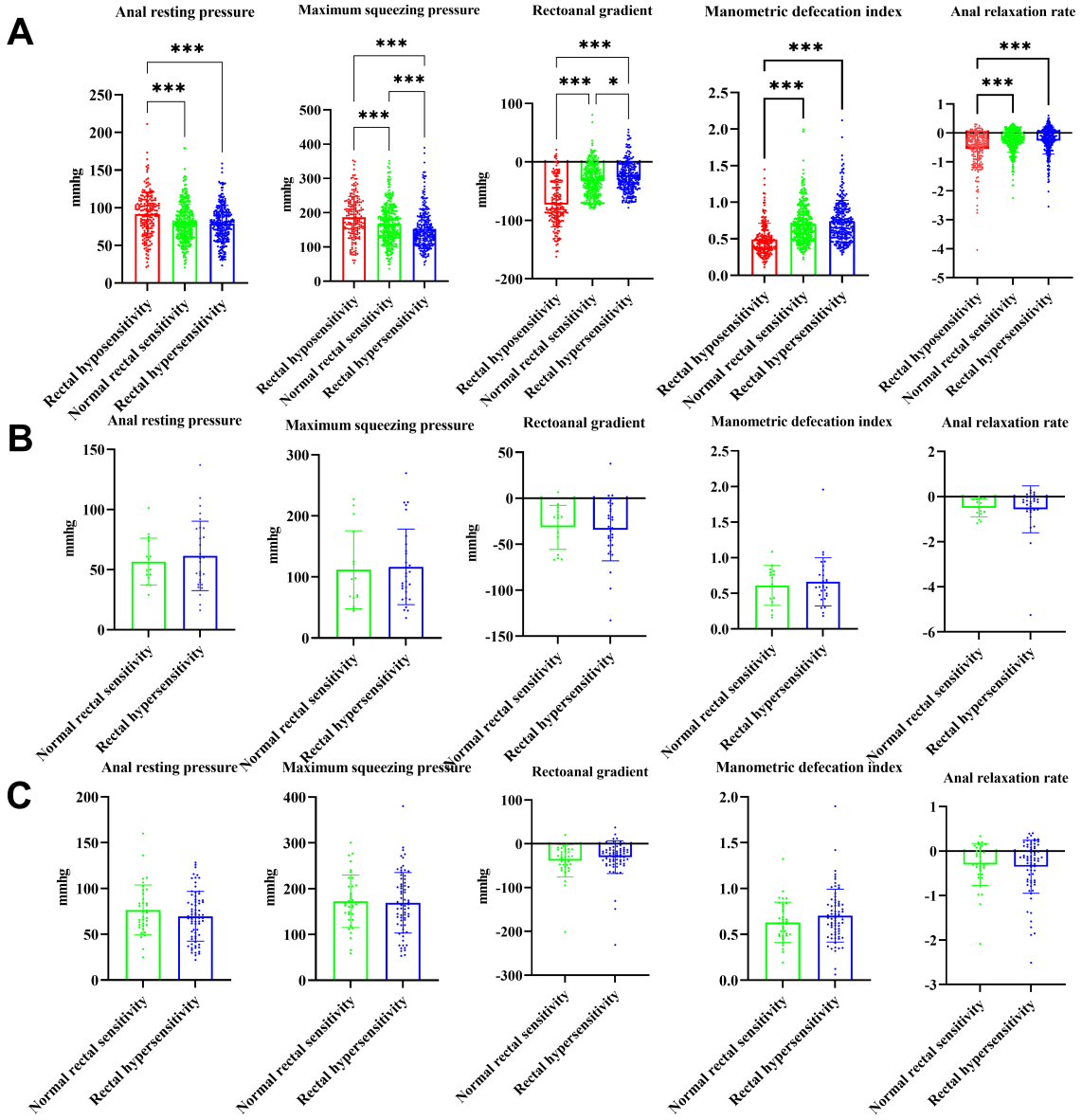

Fig. 2. Differences in rectal motility between various diseases with different rectal sensitivity

(A) Differences in rectal motility among patients with constipation. (B) Differences in rectal motility among patients with fecal incontinence. (C) Differences in rectal motility among patients with rectal cancer. *p<0.05 **p<0.01 ***p<0.001

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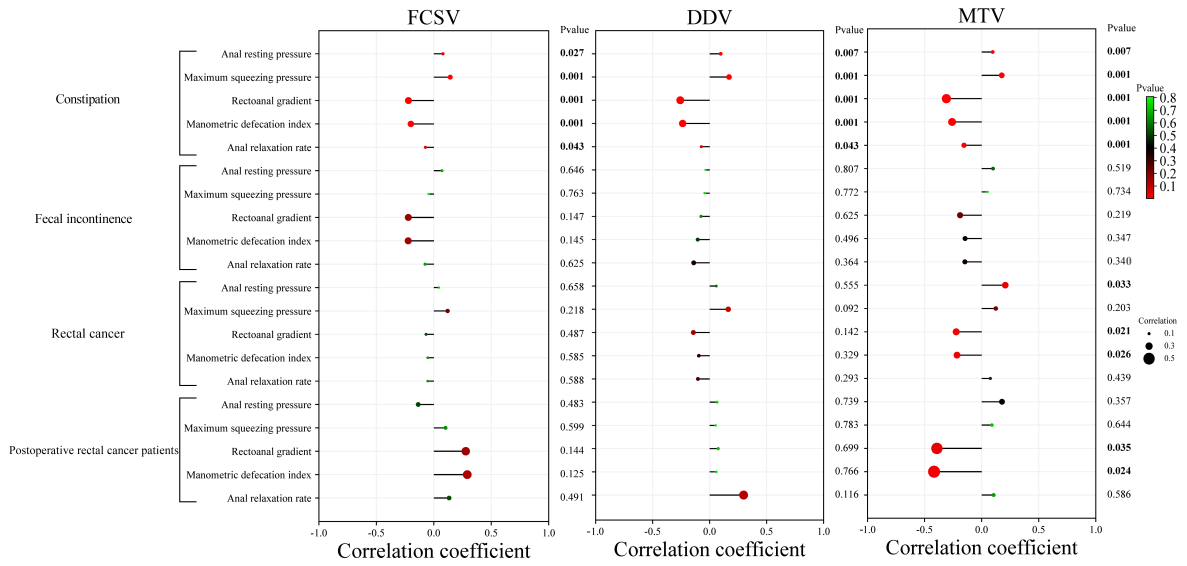

Fig.3. Correlation between rectal sensation and motility. Abbreviations: FCSV: first constant sensation volume, DDV: defecatory desire volume, MTV: maximum tolerable volume