



## Research Paper

## A comparison of the usage of anal verge and dentate line in measuring distances within the rectum

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## ABSTRACT

**Introduction:** The anal verge is key in determining measurement-based suitability for neoadjuvant radiotherapy in rectal cancer. The dentate line is a distinct anatomic landmark and may permit more accurate measurement for rectal lesions. This study aimed to establish mesurative ranges for distances of the rectal valves from the dentate line and the anal verge and to compare variability between the two.

**Methods:** Patients (n = 104) undergoing colonoscopy and sigmoidoscopy were prospectively accrued. The distances of rectal valves were measured from the anal verge and the dentate line respectively by using a vector subtraction-based approach. Distances were correlated with gender, age and body mass index. Standard deviation was the measure of variability.

**Results:** The gross topography of the rectum was remarkably consistent with three valves identifiable in the majority (99 of 104) of patients. The median distance between the dentate line and the anal verge was 2.0 cm. The distances of each rectal valve (proximal to distal) to the anal verge and dentate line were  $11.4 \pm 2.0$  cm,  $8.6 \pm 2.0$  cm,  $6.0 \pm 1.7$  cm and  $9.1 \pm 1.6$  cm,  $6.3 \pm 1.6$  cm,  $3.7 \pm 1.5$  cm, respectively. Between-group variability was minimally reduced when using the dentate line as a reference point. Obesity was associated with an increased distance of the proximal rectal valve from the anal verge and the dentate line ( $p = 0.004$  and  $0.015$  respectively).

**Conclusions:** Rectal valve anatomy is remarkably consistent. Both dentate line and anal verge are reliable landmarks from which distances can be measured within the rectum.

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## 1. Introduction

Accurate measurement of the location of rectal tumors during lower gastrointestinal endoscopy has important implications in determining the need for neoadjuvant therapy and feasibility of sphincter preservation. In defining distance, the most frequently used reference point is the anal verge or margin [1,2]. The anal verge is defined as the junction between the anoderm and the skin (*i.e.* the transitional zone between the anal mucosa and the perianal skin) [3]. The word “verge” or “bend” comes from the French word “verger”, meaning “to bend.” While the anal verge is an external landmark and easily accessible for measurements, a “bend” is not a distinct anatomical landmark and may vary considerably between individuals depending on body habitus and position. In compari-

son, the dentate line is a well defined landmark. The dentate line is clearly visible as a serrated line in most individuals, and thus could provide a more accurate reference point for the measurement of rectal lesions.

Additional landmarks that may be used as reference points during endoscopy include the transverse rectal valves (of Houston), which are mucosal valves that project into the lumen. Since their first description by Houston in 1830 [4], a number of studies have reported varying valve numbers with three being the commonest pattern [5–7]. While the valves conveniently divide the rectum into upper, mid and lower segments, their location from the anal verge is highly variable [7]. Surprisingly, the majority of studies reporting anorectal valve anatomy were conducted on cadaveric specimens, and data on living subjects are limited [5–8].

The accurate measurement of anorectal distances has important clinical implications. The Swedish, Dutch and German rectal cancer trials have established neoadjuvant therapy as the ‘gold standard’ in the management of locally advanced rectal cancer (in combination with total mesorectal excision) to achieve local control and decrease local recurrence rates [9–11]. In the Dutch trial, rectal cancers included tumors for which the inferior margin was not

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farther than 15 cm from the anal verge. The German trial used 16 cm as the cut off value. The Swedish trial included patients in whom the lower border of the rectal lesion was below the level of sacral promontory on barium enema. Neoadjuvant therapy conferred no statistically significant benefit in patients in whom the inferior margin of the rectal cancer was greater than 10 cm from the anal verge [9]. These points highlight the importance of accurate determination of distances and location within the rectum. In this context, it is important to utilize a reliable landmark from which such distances can be established.

Given the above, this study firstly aimed to characterize distances of each rectal valve from both anal verge and dentate line. A secondary aim was to compare the variability inherent in both sets of measurements with a view to discussing which may be more accurate. A final aim was to characterize the relationship between patient-related factors and valve distances using both references.

## 2. Materials and methods

### 2.1. Study design

Following ethics approval and patient informed consent, participants were prospectively accrued from adult patients who underwent lower gastrointestinal endoscopy in St. John's Hospital, Ennis General Hospital and University Hospital Limerick, Ireland between January and July 2012. Demographic data on patient age, sex and body mass index (BMI) were collected. Prior to the study, all endoscopists underwent a briefing on the technique of measuring anorectal landmarks using the approach detailed below.

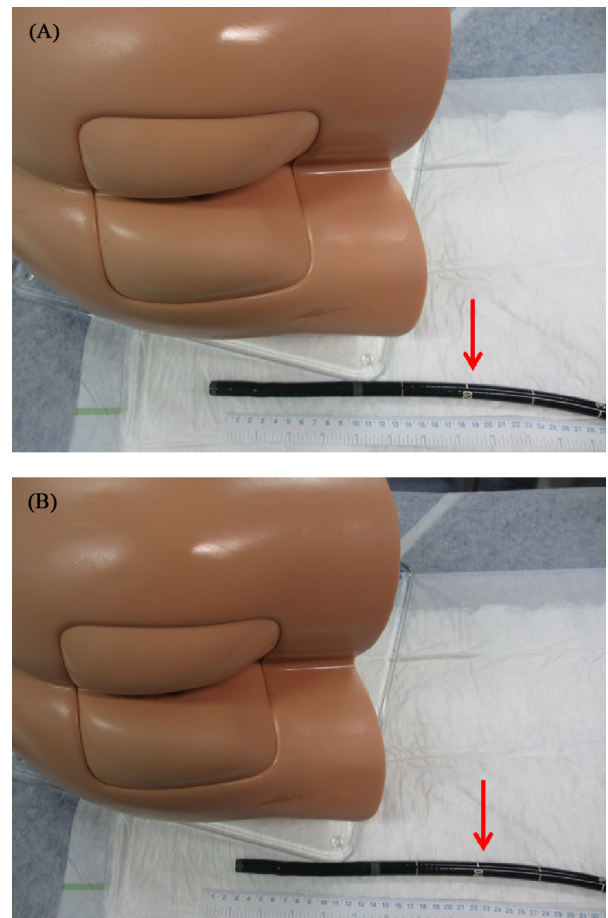
### 2.2. Endoscopy protocol

All lower gastrointestinal endoscopic procedures were carried out with the patient in the left lateral decubitus position, with maximal tolerable hip and knee flexions. Patients received a combination of midazolam 2–5 mg titrated accordingly and fentanyl 50–100 µg or meperidine hydrochloride 25–50 mg for conscious sedation complying with the British Society of Gastroenterology guidelines [12]. Endoscopic procedures were performed using video colonoscope (Olympus© America Inc., PA, USA).

### 2.3. Endoscopic measurement techniques

During withdrawal of endoscope from the rectosigmoid junction, a disposable plastic ruler was placed horizontally on the bed. The position of the ruler, relative to the patient, was not fixed, but was close enough to permit dropping a second ruler in a perpendicular manner from the endoscope to the first ruler (Fig. 1). A point of the endoscope was arbitrarily selected from which markings would be serially drawn as the endoscope was then withdrawn. In this manner, a point was marked on the ruler for the proximal rectal valve (V3), middle rectal valve (V2), distal rectal valve (V1), dentate line (DL) and anal verge (AV). An aberrant fourth rectal valve was labeled as V4. Prior to withdrawal, the rigidity of the scope was maximized and the scope was maintained as parallel as was feasible, with the ruler.

When the endoscope was in line with the proximal-most rectal valve, one of the endoscopic distance markings situated over the ruler (typically the 20 or 30 cm marking) was identified, and a disposable marker was used to mark the position of the distance marking on the ruler directly below. When the endoscope was withdrawn to the next anatomical landmark, the new position of the distance marking was marked on the ruler. At the end of the procedure, the distances between the markings on the ruler were recorded, allowing for the relative positions of the anatomical landmarks to be calculated. Distance measurements were made across



**Fig. 1.** Technique for measuring endoscopic landmarks within the anorectum during lower gastrointestinal endoscopy. (A) With the colonoscope at one of the landmarks, the position of the 20 cm mark is noted relative to the ruler. (B) The relative distance to an adjacent landmark is determined by measuring the difference in the position of the 20 cm mark relative to the ruler.

all patients by eight endoscopists accredited according to the Joint Advisory Group on GI endoscopy recommendations on assessment and appraisal.

### 2.4. Statistical analysis

Statistical analysis was performed using SPSS 18.0 (Chicago, IL, USA). Distribution of continuous data was determined using the Kolmogorov–Smirnov Z test. Student's t-test and Analysis of Variance (ANOVA) test were used for parametric data. Mann–Whitney U test and Kruskal–Wallis test were used for non-parametric data. A *p* value of less than 0.05 was considered statistically significant for all tests.

## 3. Results

### 3.1. Patient characteristics

A total of 111 patients were accrued and patient demographics are summarized in Table 1. Seven were excluded due to the presence of rectal pathology that distorted anatomy. None of the remaining patients had pathology evident and thus were regarded as normal.

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