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The value of sphincter asymmetry index in anal incontinence

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Abstract We tested the value of the sphincter asymmetry index (SAI), an adjunct study of vectormanometry for detecting sphincter defects of difficult clinical diagnosis, in patients with anal incontinence referred for anal manometry. Patients were prospectively classified as having no previous anal trauma (group I, *n*=13), those with possible trauma (including previous vaginal delivery and anorectal surgery unrelated to the onset of incontinence; group II, *n*=53), and those with previous anal trauma directly related by the patient to the onset of symptoms (group III, *n*=39). These were compared to 30 healthy volunteers. Clinical data were compiled to obtain an incontinence score, sphincter defect, mean and maximal pressures, functional anal canal length, and SAI for both resting and squeeze pressure profiles. SAI values for the control group were 7.2±2.3% and 5.8±2.4% for resting and squeeze pressures, respectively. Female controls had shorter anal canals (*P*=0.0001) and higher SAI during squeeze (*P*<0.005) than male controls. Incontinence scores were 6.1±3.1, 8.6±3.9, and 12.5±4.9, in groups I, II, and III, respectively (*P*<0.001). Mean SAI values at rest were 10.3±4.9% in group I, 19.0±10.6% in group II, and 23.6±14.0% in group III (*P*<0.001); corresponding values during squeeze were 8.6±5.3%, 13.9±7.9%, and 16.8±8.0% (*P*<0.01). Pressure profiles both at rest and during squeeze were inversely correlated with SAI; therefore the accuracy of SAI was not affected in patients with severe incontinence. Incontinent patients with a previous history of sphincter trauma thus had more severe incontinence, both clinically and manometrically, and higher SAI values than patients without prior trauma. The analysis of the SAI is a valuable tool for determining a traumatic cause of anal incontinence.

Keywords Anal manometry · Anal sphincters · Fecal incontinence · Traumatic incontinence · Anorectal physiology

Introduction

Trauma-related anal incontinence presents a major clinical problem to young and productive individuals in whom surgery can greatly improve symptoms [1, 2]. Young adults are prone to obstetrical complications, anorectal diseases and their sequelae, and, less frequently, to accidental trauma of the perineum. Acute or severe sphincter defects such as those related to third- or fourth-degree lacerations can be clinically diagnosed. However, many of these lesions are well compensated, especially in younger patients, by the remaining sphincter and become clinically apparent only in later years. During the healing process, scars become smaller and may not be detected by physical examination. Therefore many of these patients are diagnosed with idiopathic or neurogenic incontinence and are consequently denied surgical treatment.

Physical examination yields valuable data regarding continence status and evidence of a significant sphincter defect. However, the sensitivity, specificity, and predictive values for physical examination in estimating resting and squeeze pressures are suboptimal [3, 4]. Conventional water-perfused manometry detects single, localized, and isolated samples of pressures which may not be representative of the global pressure profile of the anorectal sphincter apparatus [5]. The advent of multilumen perfused catheters has allowed multiple simultaneous sampling of pressures, and considerable variations among samples of pressures within the anal canal have been demonstrated. This functional asymmetry demands a more detailed evaluation of the sphincter pressure profile [6, 7].

Since anatomically the anal canal is asymmetrical, some degree of functional asymmetry is expected. The study of sphincter symmetry is graphically represented by the vectorgram, a tridimensional composition of both radial and longitudinal pressure profiles of the anal canal. Although use of the sphincter asymmetry index (SAI) has recently increased, some difficulties still persist [8, 9, 10, 11]. Therefore additional data are required to establish normal values and to permit correct interpretation of the results in different subgroups of patients. We determined the SAI in healthy individuals and assessed its correlation to anal incontinence of traumatic cause.

Materials and methods

Patients

All 105 patients with anal incontinence referred to the anorectal physiology laboratory between 1993 and 1995 were studied. Patients were classified into three groups according to their clinical history: those with no previous sphincter trauma (group I, n=13), those with possible traumatic cause (including previous vaginal delivery or anorectal surgery, unrelated to the onset of incontinence; group II, n=53), and those with previous traumatic cause directly related by the patient to the onset of the symptom (group III, n=39). During the study period 30 healthy volunteers with normal bowel habits ranging from three evacuations per day to one every 3 days were also examined and made up the control group [12, 13]. Individuals with a history of anorectal or pelvic trauma or surgery, or vaginal delivery were excluded. Clinical data from a patient questionnaire were compiled to obtain an incontinence score, ranging from 0 (perfect continence) to 20 (total incontinence) [14]. Additional data included the onset of incontinence and its relationship to prior sphincter trauma, a history of constipation, and an association with urinary incontinence. Demographic data on the patient groups and controls are presented in Table 1; the mean age among controls was significantly lower than that of the incontinent group (P<0.00001).

Anorectal manometry

Anorectal manometry was performed with the subject in the left lateral decubitus position using a flexible 8.0-mm polyethylene 8-channel water-perfused catheter (MUI Scientific, Mississauga, Ontario, Canada). Channel 1 was located posteriorly in the anal canal, labeled as 0°, with the other channels numbered in a clockwise fashion. Pressure samples were registered in a stationary manner 6.0–1.0 cm from the anal verge at rest and during maximal voluntary contraction. Subsequently a continuous pull-through of the catheter from 6.0 cm until total exteriorization of the ports at the anal verge was achieved. The continuous pull-through was repeated three times to obtain three samples of pressure profiles for both rest and voluntary contraction. The manometric technique used has been previously described in detail [15, 16].

Mean and maximal values for rest and squeeze pressures, functional anal canal length, and SAI at rest and during squeeze were obtained by computerized analysis of all channels. The mean pressure values were calculated as the mean of eight-channel recordings within the functional anal canal length. The functional anal canal length was defined as the extension of the anal canal with pressures equal to or greater than 50% of the highest mean value obtained among eight channels at the same level within the anal canal [15]. The maximal values of resting and squeeze pressures were considered as the highest values obtained within the functional anal canal length. SAI rest and squeeze pressure profiles were developed using a computerized analysis of the mean values of pressures obtained with the eight channels radially distributed within the anal canal (Lower GI Polygram, Synetics Medical, Sweden).

Statistical analysis

Kruskall-Wallis and χ^2 tests were used for comparison, with significance established at a P<0.05.

Table 1 Distribution of controls and patients

	Age (years)			Gender			
	Mean ±SD	Median	Range	Women		Men	
				n	%	*n*	%
Controls (n=30)	38.8±12.8*	35	19–69	15	50.0	15	50.0
Patients (n=105)	57.6±14.8*	59	16–92	88	83.8	17	16.1
Group I (n=13)	49.5±17.3	48	16–72	9	69.2	4	30.8
Group II (n=53)	65.9±11.5	67	28–92	47	88.7	6	11.3
Group III (n=39)	49.0±11.4	50	24–73	32	82.0	7	18.0

*P<0.00001 between controls and patients

Table 2 Results of clinical evaluation of incontinent patients

Clinical parameters	Group I (n=13)	Group II (n=53)	Group III (n=39)	Total (n=105)
Duration of symptoms (years)	3.6±5.8	3.2±3.7	6.4±7.3	4.5±5.7
Type of incontinence				
Gas	1 (8%)	4 (8%)	2 (5%)	7 (7%)
Liquid stool	11 (85%)	35 (66%)	16 (42%)	62 (59%)
Solid stool	1 (8%)	14 (27%)	21 (54%)	36 (34%)
Incontinence score* (0–20)	6.1±3.1	8.6±3.9	12.5±4.9	9.7±4.8
History of constipation	5 (38%)	24 (45%)	5 (13%)	34 (32%)
Urinary incontinence	7 (54%)	12 (23%)	8 (20%)	27 (26%)
Sphincter defect on physical examination	0	5 (9.4%)	22 (56.4%)	27 (25.7%)

*P<0.001

Table 3 Traumatic causes of incontinence in groups II and III

Trauma	Group I	Group II	Total
Vaginal delivery[a]	40	11	45
Hemorrhoidectomy	14	11	25
Fistulectomy	01	11	12
Rectal prolapse repair	02	01	03
Coloanal anastomosis	01	02	03
Rectocele repair	01	01	02
Fissurectomy	0	01	01
Perineal trauma	0	01	01

[a]In five patients there was an association of vaginal delivery and hemorrhoidectomy, and in one patient an association of vaginal delivery and rectocele repair

Results

Clinical evaluation

Results of clinical evaluation and traumatic causal factors for groups I and II are presented in Tables 2 and 3, respectively.

Anorectal manometry

Among control subjects mean and maximum resting pressures did not differ between men and women; however in women, the functional anal canal was significantly shorter than in men (P<0.05), andthe mean squeeze pressure was significantly lower than in men (P<0.05; Table 4). SAI during squeeze was significantly higher in women (P<0.005), but there was no statistically significant difference between the sexes regarding SAI at rest (P>0.05; Figs. 1, 2).

Among patients with anal incontinence the mean and maximum resting and squeeze pressures were lower and the functional anal canal shorter in group III than in group II, which in turn had lower values than in group I (P<0.00001; Table 4). SAI values in incontinent patients were significantly higher than in controls (P<0.00001). Groups II and III had higher SAI values both at rest and during squeeze than the control group (P<0.00001). However, there was no statistically significant difference between group I and the control group on SAI at rest (P=0.05) or during squeeze (P=0.07; (Figs. 3, 4, 5).

Figure 6 presents the correlation between the sphincter defect diagnosed during physical examination and SAI values. Although none of the 13 patients in group I had any sphincter defects during physical examination, 3 (23.1%) had high SAI values in both rest and squeeze pressure profiles. Of the 53 patients in group II with a sphincter defect on physical examination 5 (9.4%) had high SAI values both at rest (32.8±2.6%) and during squeeze (12.8±6.4%). The other 48 patients in group II (91%) had no defect on physical examination, with mean

Table 4 Results of voluntary contraction pressure parameters for controls and incontinent patients

Parameters	Controls			Patients		
	Women (n=15)	Men (n=15)	Total (n=30)	Group I (n=13)	Group II (n=53)	Group III (n=39)
Mean resting pressure** (mmHg)	67.0±13	68.4±17	67.7±15	43.6±12	34.5±14	29.7±15
Maximum resting** pressure (mmHg)	100.3±23	95.0±21	97.7±22	67.2±22	54.8±23	51.6±24
Functional anal canal** length (cm)	2.8±0.8	3.4±0.6	3.1±0.8	2.7±0.7	2.2±1.0	1.8±1.3
Mean squeeze pressure*,** (mmHg)	96.9±49	139.4±63	118.1±59.6	84.5±54	54.6±42	51.3±39
Maximum squeeze pressure** (mmHg)	140.3±60	193.3±87	166.8±79	132.3+78	80.9+54	83.8+58

*P<0.05 (Kruskal-Wallis) men vs. women among controls; **P<0.00001 (Kruskal-Wallis) controls vs. patients

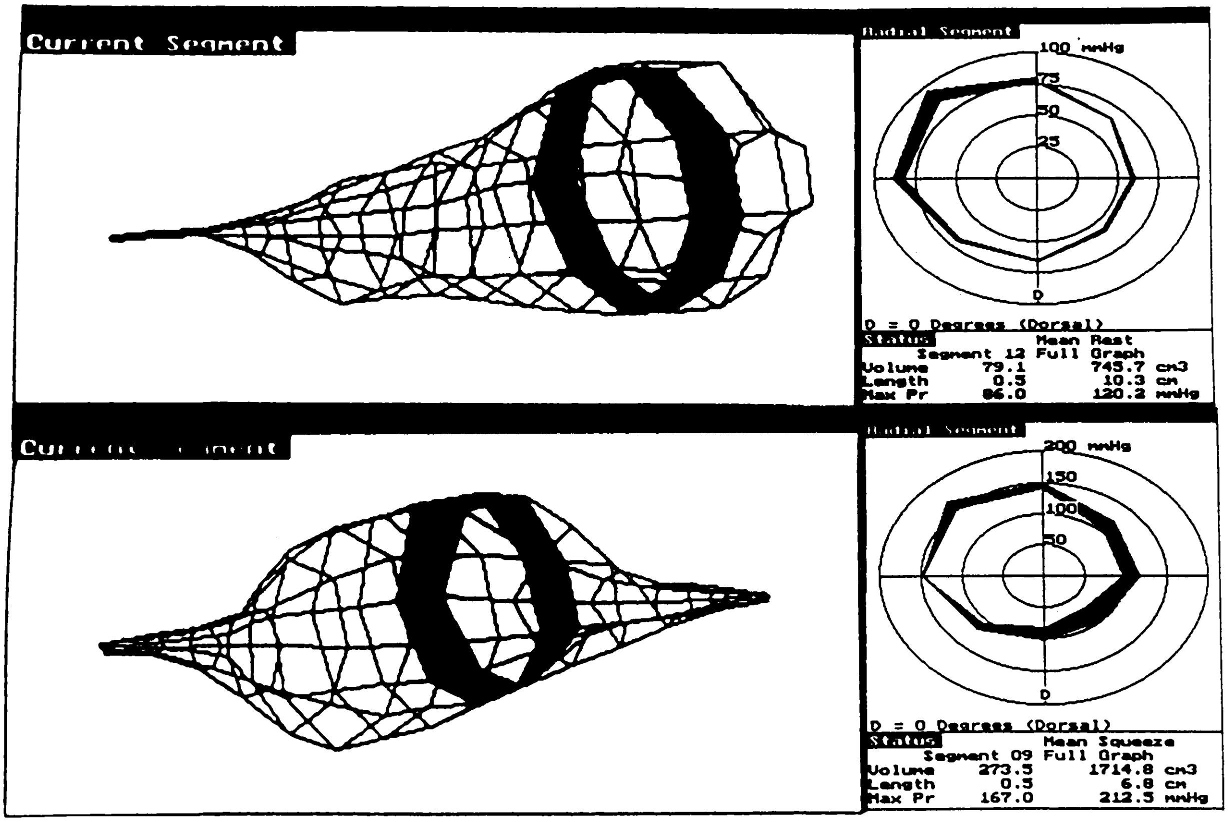

Fig. 1 Vectorgram at rest (SAI=6.0%; *above*), and during squeeze (SAI=6.0%; *below*) in the control group

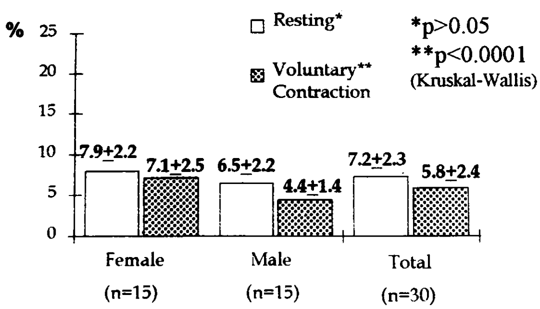

Fig. 2 Comparison of SAI at rest and during voluntary contraction in male and female controls

SAI values of 17.6±8.0% at rest and 24.4±13.7% during squeeze. In 34 patients (70.8%) there were high SAI values at rest and in 26 (54.2%) during squeeze. In group III there were 22 patients with sphincter defects on physical examination (56.4%), 20 of whom (90.9%) had high SAI values both at rest and during squeeze. Mean SAI values were 26.7±16.4% and at rest and 19.0±7.8% during voluntary contraction. The remaining 17 patients in group III (90.6%) had no sphincter defects during physical examination, with mean SAI values of 19.7%±9.2 at rest and 14.0%±7.6 during squeeze. High SAI values were observed in 14 (82.4%) and 11 (64.7%) patients, respectively.

Resting and squeeze pressures were inversely correlated with SAI values, i.e., patients with lower pressures had higher SAI values (Fig. 7).

Discussion

Vectormanometry, vector volume, and pressure tridimensional vectorgram are somewhat confusing terminology as recently applied to conventional manometry. Essentially this technique was developed after multiple sampling of pressures within the anal canal became possible through multilumen catheters and subsequent demonstration of longitudinal and radial variation in pressures [5, 7]. Vectormanometry permits a more accurate calculation of mean pressure and can be performed by continuous [8, 17] or stationary pull-through [18, 19, 20]. The SAI, also known as a coefficient of variation, has proven helpful in uncovering occult sphincter defects [9].

Historically, the difference in functional anal canal length between men and women has been ascribed to multiparity [21, 22, 23]. However, although we found the functional anal canal length in controls to be signifi-

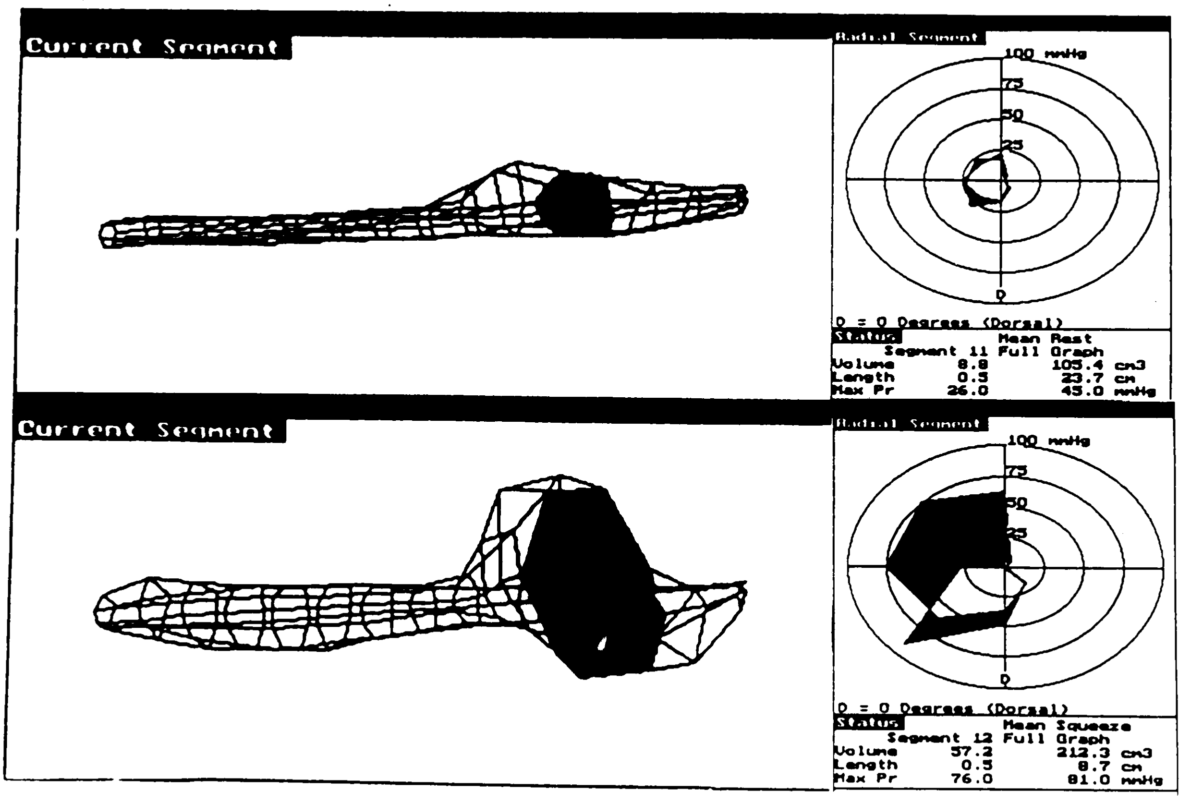

Fig. 3 Vectorgram at rest (SAI=20.6%; *above*), and during squeeze (SAI=22.0%; *below*) in a woman with incontinence after fistulectomy. Note that the asymmetry is more pronounced during squeeze. Despite the very low pressure profile at rest and the relatively symmetric aspect visually, the SAI value is high

cantly shorter in women than in men, all of the women were nulliparous ($P<0.05$). Similarly, Cali et al. [11] found no differences in anal sphincter length between nulliparous and multiparous women (2.8 cm vs. 3.0 cm at rest and 3.8 cm vs. 3.7 cm during squeeze). These findings reinforce the hypothesis that factors other than parity may be responsible for the lower anal canal pressures in women and, possibly, for the greater prevalence of functional disorders [24].

The asymmetry index of a sphincter system by definition is a consequence of the individual arrangement and traction of its various muscular components. Therefore, because the sphincteric complex is considered an asymmetrical structure [25, 26, 27], it is expected that its function will manifest asymmetrically [18]. In fact, this has been demonstrated both at rest and during squeeze, and during reflex relaxation after rectal stimulation. Using four channels Taylor et al. [7] demonstrated higher pressures in the posterior aspect of the anal canal proximally, whereas distally pressures were higher in the anterior aspect.

Although the degree of sphincter asymmetry has been a subject of interest for many years, its quantification in terms of percentages has become available only recently. In this study controls had SAI values between 12.9% and 2.1%. SAI values during squeeze (but not at rest) were significantly higher in women than in men ($P<0.005$). Braun et al. [8] observed that none of their eight controls had a SAI value higher than 10%; no difference in SAI between genders has been previously reported by others [8, 11].

At approximately the fourth decade of life, the prevalence of incontinence in women vs. men is 8:1 [28]. In the current study 83.8% of the incontinent patients were women; this preponderance was even more pronounced in groups II and III in which patients with possible traumatic causes had more severe incontinence. Clearly these data are also related to obstetrical factors, as the incidence of temporary or permanent incontinence following vaginal delivery is estimated at 3% or even higher depending upon the type of episiotomy or the coexistence of perineal lacerations [29, 30, 31]. Anorectal surgery, particularly fistulectomy, represents the most common cause of iatrogenic anorectal sphincter trauma, with an overall prevalence of 34% or higher [32, 33]. In this study hemorrhoidectomy was the most common iatrogenic cause. The effect of this operation on the sphincter is primarily a reduction in pressure, which may occasionally cause some degree of incontinence [34, 35, 36]. Neurogenic causes may have been responsible for most cases of incontinence in groups I and II; these groups had a higher prevalence of previous constipation than

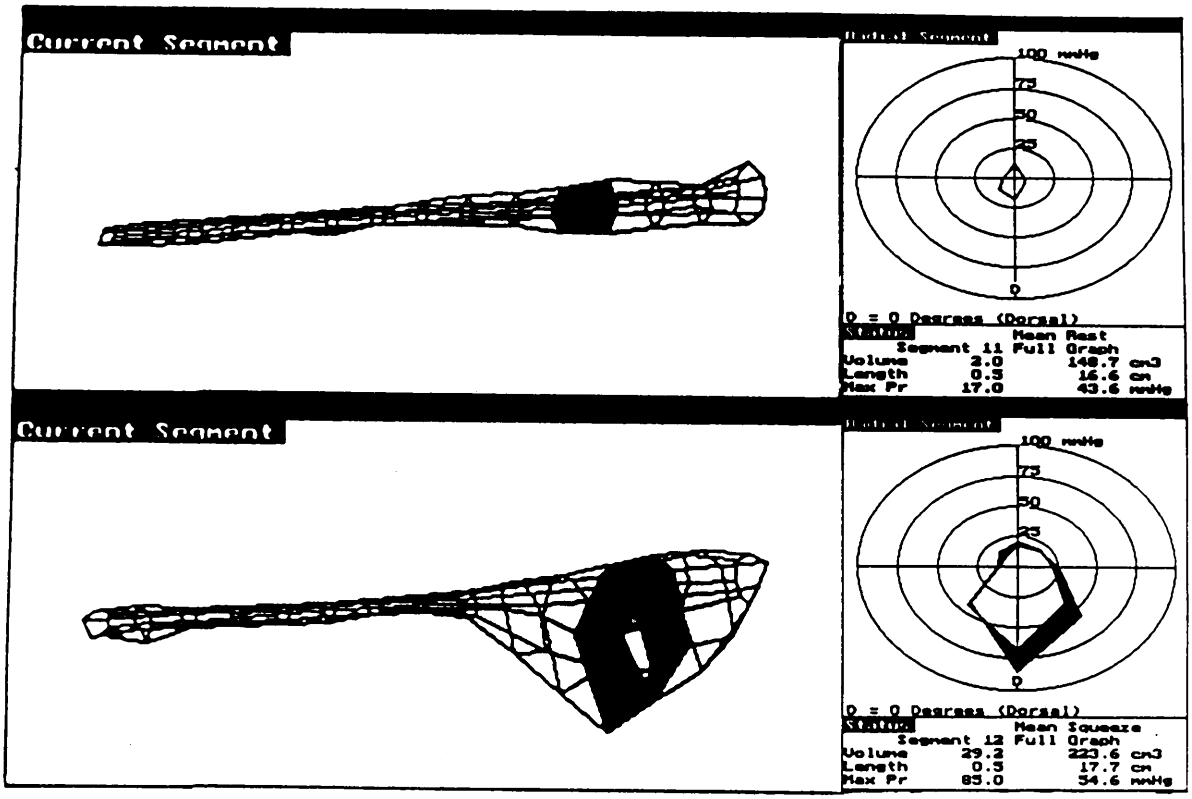

Fig. 4 Vectorgram at rest (SAI=25.2%; *above*), and during squeeze (SAI=19.4%; *below*) of a patient with history of traumatic incontinence

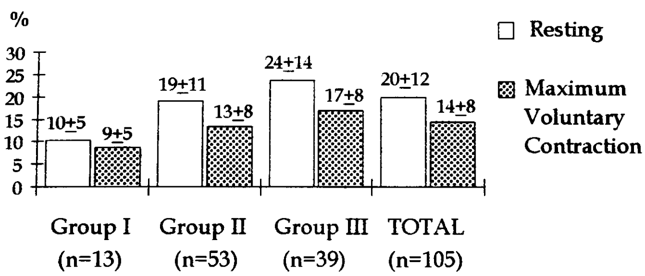

Fig. 5 Comparison of SAI at rest (P<0.001; Kruskal-Wallis) and during voluntary contraction (P<0.01; Kruskal-Wallis) among the incontinent groups

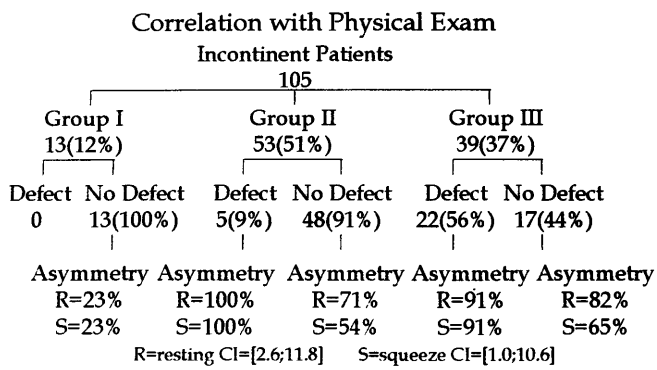

Fig. 6 Distribution of patients based on clinical history, physical examination, and vectormanometry

group III. Additionally, association of urinary incontinence (double incontinence) was also more prevelant in these patients, particularly those in group I. Both electromyography and histopathology demonstrate abnormal findings in up to 80% of patients with idiopathic incontinence, and neuropathy of the perineal branches of the pudendal nerves have also been demonstrated in cases of double incontinence [23, 37, 38, 39, 40, 41].

Incontinence scores were significantly different between the groups of incontinent patients in this study, with progressively higher values for groups I, II, and III, which were significantly correlated with SAI values. These findings suggest that patients with a history of trauma, particularly if directly related to the onset of symptoms (group III), had more severe symptoms, higher SAI values, and therefore may be potential candidates for sphincter repair. Braun et al. [8], in a study of 23 women with anal incontinence, reported higher SAI values in patients with a sphincter defect both at rest and during squeeze than in the control

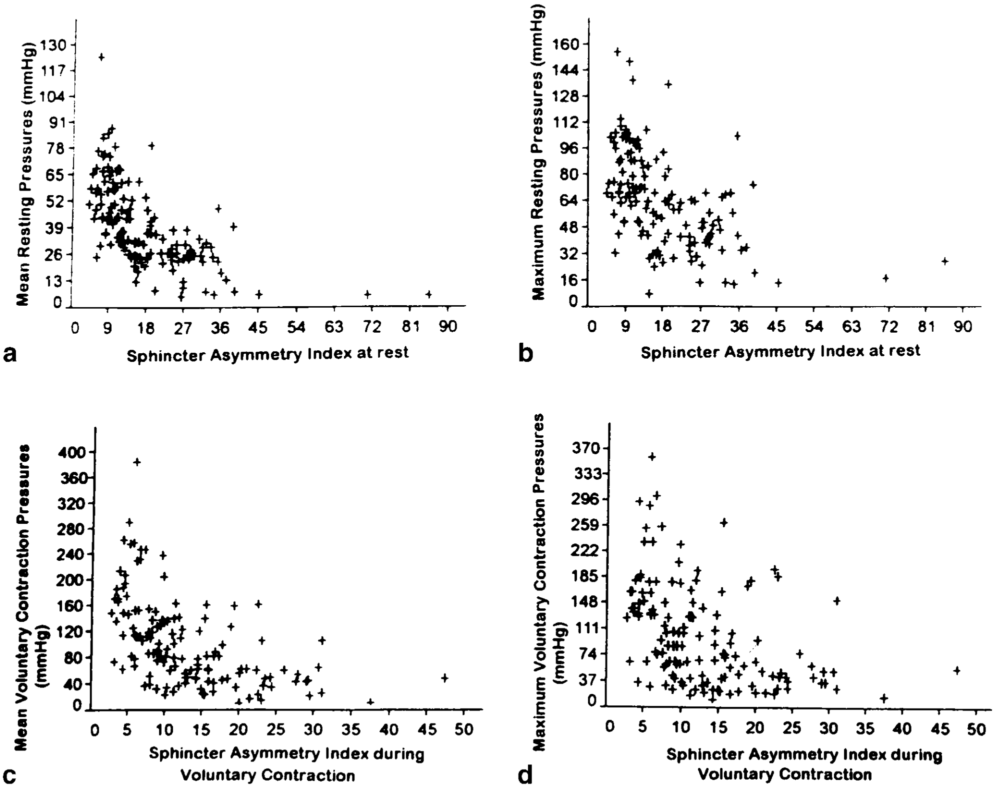

Fig. 7a–d Inverse correlations between SAI and contraction pressures. **a**,**b** At rest: SAI and mean pressure (**a**; *r*=–0.62, –0.71 to –0.50) and maximum pressure (**b**; *r*=–0.51, –0.62 to –0.37). **c**,**d** During voluntary contraction (pressure 8.2): SAI and mean pressure (**c**; *r*=–0.44, to –0.57 –0.30) and maximum pressure (**d**; *r*=–0.43, –0.56 to –0.28)

group and in patients with trauma-associated incontinence. They concluded that vectormanometry permits differentiation between global and segmental sphincter insufficiency.

Although the accuracy of the vectorgram in detecting defects in severely reduced pressures has been questioned, this study noted an inverse correlation between the pressure parameters, including mean and maximum values for resting and squeeze pressures, and SAI values. Thus patients with lower pressures had higher values of SAI; consequently the accuracy of the vectorgram analysis was not affected in more severe incontinence.

Although the SAI is useful in discriminating traumatic causes, locating the defect by visual graphic analysis still seems somewhat inaccurate. The topographic characterization of the defect must be corroborated by other methods such as electromyography and anal ultrasound. Electromyography provides an accurate mapping of the anal sphincter; however, for this purpose, it requires at least four needle insertions, which is very uncomfortable for the patient. Anal ultrasound in turn has gained increased acceptance as a painless study that allows detailed visualization of the defect. Nonetheless, anal ultrasound does not offer quantitative data on the functional status of the remainder of the sphincter. Vectormanometry, on the other hand, is able to quantify the degree of asymmetry and consequently to detect localized pressure deficiencies. Anal incontinence is a multifactorial and very complex disorder, and as such patients most frequently benefit from a combination of tests for a more judicious therapeutic decision.

Conclusion

Incontinent patients with a previous history of sphincter trauma had more severe incontinence, both clinically and manometrically, and higher SAI values than patients without prior trauma. Therefore SAI analysis is a valuable tool in the assessment of anal incontinence to discriminate traumatic causes.

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