Towards evidence based practice in pelvic floor physiotherapy

Voorham-van der Zalm, P.J.

Chapter 5

Placement of probes in electro stimulation and biofeedback training in pelvic floor dysfunction

Petra J. Voorham-van der Zalm (a)' Rob C.M. Pelger (a), Ingrid C. van Heeswijk-Faase,

Henk W. Elzevier (a), Theo J. Ouwerkerk (a), John Verhoef (b),

Guus A.B. Lycklama à Nijeholt (a).

From the Departments of Urology (a) and Physiotherapy (b)

Leiden University Medical Center, the Netherlands

Acta Obstet Gynecol Scand 2006; 85: 850-855

Introduction

Since the introduction of the manometric probe used as a perineometer by Kegel (1), many electrodes have been developed for intravaginal and intra-anal electrostimulation and biofeedback training in the treatment of pelvic floor dysfunction. Intravaginal and intra-anal electrostimulation and biofeedback training are used for treatment of urinary urge- and stress incontinence, anal dysfunction, and sexual dysfunction. For optimal treatment, knowledge of the structures that are the main targets in stimulating and in biofeedback training is needed. This knowledge of both the anatomy of the pelvic floor and physiological aspects should result in optimal design of probes. However, lack of uniformity in description of the anatomy per se, the nomenclature of the pelvic floor (2-4), and stimulation techniques is hampering such a design (5–8). Moreover, the available, commonly used probes have been developed empirically.

Based on the present knowledge, the pelvic floor basically comprises the levator ani and the puborectal muscle. Pelvic floor muscle contraction presumably involves contraction of these two muscles (9). The levator ani is a muscle active in the process of evacuation (9–11). On contraction it facilitates the process of defecation and micturition. In contrast, the puborectal muscle is a muscle active in the process of continence. The puborectal muscle is a vertically lying U-shaped sling embracing the urethra and anal canal. Furthermore, the external anal and urethral sphincters originate in the puborectal muscle (11–14). During puborectal muscle contraction, the two sphincters contract synchronously, resulting in a closure (‘sealing’) of the urethra and anal canal (15). Continence, in short, is a result of the direct action of the puborectal muscle per se and the external anal and urethral sphincters.

In sphincter/stress incontinence, enforcement of the external sphincters, and/or pelvic floor musculature, the puborectal muscle is, in our opinion, the main target of electrostimulation. However the primary targets are not the muscles but the pelvic and/or pudendal nerve fibers. Those fibers directly activated by electrostimulation indirectly induce activity of the muscles.

In urge incontinence, two modes of action are described: stimulation of pudendal nerve afferents, resulting in detrusor inhibition through central reflexes, as well as stimulation of efferents resulting in enhancement of pelvic floor and urethral sphincter musculature tone, inducing detrusor inhibition through the guarding reflex (5). As these modes of action are quite different, with different targets, it is questionable whether the demands for optimal probes are uniform. It is more likely that various types of probes are needed for optimal stimulation-treatment as well as for biofeedback registration.

This investigation was performed in order to validate the anatomical positioning of commonly used commercially available probes, positioned according to standard protocol as used in daily practice by pelvic floor physiotherapists. This study was performed preliminarily to a larger study in order to construct a probe optimized for structures we want to stimulate and registration in pelvic floor treatment.

Material and methods

To investigate the positioning of the anal and vaginal probes, we used the Aloka® SSD 1700 Ultrasound, the power Doppler and the Falcon Ultrasound scanner Type 2101 from Bruel-Kjaer Medical®, with transducer type 8658/S and 1850, to localize musculature and the neurovascular bundle of the pelvic floor. The transducer 8658/S was used in combination with the Brachy balloon from Barzell-Whitmore Maroon Bells®. The anatomy of the pelvic floor was investigated in detail using the 0.5-T MRI scanner (Philips NT5, Philips Medical Systems®, Best, the Netherlands) equipped with an endoanal coil. We performed a thorough literature review on pelvic floor anatomy and placements of probes in pelvic floor physiotherapy.

We evaluated the optimal placement of probes in two healthy multiparous women, without pelvic floor dysfunction. The distance from the recording rings to the muscles is described at the proximal parts of the puborectal muscle and the anal external sphincter. Positioning of the anal probes was examined in left lateral decubitis position, with the ultrasound transducer introduced in the vagina. The positioning of the vaginal probes was examined in lithotomic position with the ultrasound transducer in the anal canal. The anatomy was compared with a vast number of MRI examinations performed with an endoanal coil according to protocol in our institute.

During the examination the women were asked to strain and to bear down. Repeated measures were performed on both subjects with a time interval of three weeks. The time elapsed between using each test probe was 15 min and we requested both women to do 10 fast twitch contractions and 5 slow twitch contractions. Five probes, 3 vaginal and 2 anal, were tested and technically described. Three probes have longitudinal recording plates and two have concentric recording plates (Table I).

Table 1. Description of investigated probes (Prm = puborectal muscle; numbers are expressed in centimeters)

Type of probes	Probe 1. Neen, vaginal	Probe 2. Veriprobe, vaginal	Probe 3. EMG, vaginal	Probe 4. Neen, anuform	Probe 5. EMG, anal
Shape of recording plates	Longitudinal	Longitudinal, rectangle	Concentric	Longitudinal, trapezoid	Concentric
Length of recording plates	3.5	3.5	–	2.7	–
Width of recording plates	1.5	2.0	1.0	0.5–1.0	0.5
Circumference of probe	10.0	8.2	7.7	7.0	5.0
Length of probe	7.5	8.8	12.7	8.4	13.6
Place of insertion	Introitus	Introitus	Introitus	Anal verge	Anal verge
Position of recording plates in relation to puborectal muscle	3 cm cranial of prm	At prm	6 cm cranial of prm	1 cm caudal of prm	2 cm cranial of prm

Neen, vaginal probe, Verity Medical Ltd® (Figure 1, probe 1)

This probe has a total length of 7.5 cm and a circumference of 10 cm. It has two longitudinal recording plates. The distance between the top of the probe and both recording plates is 1.5 cm. The two recording plates are situated alongside the body of the probe and are 1.5 cm wide and 3.5 cm long. The distance of the base of the probe to both recording plates is 3.0 cm. The probe is inserted into the vagina, up to the ring at the introitus.

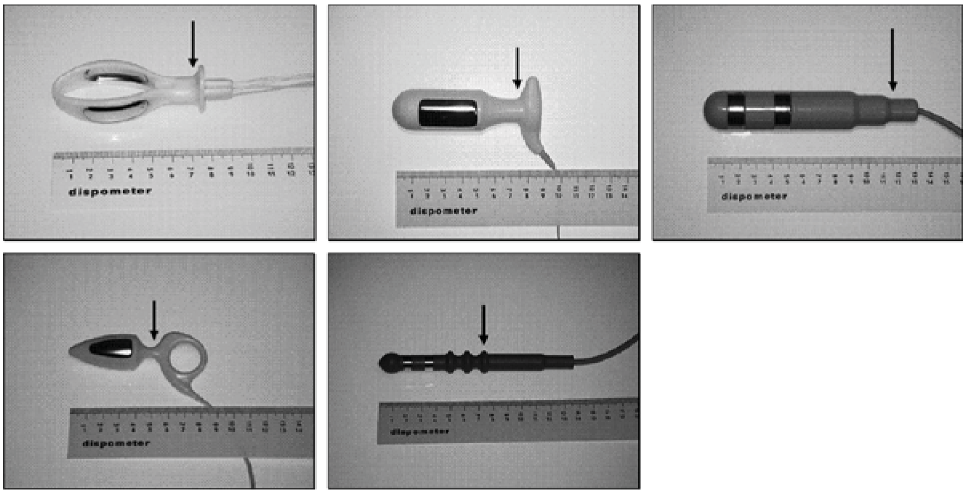

Figure 1. Probes (1–5); all probes were inserted up to the arrow, length of probe in cm. Probe 1: Neen, vaginal probe, periform. Probe 2: Veriprobe, vaginal probe. Probe 3: EMG, 2-ring vaginal probe 2 mm. Probe 4: Neen, anal probe, anuform. Probe 5: EMG, 2-ring anal probe 2 mm.

Veriprobe, vaginal probe with longitudinal plates, Verity Medical Ltd® (Figure 1, probe 2)

This probe has a total length of 8.8 cm and a circumference of 8.2 cm. Two longitudinal rectangle-shaped recording plates are situated alongside the body of the probe and are 2.0 cm wide and 3.5 cm long, and are flush with the body of the probe. The distance between the two recording plates is 2.0 cm. The distance of the recording plate to the top is 1.5

cm, to the bottom 2.1 cm. The external part of the probe is 1.3 cm long. This probe is inserted up to the handle at the introitus.

EMG, 2-ring vaginal probe 2 mm, V.M.P. Bioparc® (Figure 1, probe 3)

This probe has two circular recording plates. The total length of this probe is 12.7 cm, the circumference 7.7 cm. The distance from the top ring to the top of the probe is 1.4 cm. The distance between the two rings is 1.8 cm and the width of both rings is 1.0 cm. This probe is inserted up to the thinnest part, at the level of the introitus.

Neen, anal probe, anuform, Verity Medical Ltd® (Figure 1, probe 4)

This probe has a total length of 8.4 cm and a maximal circumference of 7.0 cm. It consists of a body, with two longitudinal recording plates, a neck and an open ring. The recording plates are trapezoid like. The distal side of the recording plate is 0.5 cm wide, the proximal side 1.0 cm. The length of the recording plate is 2.7 cm. The distance between the two recording plates is about 2.0 cm. The distance of the recording plate to the top of the probe is 1.0 cm, to the base 0.5 cm. The length of the ring is 3.0 cm. This probe is inserted with the ring up to the anal verge.

EMG, 2-ring anal probe 2 mm, V.M.P. Bioparc® (Figure 1, probe 5)

This probe has two circular recording plates. The probe has a total length of 13.6 cm. The circumference of the top of the probe is 5.0 cm. The distance from the distal recording ring to the top is 1.8 cm. The distance between the two rings is 1.0 cm. The width of both rings is 0.5 cm. The distance from the proximal ring to the next bulge is 1.0 cm. There are three bulges with two gaps of 1.0 cm in between. These bulges are for the purpose of fixation. The distance from the proximal bulge to the base of the probe is 6.0 cm. This probe is inserted with the proximal bulge at the anal verge.

Results

Ultrasonography was used to document relevant anatomical structures in both women: first, at 0.5 cm of the anal verge, the anal external sphincter is visualized with a width of about 2.5 cm. The fibers of this muscle are confluent with the fibers of the puborectal muscle cranially. The width of the puborectal muscle is 2.5 cm. Surrounded by these muscles, the internal anal sphincter together with circular and longitudinal layers of the rectum are pictured (Figure 2). The levator ani is positioned above the puborectal muscle, as a dome from left to right (Figures 2 and 4). The urethral external sphincter could not be visualized.

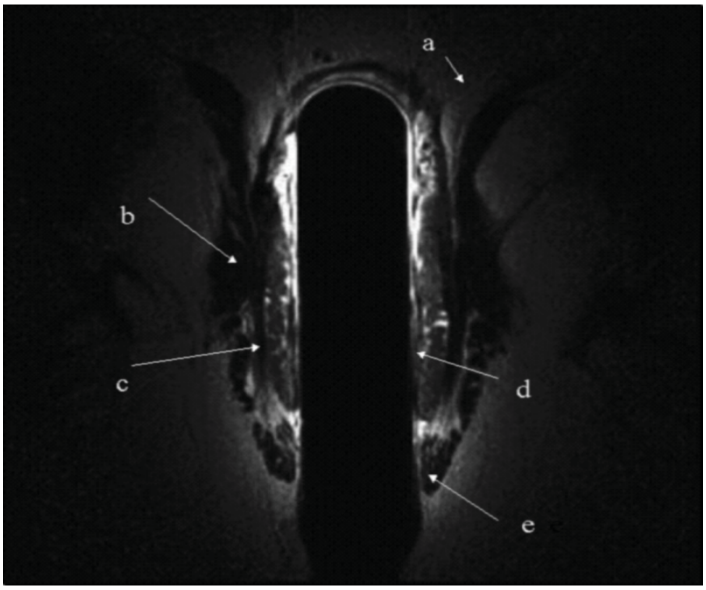

Figure 2. MRI of the anorectal canal with the anal rectal coil. (a) levator ani, (b) puborectal muscle, (c) anal internal sphincter, (d) longitudinal layers of the rectum, (e) anal external sphincter. From caudal to cranial the anal external sphincter is visualized first. The fibers of this muscle turn into the fibers of the puborectal muscle cranially. Encircled by these muscles is the internal anal sphincter together with the circular and longitudinal layers of the rectum.

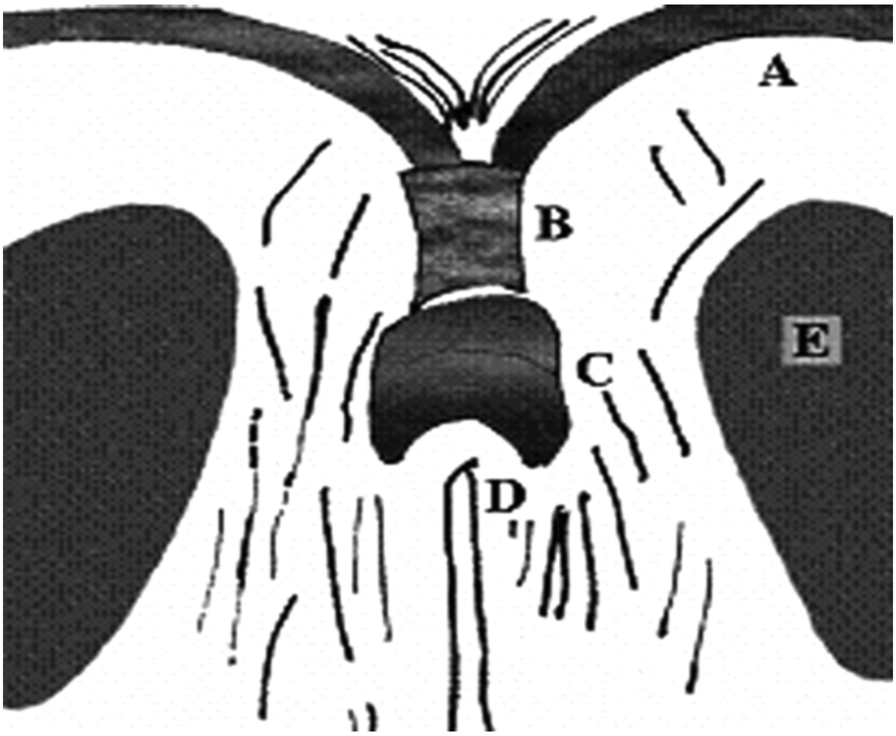

Figure 4: Pelvic floor anatomy. The anal external sphincter (C) is visualized first. The fibers of this muscle turn into the fibers of the puborectal muscle (B) cranially. Encircled by these muscles is the anal internal sphincter together with the circular and longitudinal layers of the rectum. The levator ani (A) is positioned above the puborectal muscle, as a dome from the left to the right. Other structures demonstrated in the figure are the anus (D) and the pelvic bone (E). Adapted from Hussain (17).

Neen vaginal probe, periform

At proper placement, the recording plates are located 3 cm cranial of the distal edge of the puborectal muscle. The bulk of this probe will take its natural place within the vagina and the vaginal wall is pushed aside gently together with the puborectal muscle.

Veriprobe, vaginal probe

Both plates were close to the puborectal muscle, 2.5 cm cranial of the anal external sphincter both in rest and during straining. While straining the probe slipped out of the vagina. Due to the size of the probe the vaginal wall with the puborectal muscle is pushed aside gently.

EMG, 2-ring vaginal probe 2 mm

On endo ultrasonography we visualized the proximal electrode 6 cm cranial of the puborectal muscle. The distal electrode was positioned against the bladder wall.

Neen probe, anuform

The recording plates are located next to the anal external sphincter, 1 cm caudal of the puborectal muscle. Because of the configuration and the size of the probe, the probe fits naturally in the anorectal canal. On contracting both the anal external sphincter and the puborectal muscle pushed the probe upwards into the rectum. Due to the size of the probe the rectal wall as well as the puborectal muscle is pushed aside gently.

EMG, 2-ring anal probe

With the probe positioned as described, with the proximal bulge at the anal verge, the electrodes were positioned 2 cm cranial of the puborectal muscle and 4 cm cranial of the anal external sphincter. When the probe was inserted less deep with the proximal bulge outside the anus, the plates were located near the puborectal muscle. If the probe is positioned even less deep with the distal bulge at the level of the anal verge, the distal ring of the electrode was exactly at the puborectal muscle and the proximal ring at the anal external sphincter (Figure 3).

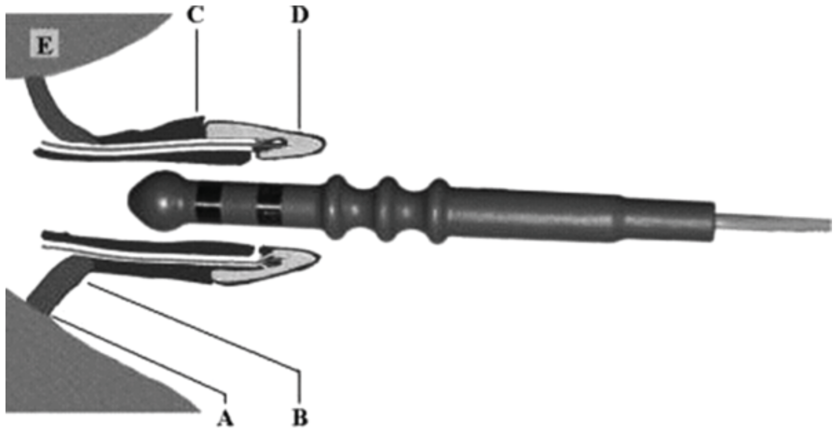

Figure 3. Pelvic floor anatomy. The EMG probe anal, 2 rings, is positioned with the distal electrode at the puborectal muscle (C) and the proximal electrode at the anal external sphincter (D). Other structures demonstrated in the figure are arcus tendineus (A) and the levator ani (B) relative close to the pelvic bone (E). Adapted from Hussain (17).

Discussion

The literature on this topic is scarce. The commercially available probes studied vary in design that is in shape and size of the body of the probe and in type of recording electrodes (plates or rings). Notwithstanding, they all have the same purpose: proper placement during treatment of pelvic floor dysfunction. What proper placement means depends on the structures that need to be stimulated or registered (nerves, external sphincters, puborectal muscle, or other pelvic floor muscles). The muscular anatomy can be described as consisting of, roughly speaking, 3 layers of muscles: from caudal to cranial: the anal external sphincter, the puborectal muscle, and the levator group. The results of the measurements of the vaginal electrodes vary from close to the puborectal muscle (Veriprobe) to 6cm cranial of the puborectal muscle (EMG 2-ring vaginal probe 2mm). The anal electrodes vary from next to the anal external sphincter, 1cm caudal of the puborectal muscle (Neen probe, anuform), to 2 cm cranial of the puborectal muscle and 4cm cranial at the anal external sphincter (EMG probe anal, 2 rings). Measurements were reproducible in each subject and for each probe, independently of the sequence. Readings of the probe were not influenced by the presence or absence of the ultrasound probe in the adjacent orifice.

In case of electrostimulation for treatment of urinary urge incontinence, stimulating should be focused on afferent nerve fibers of the plexus pelvicus and the pudendal nerve (5) or, if the guarding reflex is involved as well, as in case of stress incontinence, on the external sphincter and pelvic floor musculature. It is assumed that, in this respect, of all pelvic floor muscles, the puborectal muscle is the most relevant one (15). Using electrostimulation in cases of fecal incontinence, the focus is on the anal external sphincter as well as on the puborectal muscle. In biofeedback training we aim to record the function of the urethral and anal sphincters and the puborectal muscle. This means that for biofeedback training a close relation between the electrode plates and the muscle itself is important. However, in cases of electrostimulation of pelvic floor dysfunction (stress and urge incontinence, fecal incontinence, and obstructed defecation), stimulation of afferent and/or efferent nerves is mandatory and not necessarily direct stimulation of the involved muscles. The general requirement to obtain an effect of electrical stimulation is that the intensity of stimulation is sufficient to elicit impulses in a relevant nerve. The threshold intensity to evoke a response in the muscles varies inversely with the nerve fiber diameter, the distance between the nerve and the size of the stimulating electrode, and the pulse configuration. All tested probes had a large electrode area. The effect of this is that a relatively large current is needed to elicit an effect, but this is not by itself harmful. If the electrodes are not positioned at the anal external sphincter and/or the puborectal muscle, we assume that in biofeedback training we are in fact registering a composite EMG signal of the total area, not only the pelvic floor, but the sum of all active surrounding muscles as well as the response to intra-abdominal pressure.

Based on our findings we conclude that the electrodes of the probes, as we use them now during electrostimulation and biofeedback training in the treatment of pelvic floor dysfunction, are not optimal for the structures we want to stimulate or to register.

Observation of the anal positioning of the probe by vaginal ultrasound demonstrated that during an attempt to perform a pelvic floor contraction, the anal external sphincter ‘rolls’ backwards, taking the shape of a ‘drop’. Simultaneously the urethra stretches itself, elongates and is pulled down during contracting the urethral sphincter and the puborectal muscle. In contrast, during straining, the urethra is shortened and moves upwards.

Optimal probe fitting may be even more complex. According to Hussain (16), sex-dependent differences are visible in all three planes. Because of the clear difference in male and female anatomy, different electrodes are needed in the treatment of pelvic floor dysfunction.

Ultrasound and MRI imaging demonstrated that the positioning of the electrodes is close to the plexus pelvicus. Besides stimulation of afferent or efferent, motoric nerves, the mode of action of intravaginal stimulation for urge incontinence may also be related to direct stimulation of the bladder wall or the urethra. If we position the electrodes at the anal external sphincter or in the anal canal below the linea dentata, or just behind the vaginal introitus, electrostimulation is far too painful for the patient. Direct stimulation of skin and mucosa, also at lower intensity, is probably the cause of this pain sensation. In case of biofeedback, the optimal position of the probes for stimulation is quite different.

In our opinion the ideal probe must be:

1. registering;
    - vaginal: the puborectal muscle, the external urethral sphincter;
    - anal: the puborectal muscle, the anal external sphincter, the levator ani
2. stimulating the structures we want to stimulate: nerves or muscles
3. shaped and sized adapted to the local anatomy (not vice versa)
4. comfortable for the patient
5. maintaining its position
6. the reference electrode should be incorporated
7. suitable for sterilization
8. durable
9. containing rings and plates.

Conclusions

As the five examined commercially available probes vary considerably in their relationship with the, roughly speaking, three layers of muscles, it is unlikely that they are all fit for optimal use.

In our opinion, the anal and vaginal probes we use presently have a too large diameter, even in women after vaginal delivery. In view of our findings we are now re-evaluating the normal anatomy and physiology of the pelvic floor and the anatomy in men and women with pelvic floor dysfunction. Studies to determine the primary anatomical and physiological focus for both vaginal or anal electrostimulation and feedback will be conducted at our institute in order to meet the demand for optimized probes.

Reference list

1. Kegel, AH. (1948) Progressive resistance exercise in the functional restoration of perineal muscles. Am J Obst Gynecol,56, pp. 238–304.

2. Marani, E. (2002) The Pelvis – Another View, Anatomy of the pelvic wall, pp. 69–86. Enschede. The Netherlands: Twente University Press.

3. Shafik, A and Shafik, IA. (2003) Overactive bladder inhibition in response to pelvic floor muscle exercises. World J Urol , 20(6), pp. 374–377.

4. Kearney, R, Sawhney, R and DeLancey, JO. (2004) Levator ani muscle anatomy evaluated by origin-insertion pairs. Obstet Gynecol, 104, pp. 168–173.

5. Fall, M and Lindström, S. (1994) Functional electrical stimulation: physiological basis and clinical principles. Review article, Int J Urogynecol, 5, pp. 296–304.

6. Smith, JJ. (1996) Intravaginal stimulation: randomized trial, J Urol , 155, pp. 127–130.

7. Siegel, SW, Richardson, DA, Miller, KL, Karam, MM, Blackwood, NB and Sand, PK et al. (1997) Pelvic floor electrical stimulation for the treatment of urge and mixed urinary incontinence in women. Urology, 50(6), pp. 934–940.

8. Brubaker, L, Benson, JT, Bent, A, Clark, A and Shott, S. (1997) Transvaginal electrical stimulation for female urinary incontinence, Am J Obstet Gynecol. 177, pp. 536–540.

9. Shafik, A. (1979) A new concept of the anatomy of the anal sphincter mechanism and the physiology of defecation. VIII. Levator hiatus and tunnel. Anatomy and function, Dis Colon Rectum, 22, pp. 539–549.

10. Shafik, A. (1984) Pelvic double-sphincter control complex. Theory of pelvic organ continence with clinical application. Urology, 23, pp. 611–618.

11. Shafik, A and El-Sibai, O. (2001) Rectal inhibition by inferior rectal nerve stimulation in dogs. Recognition of a new reflex: the 'voluntary anorectal inhibition reflex'. Eur J Gastroenterol Hepatol, 13, pp. 413–418.

12. Shafik, A. (1997) A study on the origin of the external anal, urethral, vaginal and prostatic sphincters. Int Urogynecol J, 8, pp. 126–129.

13. Shafik, A. (1998) A new concept of the anatomy of the anal sphincter mechanism and the physiology of defecation: mass contraction of the pelvic floor muscles. Int Urogynecol J, 9, pp. 28–32.

14. Shafik, A. (1999) A study on the continent mechanism of the external urethral sphincter with identification of the "voluntary urinary inhibition reflex". J Urol, 162, pp. 1967–1971.

15. Shafik, A. (1975) A new concept of the anatomy of the anal sphincter mechanism and the physiology of defecation. II. Anatomy of the levator ani muscle with special reference to puborectalis. Invest Urol, 13, pp. 175–182.

16. Hussain, SM. (1998) Normal imaging findings, in: SM Hussain (Ed.). Imaging of Anorectal Diseases. pp. 29–54. London: Greenwich Medical Media Ltd.