

Medical Radiology · Diagnostic Imaging

Series Editors: H.-U. Kauczor · P. M. Parizel · W. C. G. Peh

Rosemarie Forstner

Teresa Margarida Cunha

Bernd Hamm *Editors*

# MRI and CT of the Female Pelvis

*Second Edition*

 Springer

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# Medical Radiology

## Diagnostic Imaging

### **Series Editors**

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Rosemarie Forstner  
Teresa Margarida Cunha • Bernd Hamm  
Editors

# MRI and CT of the Female Pelvis

Second Edition

 Springer

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# Clinical Anatomy of the Female Pelvis

Helga Fritsch

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*This chapter is dedicated to my friend Harald Höttinger who was an excellent radiologist and a good coworker.*

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## Abstract

The pelvic floor constitutes the caudal border of the human's visceral cavity. It is characterized by a complex morphology because different functional systems join here. A clear understanding of the pelvic anatomy is crucial for the diagnosis of female pelvic diseases, for female pelvic surgery, as well as for fundamental mechanisms of urogenital dysfunction and treatment.

## 1 Introduction

The pelvic floor constitutes the caudal border of the human's visceral cavity. It is characterized by a complex morphology because different functional systems join here. A clear understanding of the pelvic anatomy is crucial for the diagnosis of female pelvic diseases, for female pelvic surgery, as well as for fundamental mechanisms of urogenital dysfunction and treatment.

Modern imaging techniques are used for the diagnosis of pelvic floor or sphincter disorders. Furthermore, they are employed to determine the extent of pelvic diseases and the staging of pelvic tumors. In order to be able to recognize the structures seen on CT and MRI as well as on dynamic MRI, a detailed knowledge of the relationship of the anatomical entities within the pelvic anatomy is required.

The *Terminologia Anatomica* (Federative Committee on Anatomical Terminology 1998)

contains a mixture of old and new terms describing the different structures of the pelvis. Throughout this chapter the actual anatomical terms are used and compared with clinical terms. Furthermore, they are defined and illustrated (see Table 1).

---

## 2 Morphological and Clinical Subdivision of the Female Pelvis

The anatomy of the female pelvis and perineum shows a lack of conceptual clarity. These regions are best understood when they are clearly described and subdivided according to functional and clinical requirements: The actual clinical subdivision discerns an anterior, a middle, and a posterior compartment. Whereas an anterior and posterior compartment may be found in the male as well as in the female, a middle compartment can only be found in the latter. The term “compartment” is routinely used by radiologists and all surgeons operating on the pelvic floor. This term is not identical with the term “space.” According to former literature a lot of spaces are supposed to be arranged in the region of the pelvis: retrorectal, pararectal, rectoprostatic, rectovaginal, retropubic, paravesical, etc. (Lierse 1984; Pernkopf 1941; Waldeyer 1899). From the point of view of the surgeon, “spaces” are empty (Richter and Frick 1985). They are only filled with loose connective tissue and neither contain large vessels nor nerves. Some years ago, we already proposed dropping the term “space” and speaking of compartments instead, taking into account that a compartment may be filled by different tissue components (Fritsch 1994).

Within the following chapter we first present the posterior compartment and then the anterior one. This is in accordance with the viewpoint of the radiologists and with the course of the vessels and nerves. An “extra” middle compartment that is characteristic for the female is presented in detail at the end of this chapter.

What is our common knowledge about the borders of the different pelvic compartments and what do we know about their content?

### 2.1 Posterior Compartment

The borders of the posterior compartment are the skeletal elements of the sacrum and the coccyx dorsally. They are completed by the anococcygeal body (see Table 1) dorsocaudally and by the components of the levator ani muscle laterally and caudally (Fig. 1a). The rectovaginal fascia constitutes an incomplete border ventrocranially. The ventrocaudal border is composed of the perineal body (see Table 1). The only organ of the posterior compartment is the anorectum (see Table 1) (Fig. 1a, b).

### 2.2 Anterior Compartment

The borders of the anterior compartment are the pubic symphysis ventrally, the components of the levator ani muscle laterally (Fig. 1b), and the perineal membrane (see Table 1) caudally. There is no distinct border between the anterior and middle compartment in the female. The contents of the anterior compartment are bladder and urethra (Fig. 1b).


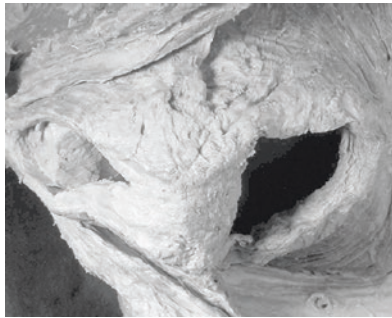
### 2.3 Middle Compartment

The borders are the components of the levator ani muscle laterally and the perineal body caudally (Fig. 1b). No distinct borders can be described ventrally, whereas the rectovaginal fascia/septum constitutes the dorsal border. The middle compartment contains the female genital organs that are arranged in a more or less coronal plane. In more detail the ovaries, uterine tubes, uterus, and vagina are situated in this compartment (Fig. 1a).

### 2.4 Perineal Body

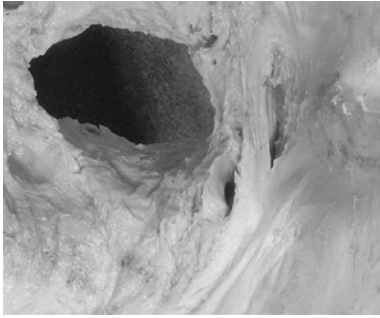
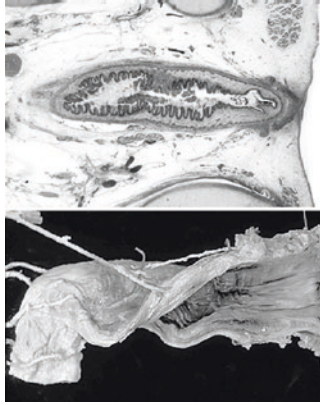
The perineal body is part of the perineum. It is situated between the genital organs and the anus and may be considered as a central or meeting point because a number of different structures join here.


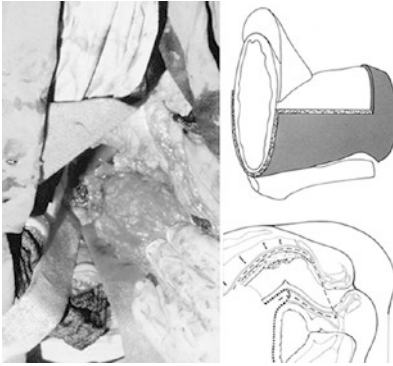
**Table 1** Box of terms and definitions

Term	Figure	Terminologia Anatomica (TA)		Clinical term	Definition	Renaming (according to our results)	Existence
		English	Latin				
1. Anococcygeal body		Anococcygeal body; anococcygeal ligament	Corpus anococcygeum; corpus anococcygeum	-	TA: The term corpus, rather than ligamentum, is used in TA because it is a stratified nonligamentous structure in which fleshy muscle attachments underlie a tendon	Not necessary	+
2. Perineal body		Perineal body	Corpus perineale; centrum perinei	-	TA: The perineal body is fibromuscular rather than tendinous and quite unlike the centrum tendineum of the diaphragm Our opinion: The perineal body itself is tendinous; nevertheless it cannot be compared with the flat centrum tendineum of the diaphragm	Though tendinous, not necessary	+

(continued)

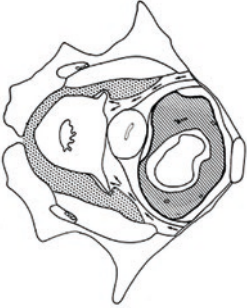

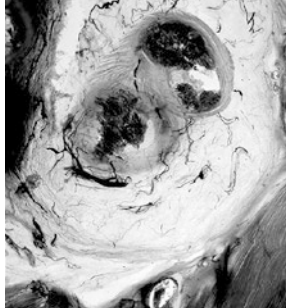
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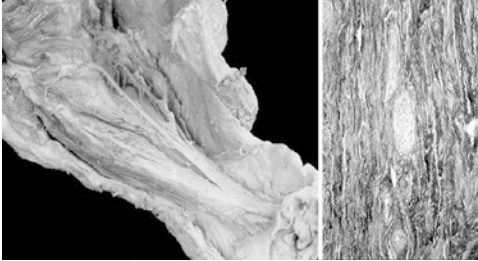
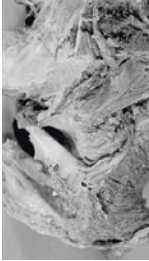
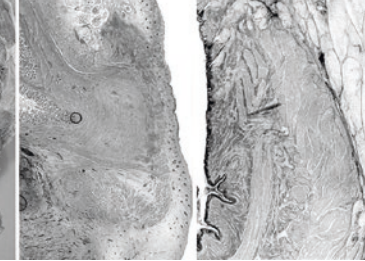
Term	Figure	Terminologia Anatomica (TA)		Clinical term	Definition	Renaming (according to our results)	Existence
		English	Latin				
3. Perineal membrane		Perineal membrane	Membrana perinea	-	Dense connective tissue between external urethral sphincter (and transverse perineal muscle in male) and pubic bone	Not necessary	+
4. Anorectum		Rectum and anal canal	Rectum et canalis analis	Ano rectum	Our option: The clinical term includes both, the rectum and the anal canal, not taking into account that they are of different origin	Necessary to pick up in TA	+

5. Presacral (sub) compartment		-	-	-	Our option: Small space between presacral fascia and sacral and coccygeal vertebrae containing vessels	Necessary to pick up in TA	+
6. Presacral fascia		Presacral fascia	Fascia presacralis	Waldeyer's fascia (?)	Caudal part of the parietal pelvic fascia		+
7. Perirectal compartment		-	-	Mesorectum	Our option: Compartment filled by the rectal adventitia including nerves, vessels, lymph nodes	Necessary to pick up in TA	+

(continued)

Table 1 (continued)

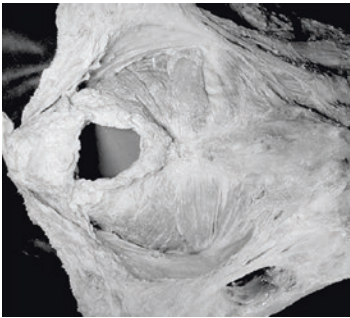

Term	Figure	Terminologia Anatomica (TA)			Clinical term	Definition	Renaming (according to our results)	Existence
		English	Latin					
8. Rectal fascia or "Grenzlamelle"		–	–	Waldeyer's fascia (?)	Our option: Outer connective tissue lamella of the rectal adventitia, bordering the perirectal compartment	Necessary to pick up in TA	+	
9. Inferior hypogastric plexus		Inferior hypogastric plexus; pelvic plexus	Plexus hypogastricus inferior; plexus pelvicus	Pelvic plexus	Autonomic nerve plexus within the rectouterine or recto-vesical fold	Exclusively into the old and clinical term: pelvic plexus	+	
10. Uterosacral ligament		Uterosacral ligament or rectouterine ligament	Li. rectouterinum	–	Dense connective tissue running from the edges of the cervix uteri to the region of the sacrospinous ligament, then ascending and joining the pelvic parietal fascia	Exclusively into the uterosacral ligament	+	



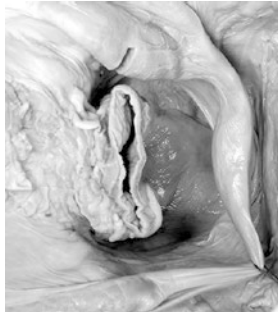
<p>11. Rectovaginal fascia</p>		<p>Rectovaginal fascia; rectovaginal septum (female)</p>	<p>Fascia rectovaginalis; septum rectovaginale</p>	<p>-</p>	<p>Our option: Plate of dense connective tissue, smooth muscle cells and nerves, locally arranged between rectum and vagina</p>	<p>Exclusively into the term rectovaginal/rectogenital septum</p>	<p>+</p>
<p>12. Anal sphincter complex</p>		<p>-</p>	<p>-</p>	<p>Includes all muscle layers of the anal canal: internal (smooth) sphincter, longitudinal (smooth) muscle, external (striated) sphincter</p>	<p>Necessary to pick up in TA</p>	<p>+</p>	
<p>13. Pubovesical ligament</p>		<p>Medial pubovesical ligament, pubovesicalis, lateral pubovesical ligament</p>	<p>Lig. mediale pubovesicale, m. pubovesicalis, lig. Laterale pubovesicalis</p>	<p>-</p>	<p>Most confusing structure! Our option: there is only one structure running from the pubic bone to the vesical neck. It mainly consists of smooth muscle cells intermingled with strands of dense connective tissue</p>	<p>Exclusively into the term pubovesical muscle</p>	<p>+</p>

(continued)




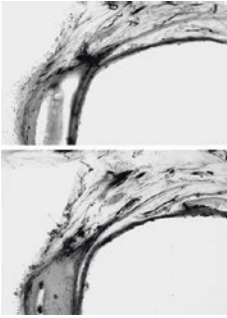
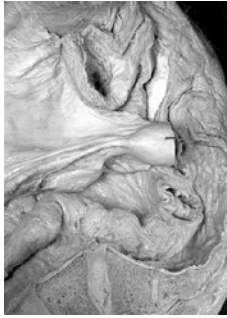
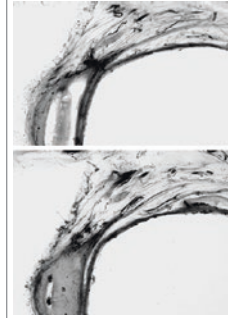

Table 1 (continued)

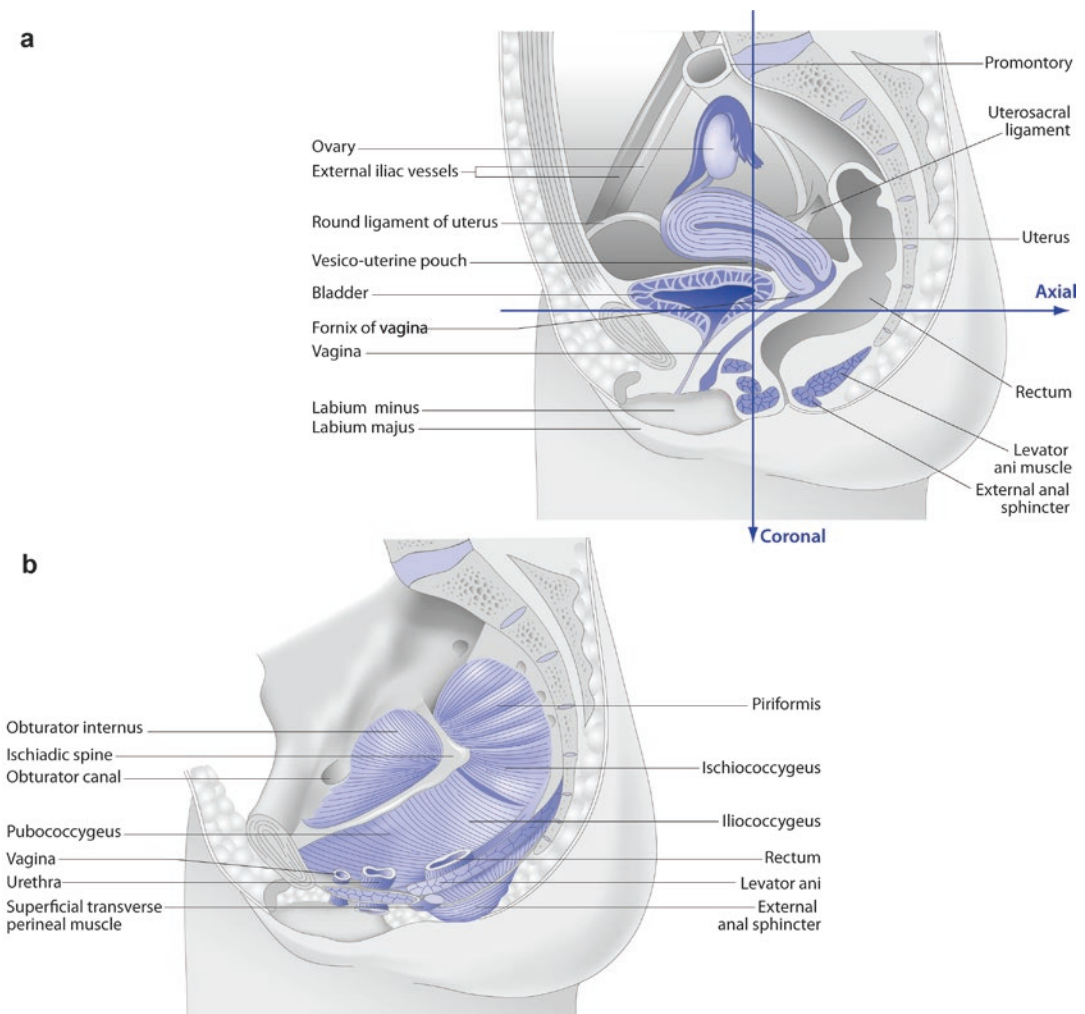
Term	Figure	Terminologia Anatomica (TA)			Clinical term	Definition	Renaming (according to our results)	Existence
		English	Latin					
14. Levator ani muscle		Levator ani	M. levator ani	-	Muscle that constitutes the main part of the pelvic diaphragm and is composed of the Mm. pubococcygeus, iliococcygeus, and puborectalis of each side		+	
15. Tendinous arch of the pelvic fascia		Tendinous arch of the pelvic fascia	Arcus tendineus fasciae pelvis	-	Our option: This structure originates from the pubic bone laterally, it is connected with the superior fascia of the pelvic diaphragm "white line" laterally and with the pubovesical ligament medially. It may falsely be called Lig. laterale puboprostaticum or Lig. laterale pubovesicale		+	

16. Paravisceral fat pad		-	-	-	Our option: Fat pad at the lateral side of the bladder that develops in situ. Functionally necessary for the movements of bladder	Necessary to pick up in TA	+
17. Broad ligament		Broad ligament of the uterus	Lig. latum uteri	-	Peritoneal fold between the uterus and the lateral wall of the pelvis		+
18. Rectouterine fold		Rectouterine fold	Plica rectouterina	-	Peritoneal fold passing from the cervix uteri on each side of the rectum to the posterior pelvic wall		+
19. Rectouterine pouch		Rectouterine pouch	Excavatio rectouterina	Space of Douglas	Deep peritoneal pouch situated between the rectouterine folds of each side		+

(continued)

Table 1 (continued)

Term	Figure	Terminologia Anatomica (TA)			Clinical term	Definition	Renaming (according to our results)	Existence
		English	Latin					
20. Vesico-uterine fold		Vesico-uterine fold	Plica vesicouterina	-	Peritoneal fold between bladder and uterus on each side		+	
21. Vesico-uterine pouch		Vesico-uterine pouch	Excavatio vesicouterina	-	Slight peritoneal pouch between the vesicouterine folds of each side		+	
22. Transverse cervical ligament or cardinal ligament		Transverse cervical ligament, cardinal ligament	Lig. transversum cervicis, lig. Cardinale	Cardinal ligament	Connective tissue structures that should extend from the side of the cervix to the lateral pelvic wall Our option: The cardinal ligament does not exist	Necessary to omit	0	
23. Mesosalpinx		Mesosalpinx	Mesosalpinx	Identical	Double fold of peritoneum at the upper margin of the broad ligament		+	
24. Mesovarium		Mesovarium	Mesovarium	Identical	Double fold of peritoneum attached at the dorsal portion of the broad ligament		+	
25. Mesometrium		Mesometrium	Mesometrium	-	So-called meso of the uterus, greatest portion of broad ligament	According to Höckel is morphogenetic unit of cervix and proximal vagina. Necessary to redefine	+	



**Fig. 1** (a) Female pelvic organs in a sagittal view. (b) Muscles of the pelvic floor

### 3 Compartments

#### 3.1 Posterior Compartment

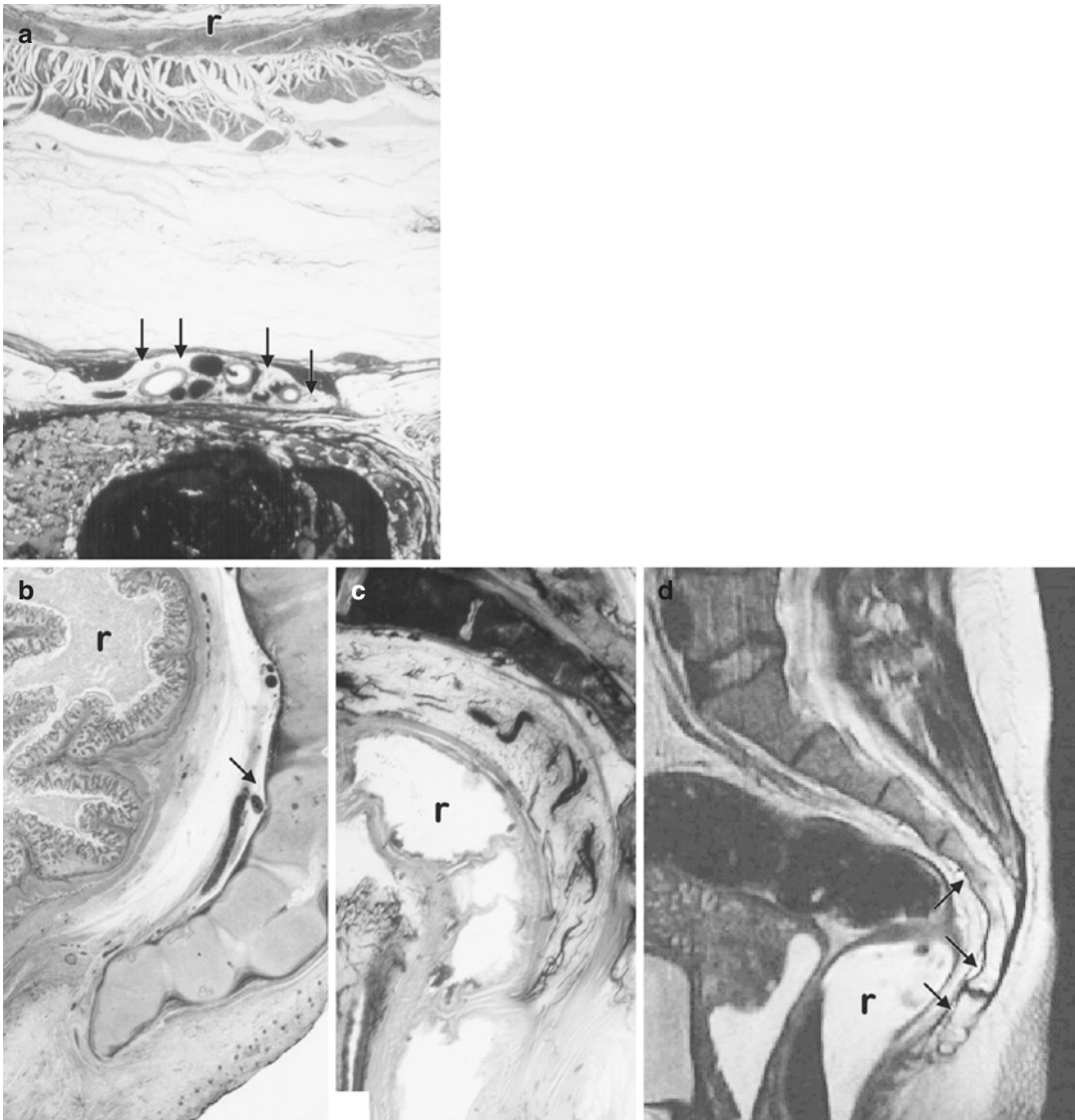
##### 3.1.1 Connective Tissue Structures

In macroscopic dissection of embalmed cadavers it is nearly impossible to distinguish subcompartments within the connective tissue of the posterior compartment. Our comparative study of adult and fetal pelvis shows that two subcompartments can be distinguished within the posterior compartment:

A small presacral subcompartment (see Table 1) is situated in front of the sacrum and

coccyx. It is bordered by the caudal segments of the vertebral column dorsally and ventrolaterally, and it is clearly demarcated by the pelvic parietal fascia (see Table 1) (Fig. 2), which is called presacral fascia (see Table 1) at this position. In fetuses, the presacral subcompartment contains loose connective tissue, but it is predominated by large presacral veins.

The major part of the posterior pelvic compartment is filled by the anorectum and its accompanying tissues, constituting the perirectal subcompartment (see Table 1). This perirectal tissue is identical with the rectal adventitial tissue (Fritsch 1990; Fritsch et al. 2004) (see



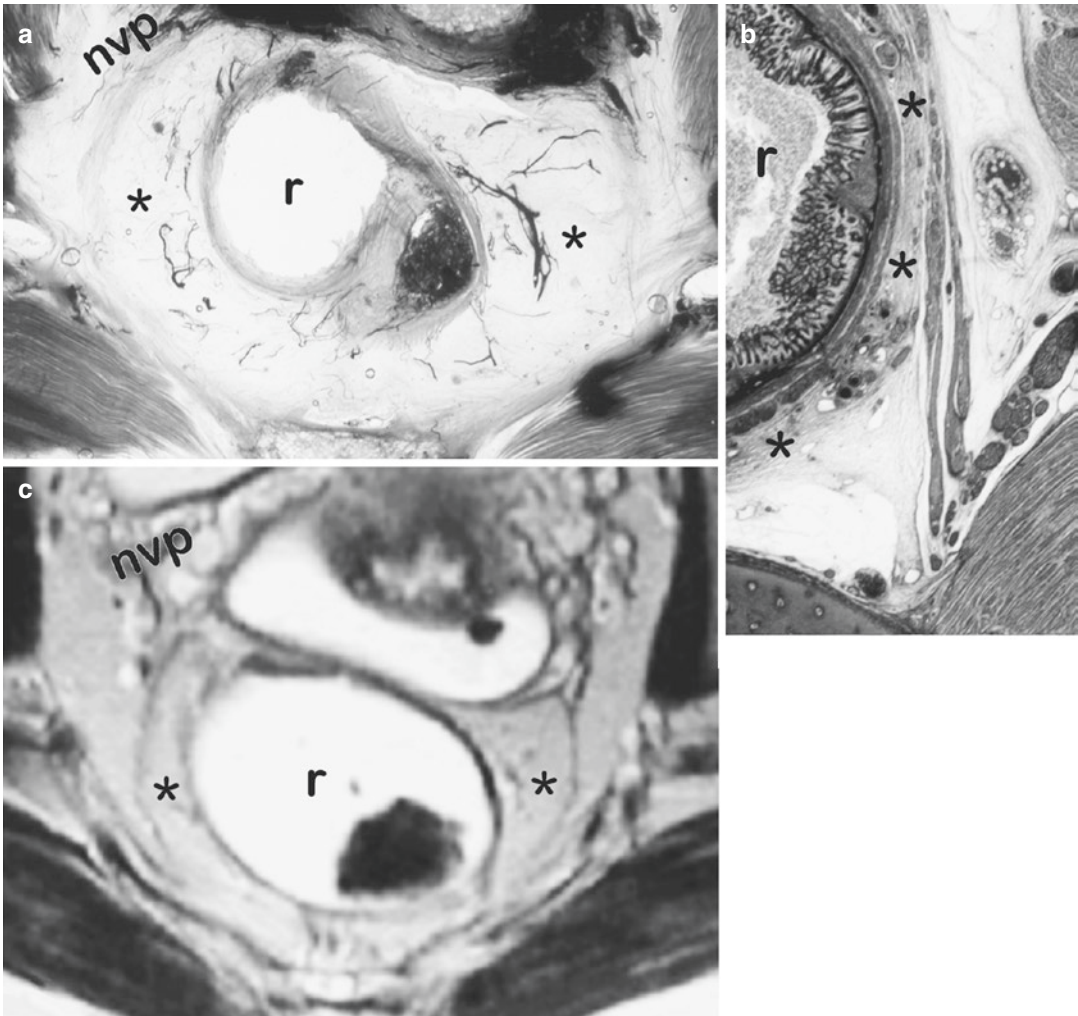
**Fig. 2** Presacral space (arrows). (a) Axial section (500  $\mu\text{m}$ ) of an adult.  $\times 4$ . (b) Sagittal section (400  $\mu\text{m}$ ) of a 24-week-old female fetus.  $\times 9$ . (c) Sagittal section

(5 mm) of an adult female.  $\times 0.45$ . (d) Midsagittal MR image of an adult female. *r* rectum

Table 1), which develops along the superior rectal vessels. In the adult, it mainly consists of adipose tissue subdivided by several connective tissue septa (Fig. 3a, b). Within this perirectal tissue the supplying structures of the rectum are enclosed: the superior rectal vessels, stems and branches, branches of the variable medial rectal vessels, rectal nerves and rectal lymphatics, vessels, and nerves. The localization of these lymphatic nodes is strikingly different from

that of the other lymph nodes of the posterior compartment that are situated laterally in the neighborhood of the iliac vessels (Nobis 1988; Stelzner 1998).

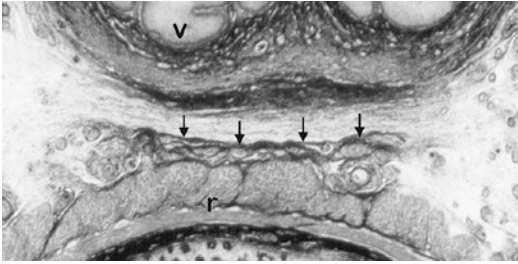
The rectal adventitia develops from a layer of condensed mesenchymal tissue, which—later on—forms a dense connective tissue in fetuses (Fig. 3c). In the newborn child it is remodeled by small fat lobules occurring between the connective tissue lamellae. The outer lamella covers the



**Fig. 3** Perirectal tissue (*asterisks*). (a) Axial section (5 mm) of an adult female.  $\times 0.45$ . (b) Axial MR image of an adult female. (c) Axial section (400  $\mu\text{m}$ ) of a 24-week old female fetus.  $\times 5$ . *nvp* nerve vessel plate, *r* rectum

perirectal subcompartment and is called “rectal fascia” (Fritsch 1990; Fritsch et al. 1996) or “Grenzlamelle” (Stelzner 1989, 1998) (see Table 1). It constitutes the morphological border of the perirectal subcompartment. The craniocaudal extent of the perirectal subcompartment depends on the branching pattern of the superior rectal vessels; thus the perirectal compartment is broad laterally and dorsally and it is often rather thin ventrally where it is only composed of some connective tissue lamellae. As can be seen in sagittal sections the extent of the perirectal subcompartment decreases in size in a craniocaudal direction (Fig. 2c).

What is situated outside the rectal fascia and therefore outside the perirectal subcompartment? Dorsally, the presacral subcompartment is loosely attached to the perirectal compartment (see above). Laterally the supplying structures (autonomic nerves and branches of the iliac vessels) of the urogenital organs constitute a nerve-vessel plate (Fig. 3c). The latter is accompanied by connective tissue and fills the remaining space between the perirectal compartment and the lateral pelvic wall. In the female, the nerves of the inferior hypogastric plexus (see Table 1) are attached to the uterosacral ligament (see Table 1) that is directly situated between the rectal fascia



**Fig. 4** Rectovaginal fascia (*arrows*). Axial section (400  $\mu\text{m}$ ) of a 24-week-old female fetus.  $\times 28$ . *v* vagina, *r* rectum

and the inferior hypogastric plexus (Fig. 3a, c) (Fritsch 1992).

The ventral border of the perirectal compartment represents the border between posterior and middle compartment. It differs in a craniocaudal direction, i.e., to the peritoneum of the rectouterine pouch at a level with the cervix uteri and the fornix vaginae and to the posterior wall of the vagina more caudally. As we have recently shown (Aigner et al. 2004; Fritsch et al. 2004; Ludwikowski et al. 2002) a two-layered rectovaginal fascia/septum (see Table 1) develops in the female and is identical to the male's rectoprostatic fascia/septum or Denonvilliers' fascia (Tobin and Benjamin 1945). At a level with the anorectal flexure, additional bundles of longitudinal smooth muscles are situated at the anterior rectal wall forming the muscular portion of the rectovaginal fascia ventrally (Fig. 4). The smooth muscle bundles are accompanied by nerves, some of them crossing the midline, and they are connected to the smooth muscle layer of the rectal wall. Caudally these additional smooth muscle bundles are attached to the connective tissue of the perineal body (Fig. 4).

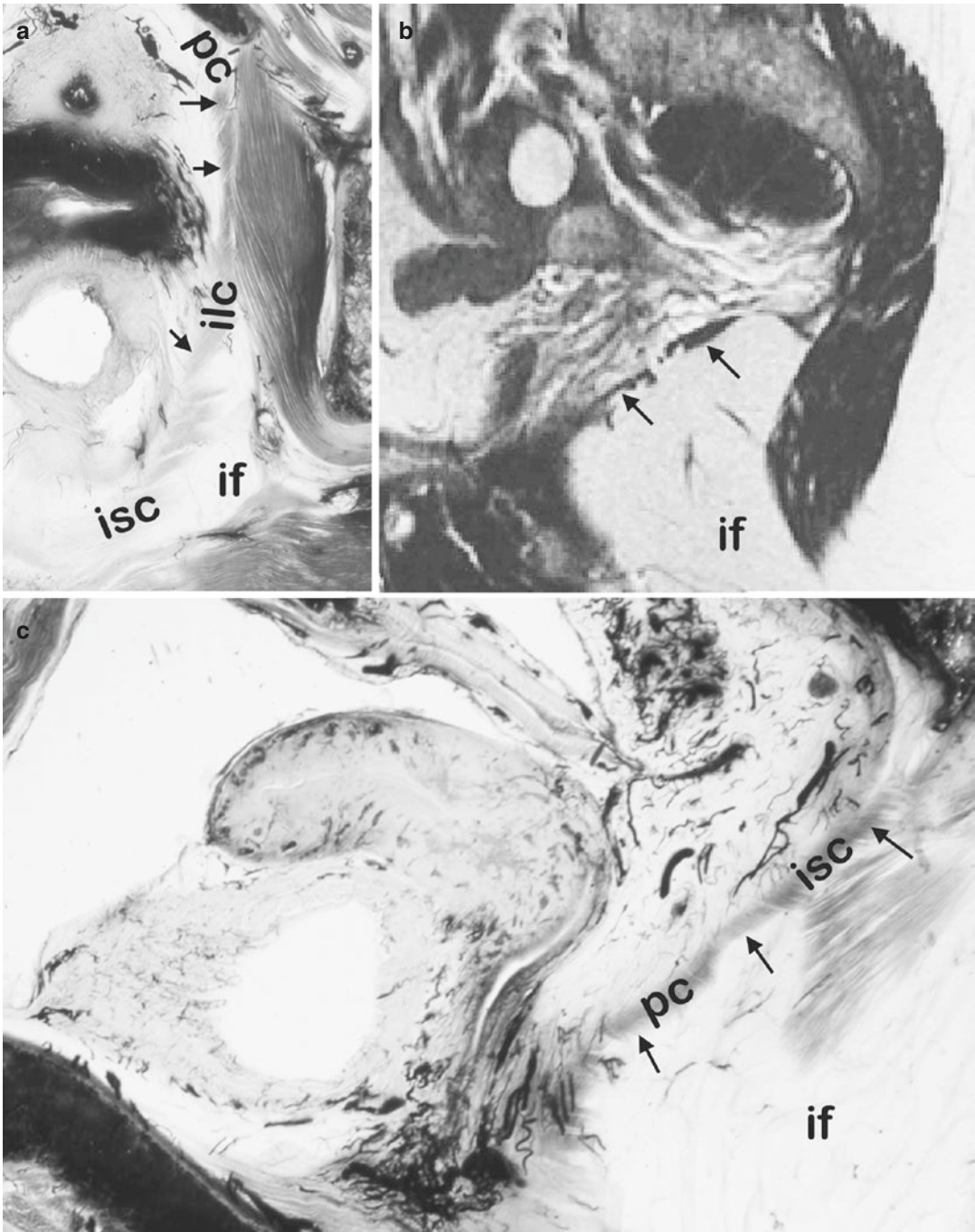
### 3.1.2 Muscles

Within the posterior pelvic compartment all components of the levator ani muscle are to be found: the pubococcygeus muscles and the iliococcygeus muscles constitute an irregular plate and insert into the coccyx where they overlap each other in a staggered arrangement (Fig. 5). The

inferior component, the puborectalis muscles, does not insert into any skeletal structure. Behind the rectal wall the fiber bundles of each puborectalis muscle crisscross, thus constituting a muscular sling around the anorectal flexure (Fig. 6). In the craniocaudal direction the pubococcygeus muscle and the puborectalis muscle are more or less continuous. In sectional anatomy they can be differentiated by the different directions of their fiber bundles, those of the pubococcygeus taking a slightly descending course, and those of the puborectalis exclusively situated in the horizontal plane. The different components of the levator ani muscle can already be distinguished in early fetal life (Fritsch and Fröhlich 1994). Sexual differences found in the levator ani muscle of the adult are already marked in late fetal life: the levator ani constitutes a thick and well-developed muscle in the male fetus whereas it is thinner and already intermingled with connective tissue in the female fetus (Fig. 6b). This is particularly true of its puborectalis portion.

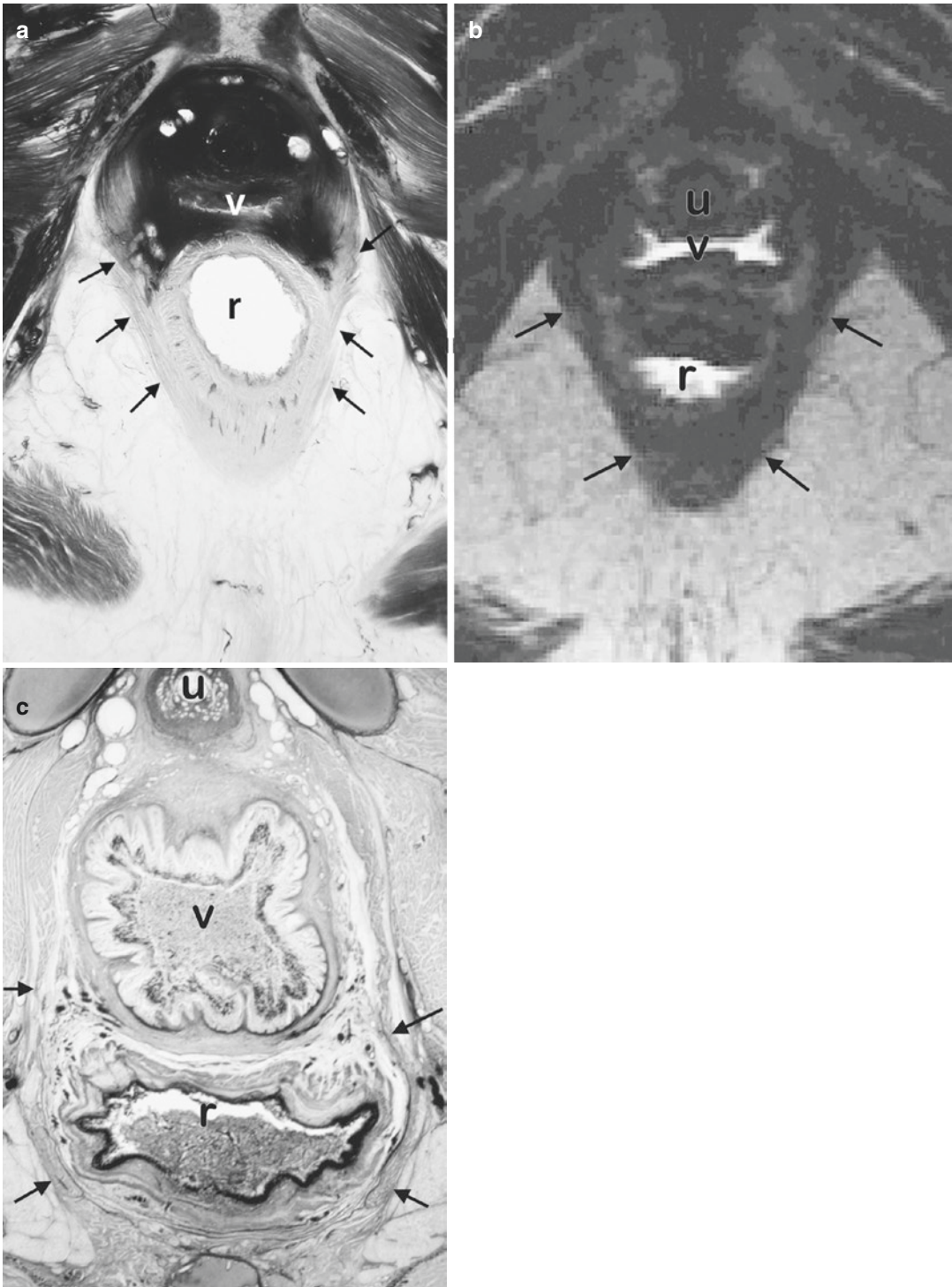
The puborectalis muscle is continuous with the external anal sphincter caudally (Fig. 7). The macroscopic distinction between both muscles is provided by the anococcygeal body. The puborectalis has no skeletal attachment dorsally, but the deep portion of the sphincter ani externus is indirectly fastened to the coccyx by the anococcygeal body.

The sphincter ani externus is the outer part of the anal sphincter complex (see Table 1). The other components are the smooth internal sphincter and the longitudinal muscle layer of the anorectum; the latter is interposed between the sphincters. Whereas macroscopically the external anal sphincter presents itself as a continuous sheet covering the anal canal (Fig. 8a), it can be subdivided into a deep, anorectal portion and a superficial, subcutaneous portion in sectional anatomy (see Fig. 8b). This deep portion is a clearly demarcated layer of circularly arranged striated muscle fibers; the superficial portion is characterized by an intermingling of the striated muscle fibers with the smooth longitudinal muscle (also called "intersphincteric



**Fig. 5** Levator ani muscle (*arrows*). (a) Axial section (5 mm) of an adult female.  $\times 0.6$ . (b) Parasagittal MR image of an adult female. (c) Sagittal section (5 mm) of an adult female.  $\times 1.0$ . *isc* ischiococcygeal muscle, *if* ischioanal fossa, *ilc* iliococcygeal muscle, *pc* pubococcygeal muscle





**Fig. 6** Puborectalis muscle (*arrows*). (a) Axial section (5 mm) of an adult female.  $\times 0.8$ . (b) Axial MR image of an adult female. (c) Axial section (400  $\mu\text{m}$ ) of a female newborn specimen.  $\times 4$ . *u* urethra, *v* vagina, *r* rectum