



Pelvik Tabanın Biyomekanik Değerlendirilmesi İnkontinans Cerrahisi Algoritmasını Değiştirir mi?

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Kadın Hastalıkları ve Doğum
Anabilimdalı

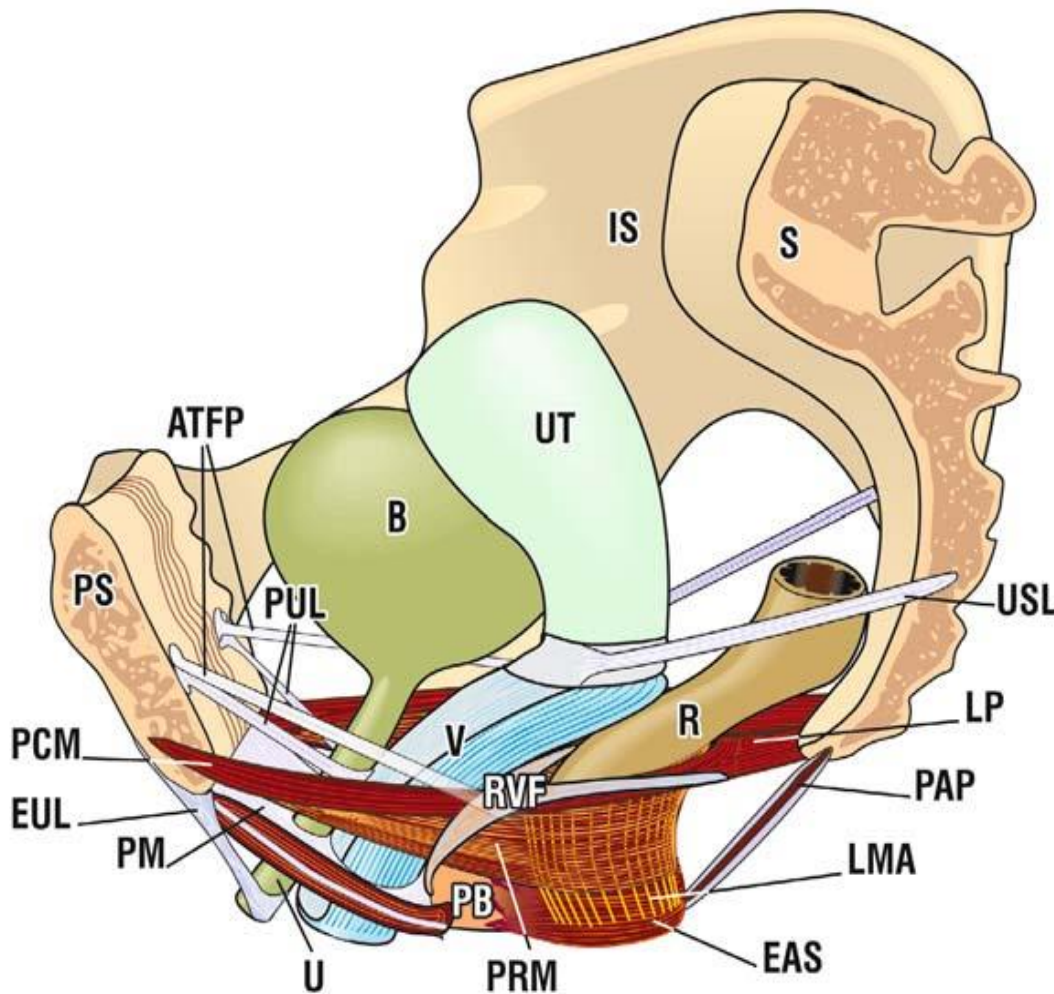


Figure 1. Anatomy of the female pelvic floor with basic organs, muscle and ligaments.

Kemikler:

PS - pubic symphysis

S - sacrum

Organlar:

B - bladder

UT - uterus

V - vagina

R - rectum

Kaslar:

PCM - pubococcygeus muscle

PRM - puborectalis muscle

PB - perineal body

LP - levator plate

LMA - longitudinal muscle of the anus

EAS - external anal sphincter

Bağlar:

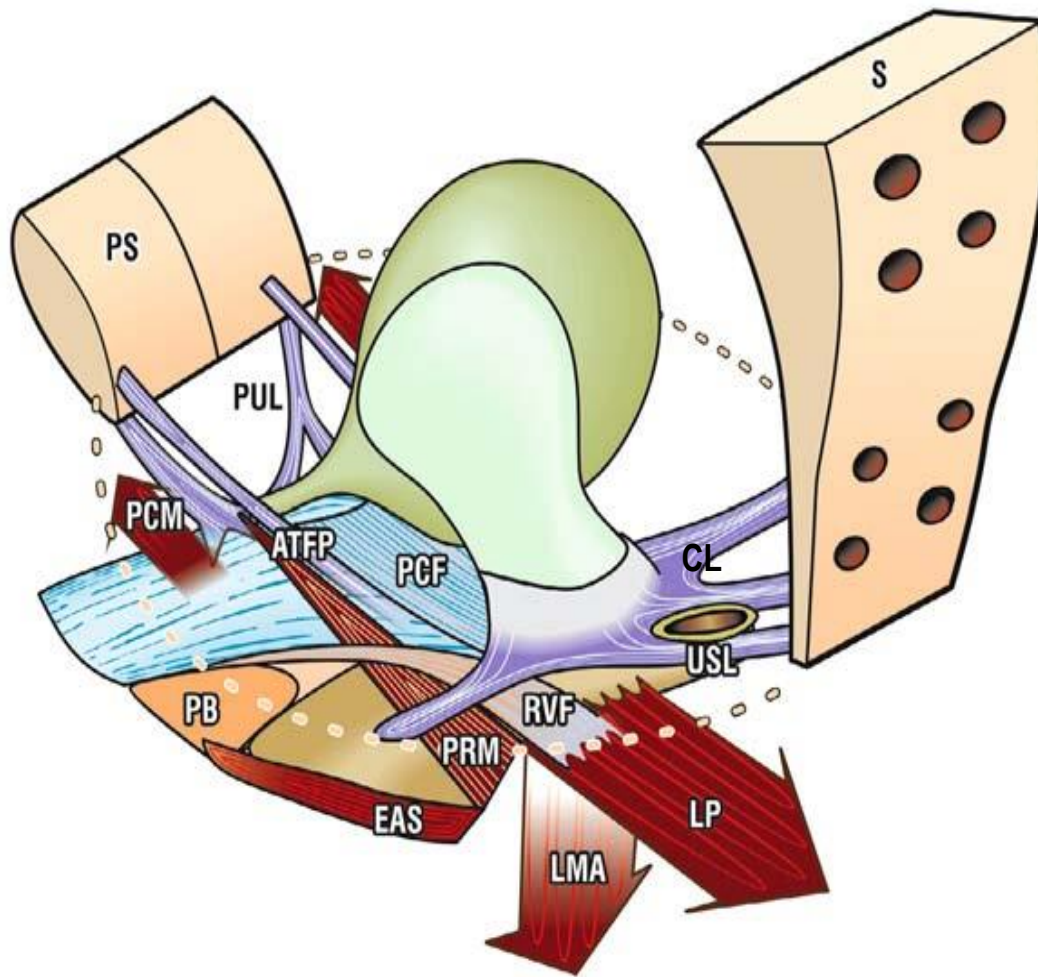
PUL - pubourethral ligament

ATFP - arcus tendineus fascia pelvis

USL - uterosacral ligament

CL - cardinal ligament (not shown)

RVEF - rectovaginal facia



Kemikler:

PS - pubic symphysis

S - sacrum

Kaslar:

PCM - pubococcygeus muscle

PRM - puborectalis muscle

LP - levator plate

LMA - longitudinal muscle of the anus

Bağlar:

PUL - pubourethral ligament

ATFP - arcus tendineus fascia pelvis

USL - uterosacral ligament

CL - cardinal ligament

RVF - rectovaginal fascia

Figure 2. Functional anatomy of the female pelvic floor with basic muscle and ligaments.

Ön Kompartman

(External urethral meatus-Bladder neck)

- 1.External urethral ligament
- 2.Suburethral hammock
- 3.Pubourethral ligament

Orta Kompartman

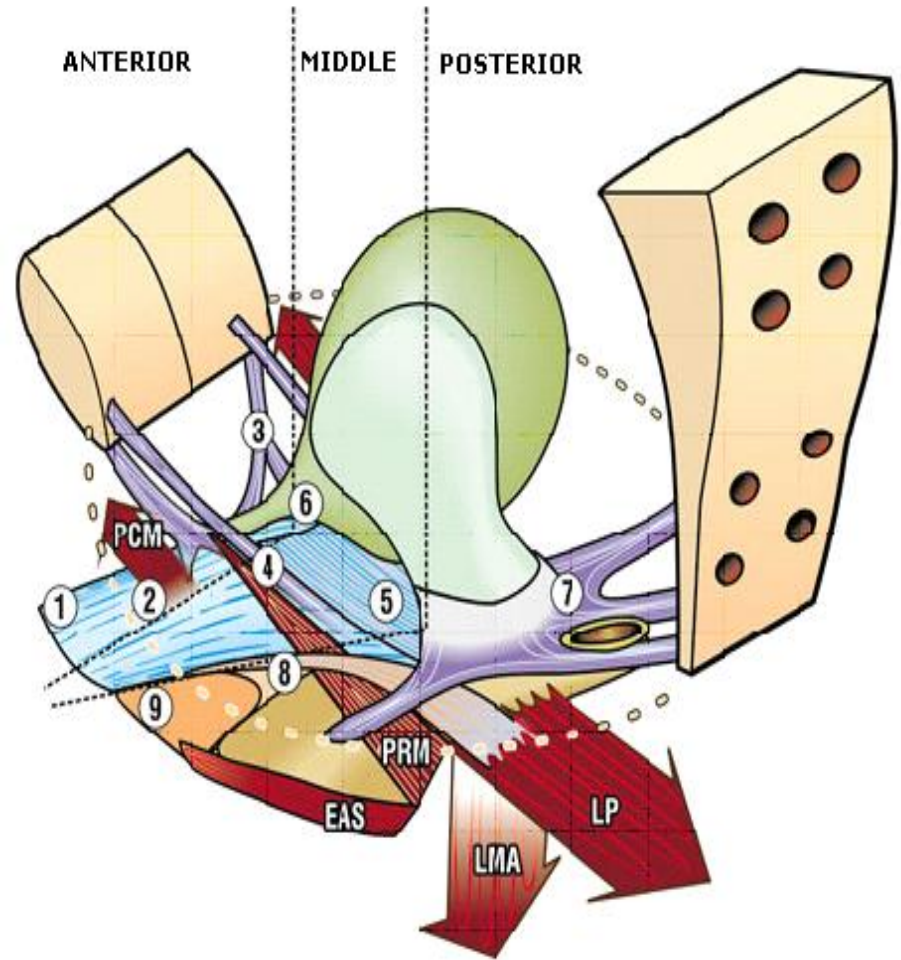
(BN-Cervix/hysterectomy scar)

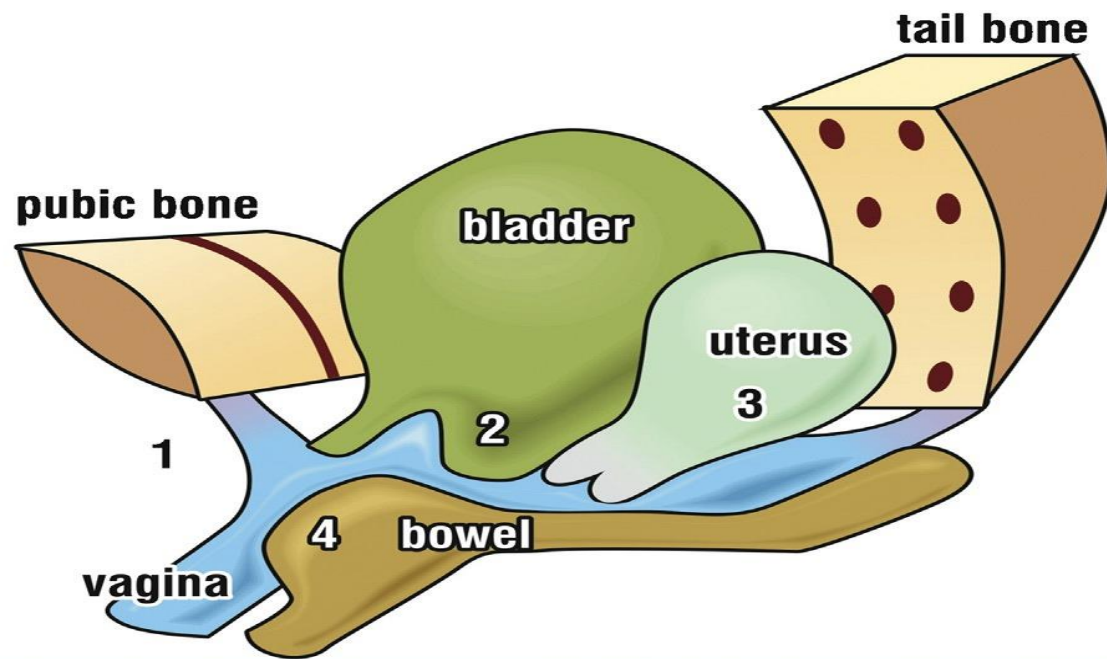
- 4.ATFP
- 5.Pubocervical fasya defekti
- 6.Critic elastikiyet alanı

Arka Kompartman

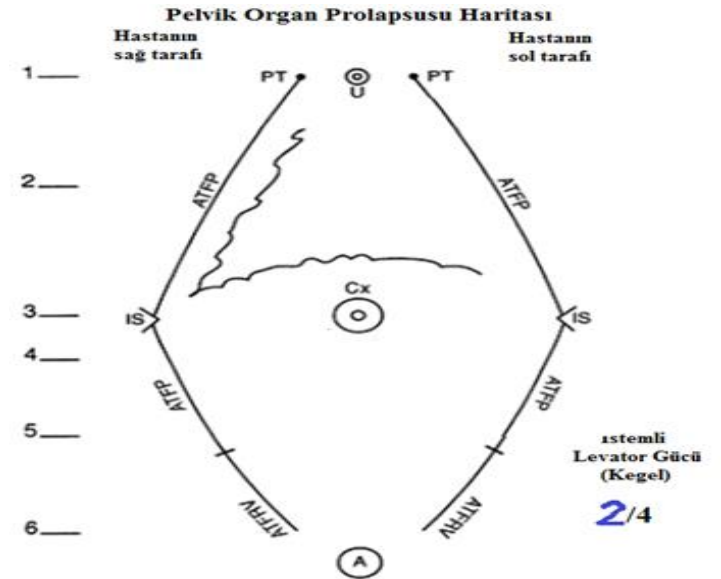
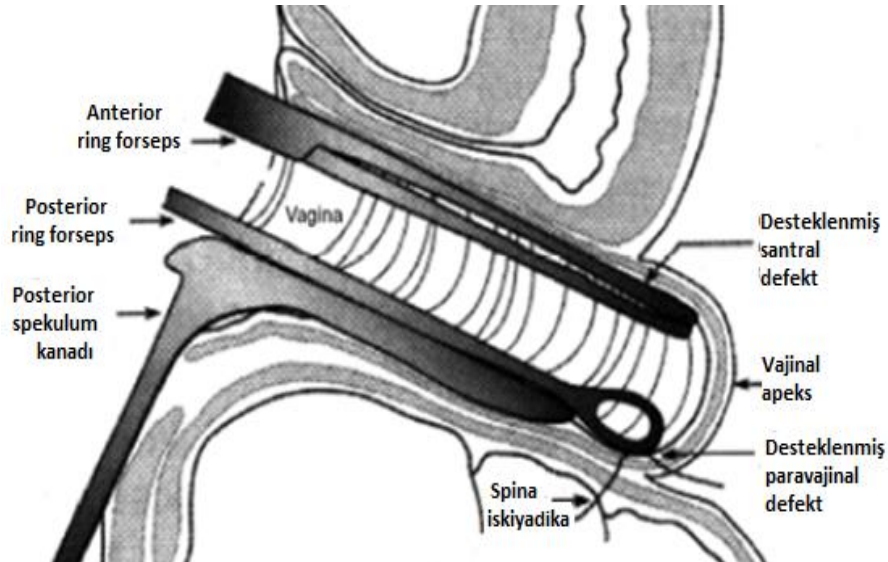
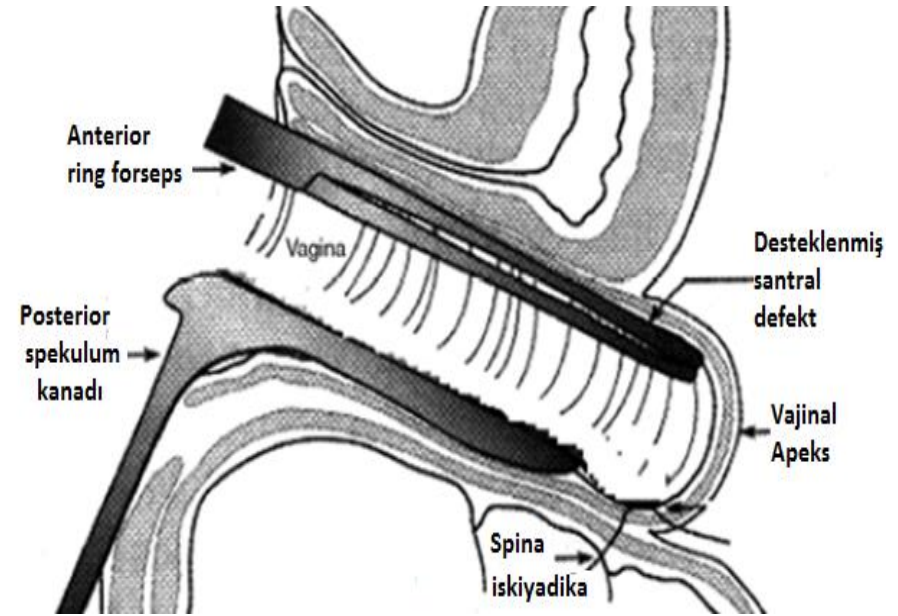
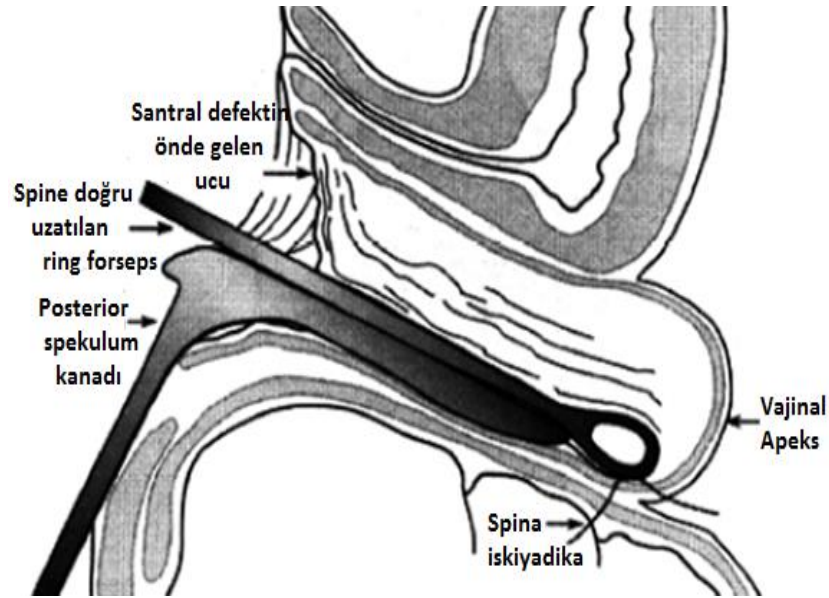
(C/HS-Perineal cisim)

- 7.Uterosakral Lig. Defekti
- 8.Retovajinal Fasya Defekti
- 9.Perineal Cisim





Ön Bağlar	Orta Bağlar ve Sistosel	Arka Bağlar, Uterus Prolapsusu Rektosel
<i>Stress incontinence</i>		
	<i>abnormal emptying</i>	
	<i>frequency and urgency</i>	
		<i>nocturia</i>
<i>faecal incontinence</i>		<i>faecal incontinence</i> <i>obstructed defecation</i>
		<i>pelvic pain</i>



Pelvik Taban USG Endikasyonları

- Tekrarlayan üriner sistem enfeksiyonları
- İşeme disfonksiyonu semptomları
- Ani işeme hissi, sık idrar çıkma, noktüri ve/veya ani işeme hisli incontinans
- SUI
- Persistan disüri
- Prolaps semptomları

- Obstrükte defekasyon semptomları (İkinma ile dışklama, kronik konstipasyon, vajinal veya perineal parmakla dışkılama ve yeterince barsakları boşaltamama hissi)
- Fekal inkontinans
- Antiinkontinans veya prolaps cerrahisinden sonra hasta takibi

Pelvik Organ Prolapsus Değerlendirmesinde Pelvik Taban Ultrasonografisi



Transperineal ultrasonda
“anormal” nedir ?

- Symphysis pubis (SP)

Sistotel: ≥ 10 mm

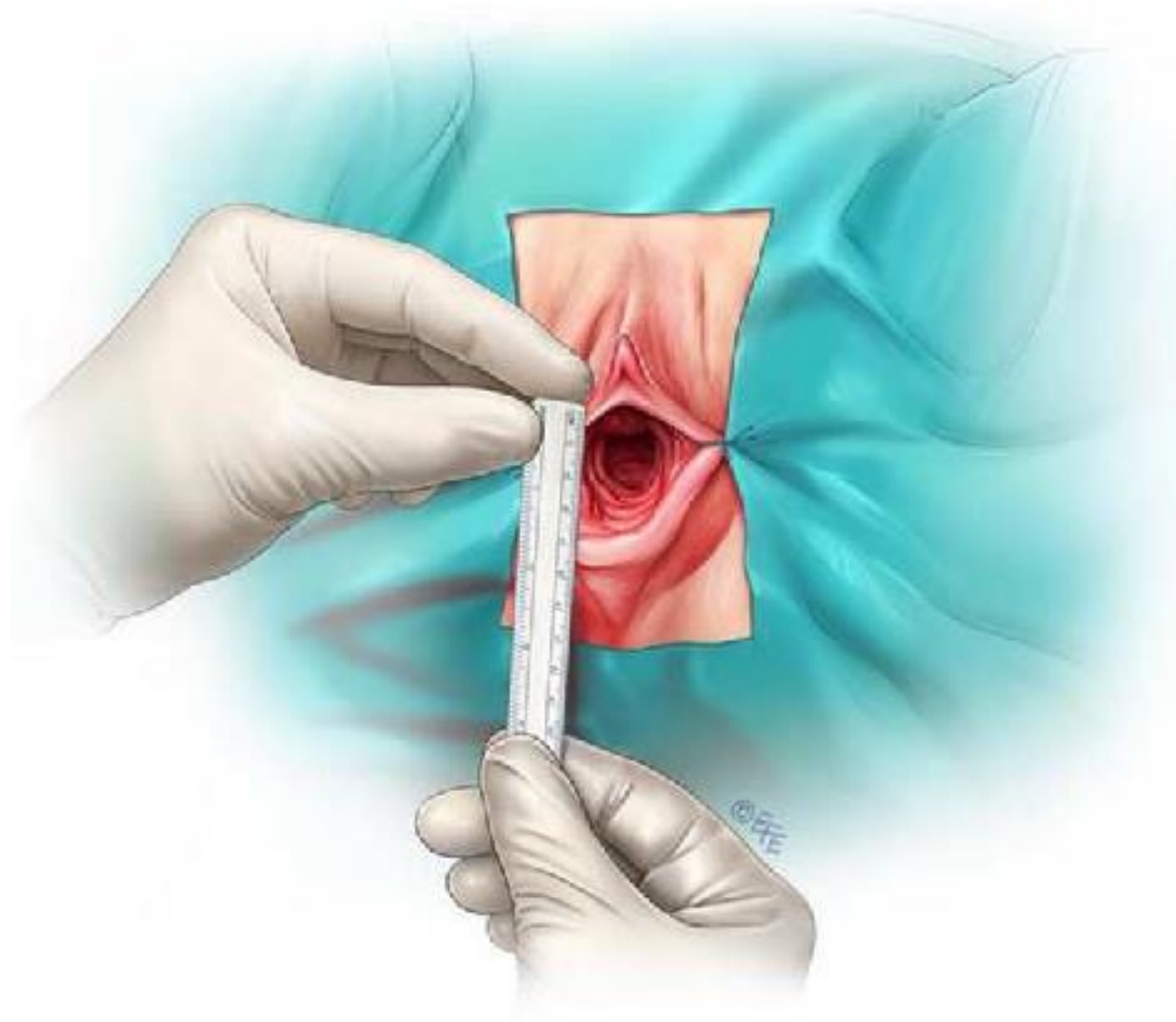
Uterin prolapsus: ≥ 15 mm

Rektotel: ≥ 15 mm

Shek, K. L., & Dietz, H. P. (2015).
What is abnormal uterine descent
on Translabial ultrasound?.

Levator hiatus: Genital hiatus (Gh) + Perineal body (Pb)

- Hiatal açıklık ~ semptomatik prolapsus ile asemptomatik kadınlar ~ cut-off: 7cm (AUC: 0.89 CI 0.854-0.925)
- Hiatal açıklık ~ semptomatik prolapsus ile asemptomatik kadınlar ~ cut-off: 25 cm² (AUC: 0.71 CI 0.66-0.76)



Tanımlar

Dokunsal Görüntüleme (Tactile Imaging) Dokunmayı tıbbi görüntüye çeviren bir sistem. $P(x,y,z)$, belirtilen koordinatlardaki dokunun değişikliğine bağlı oluşan basınç veya direnç durumunun görüntü haritalandırmasına dönüştürülmesi.

Fonksiyonel Dokunsal Görüntüleme (Functional Tactile Imaging) translates muscle activity into dynamic pressure pattern $P(x,y,t)$ ilgilenilen x,y koordinatlarında t zamanında aktif kas hareketlerinin dynamic basınç çizelgesine dönüştürülmesi :

- İstemli kas kasılmaları,
- İstemsiz reflex kasılmalar,
- İstemsiz gevşemeler,
- İstenilen manevralara göre tepkiler.

Biyomekanik Haritalama = Dokunsal ve Fonksiyonel Dokunsal Görüntüleme

Tanımlar

Biomekanik Haritalandırma

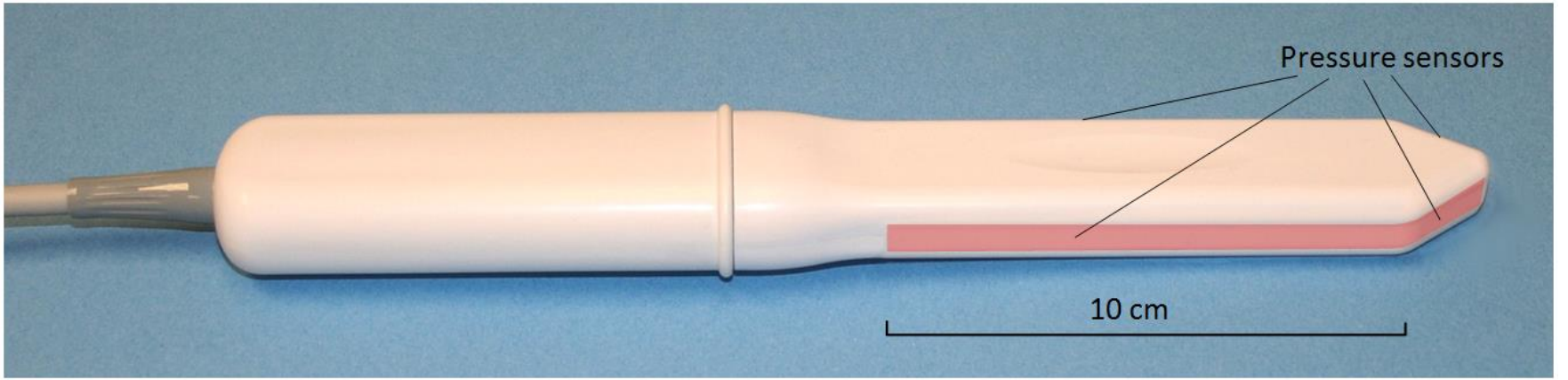
Dokunsal Görüntüleme

- Doku elastikiyeti dağılımı
- Anatomik özellikler
- Vajinal sıkılık
- Pelvik desteğin durumu

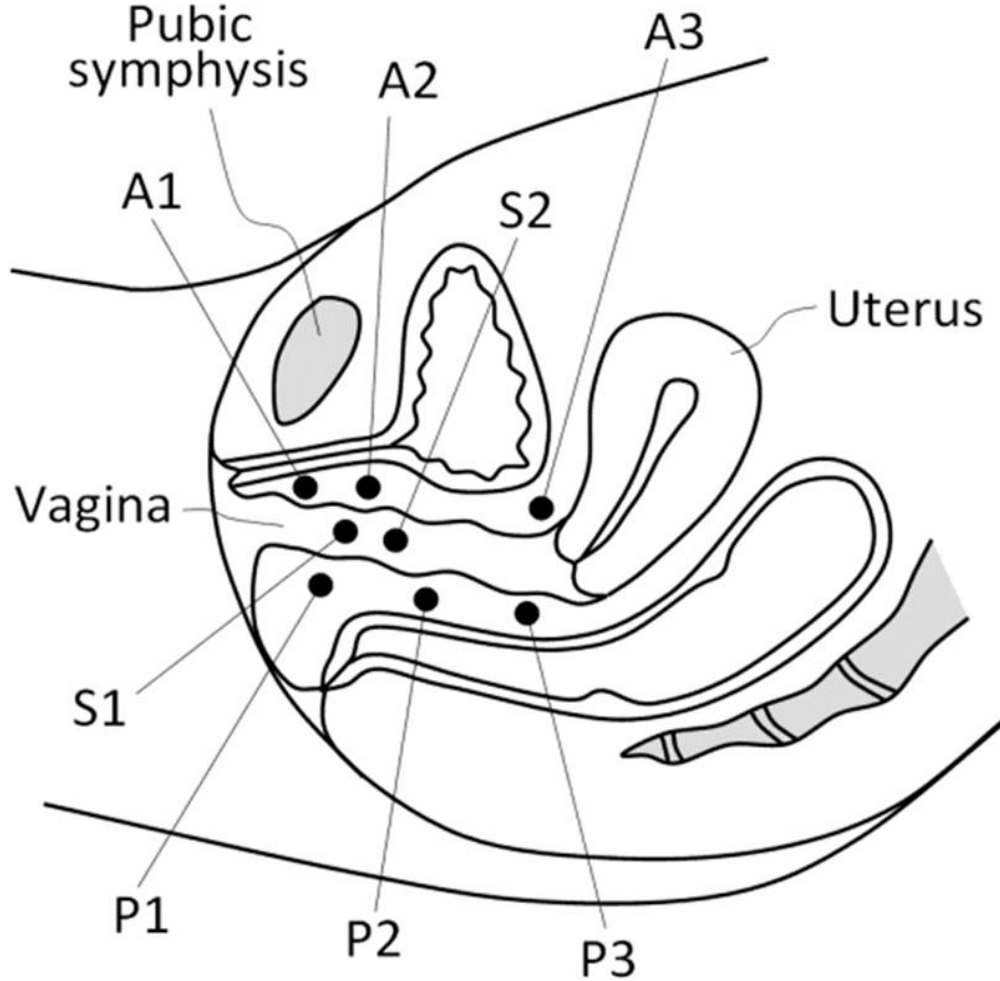
Fonksiyonel Dokunsal Görüntüleme

- Pelvik kas kontraksiyon gücü
- Kasların anatomic özellikleri
- Yapıların hareketliliği
- İstemsiz kas gevşemeleri

Dokunsal Görüntüleme Probu



Probun dış kısmında basınç algılayıcılar dizilmiş.

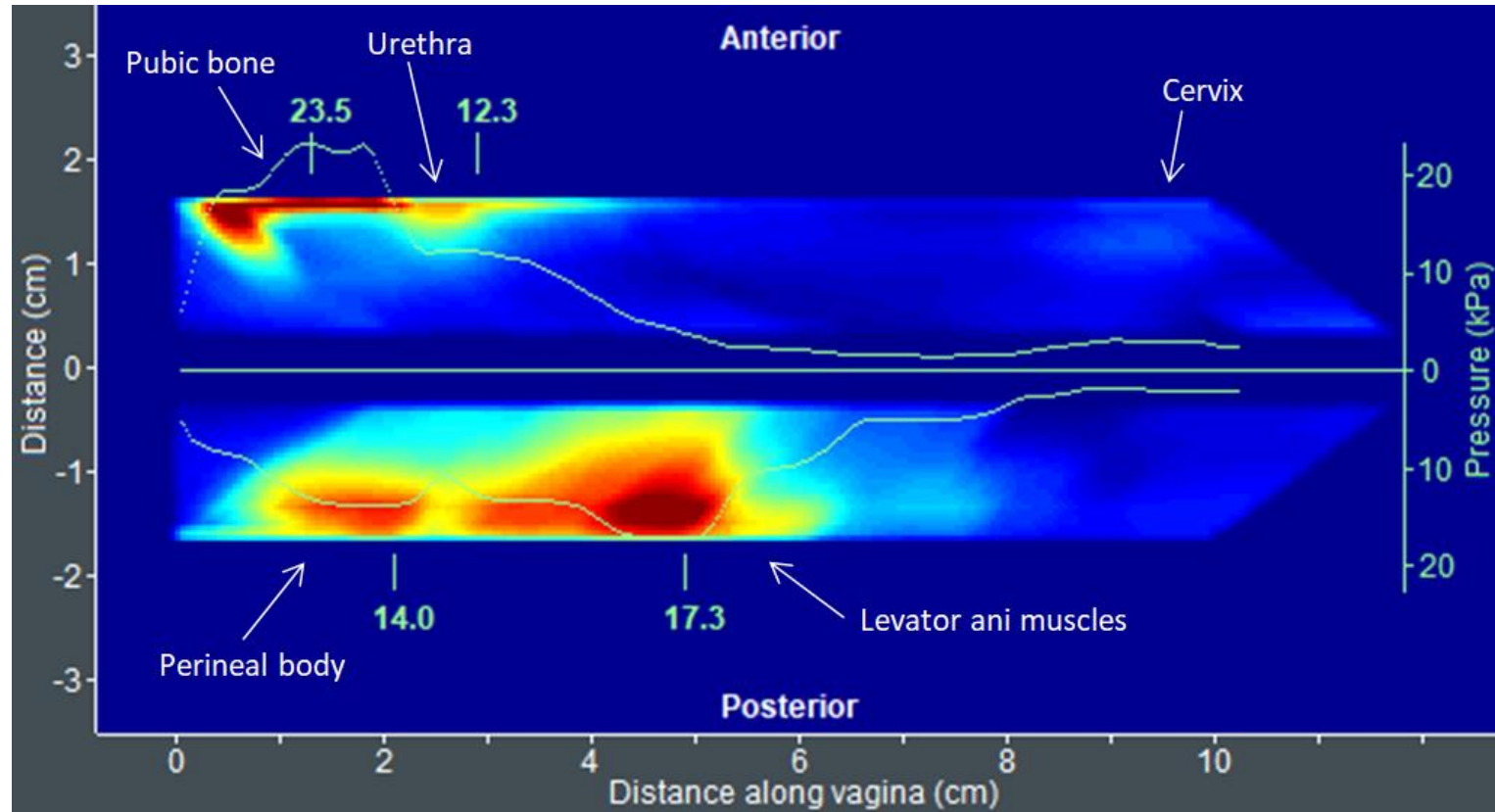


Ölçülebilen VTI parametrelerinin pelvik tabanda dağılımı.

A1-A3 ön kompartmanda (Test 2), P1-P3 arka kompartmanda (Test 2), ve S1, S2 yan kompartmanlarda (sol ve sağ taraflar, Test 3).

Test 1: Proben yerleştirilmesi

Allows Vajen ön ve arka bölmelerinin vajen boyunca görüntülenmesini sağlar. (Doku elastisitesini gösterir)



Test 1 de elde edilen maksimum basınç çizgisi (kPa) ve anatomic önemlinoktalar

Test 1: VTI ile vajinal doku elastisitesinin ölçümü

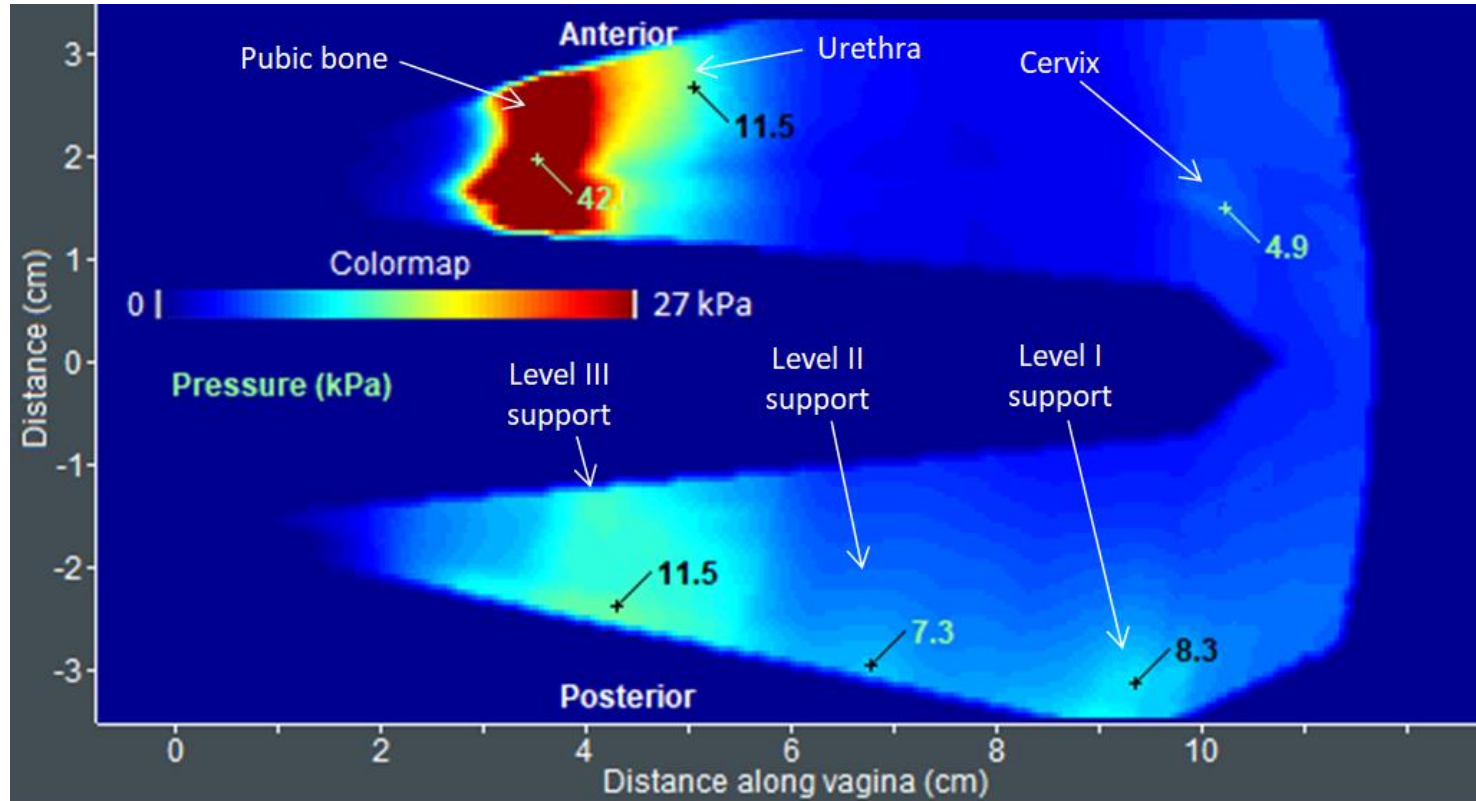
Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Structure
Fmax	N	Maximum value of force measured during the VTI probe insertion	Maximum resistance of anterior vs posterior widening; tissue elasticity at specified location (capability to resist to applied deformation)	Belirli noktalarda maksimum vajinal doku elastisitesi	Tissues behind the anterior and posterior vaginal walls at 3-15 mm depth
Work	mJ	Work completed during the probe insertion (Work = Force × Displacement)	Integral resistance of vaginal tissue (anterior and posterior) along the probe insertion	Ortalama vajinal doku elastisitesi	Tissues behind the anterior and posterior vaginal walls at 3-15 mm depth
Gmax_a	kPa/mm	Maximum value of anterior gradient (change of pressure per anterior wall displacement in orthogonal direction to the vaginal channel)	Maximum value of tissue elasticity in anterior compartment behind the vaginal at specified location	Ön vajenin maksimum elastisitesi	Tissues/structures in anterior compartment at 10-15 mm depth

Test 1: Biomechanical parameters provided by the VTI to characterize vaginal tissue elasticity

Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Struct
Gmax_p	kPa/m m	Maximum value of posterior gradient (change of pressure per posterior wall displacement in orthogonal direction to the vaginal channel)	Maximum value of tissue elasticity in posterior compartment behind the vaginal at specified location	Arka vajan dokusunun maksimum elastisitesi	Tissues/structures in anterior compartment at 10-15 mm depth
Pmax_a	kPa	Maximum value of pressure per anterior wall along the vagina	Maximum resistance of anterior tissue to vaginal wall deformation	Ön doku elastisitesi	Tissues/structures in anterior compartment
Pmax_p	kPa	Maximum value of pressure per posterior wall along the vagina	Maximum resistance of posterior tissue to vaginal wall deformation	Arka doku elastisitesi	Tissues/structures in posterior compartment

Test 2: Proben ön arka kompartmanlara basınç yapacak şekilde yer değiştirmesi

Pelvik tabanın destek yapılarına yönelik yapılan dokunsal görüntülemelerde basınç değerleri ve belirli noktalarda basınç farkları



A tactile image acquired during the VTI probe elevation (Test 2) with anatomical landmarks and pressure values at specified locations (see A1-A3 and P1-P3 in Figure 2) along anterior and posterior compartments. The VTI software automatically identified all these 6 locations and shows the pressure values and gradient values (not shown) for these locations.

Test 2: Pelvik destek yapılarının biyomekanik ölçümleri

Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Structure
P1max_a	kPa	Maximum pressure at the area of pubic bone (anterior, A1 in Figure 2)	Proximity of pubic bone to vaginal wall and perineal body strength	Anatomic aspects and tissue elasticity	Önde vajen ve pubik kemik arası doku ve arkada perineal cisim
P2max_a	kPa	Maximum pressure at the area of urethra (anterior, A2 in Figure 2)	Elasticity/mobility of urethra	and tissue elasticity Anatomic aspects	Üretra ve çevresi dokular
P3max_a	kPa	Maximum pressure at the cervix area (anterior, A3 in Figure 2)	Mobility of uterus and conditions of uterosacral and cardinal ligaments	Pelvic floor support	Kardinal ve uterosakral ligamanlar
P1max_p	kPa	Maximum pressure at the perineal body (posterior, see P1 in Figure 2)	Pressure feedback of Level III support	Pelvic floor support	Puboperineal ve puborektal kaslar

Test 2: Pelvik destek yapılarının biyomekanik ölçümleri

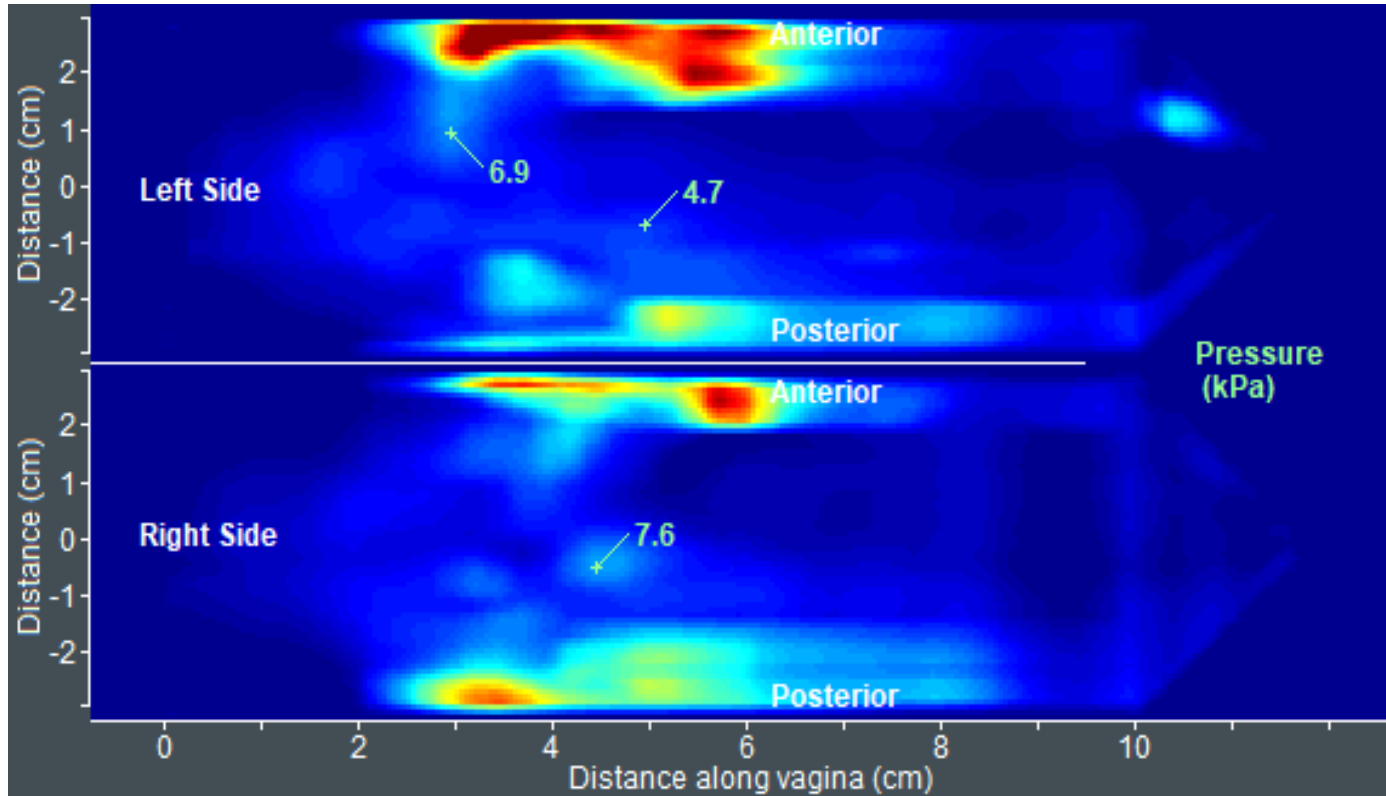
Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Structure
P2max_p	kPa	Maximum pressure at middle third of vagina (posterior, see P2 in Figure 4)	Pressure feedback of Level II support	Pelvic floor support	Pubovajinal, puboanal kaslar
P3max_p	kPa	Maximum pressure at upper third of vagina (posterior, see P3 in Figure 4)	Pressure feedback of Level I support	Pelvic floor support	İliokoksigeal kas ve levator plağı
G1max_a	kPa/mm	Maximum gradient at the area of pubic bone (anterior, see A1 in Figure 4)	Vaginal elasticity at pubic bone area	Anterior tissue elasticity	Ön pubik kemik altı vajen dokusu
G2max_a	kPa/mm	Maximum gradient at the area of urethra (anterior, see A2 in Figure 4)	Mobility and elasticity of urethra	Urethral tissue elasticity	Üretra ve çevre dokular

Test 2: Pelvik destek yapılarının biyomekanik ölçümleri

Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Struct
G3max_a	kPa/mm	Maximum gradient at the cervix area (anterior, see A3 in Figure 2)	Conditions of uterosacral and cardinal ligaments	Pelvic floor support	Uterosakral ve kardinal ligamanlar
G1max_p	kPa/mm	Maximum gradient at the perineal body (posterior, see P1 in Figure 2)	Strength of Level III support (tissue deformation up to 25 mm)	Pelvic floor support	Puboperineal ve puborektal kaslar
G2max_p	kPa/mm	Maximum gradient at middle third of vagina (posterior, see P2 in Figure 2)	Strength of Level II support (tissue deformation up to 35 mm)	Pelvic floor support	Pubovajinal ve puboanal kaslar
G3max_p	kPa/mm	Maximum gradient at upper third of vagina (posterior, see P3 in Figure 2)	Strength of Level I support (tissue deformation up to 45 mm)	Pelvic floor support	İleokoksigeal kas ve levator plağı

Test 3: Proben kendi ekseninde döndürülmesi

Tüm vajen dokusunun elastisitesinin ölçülmesi



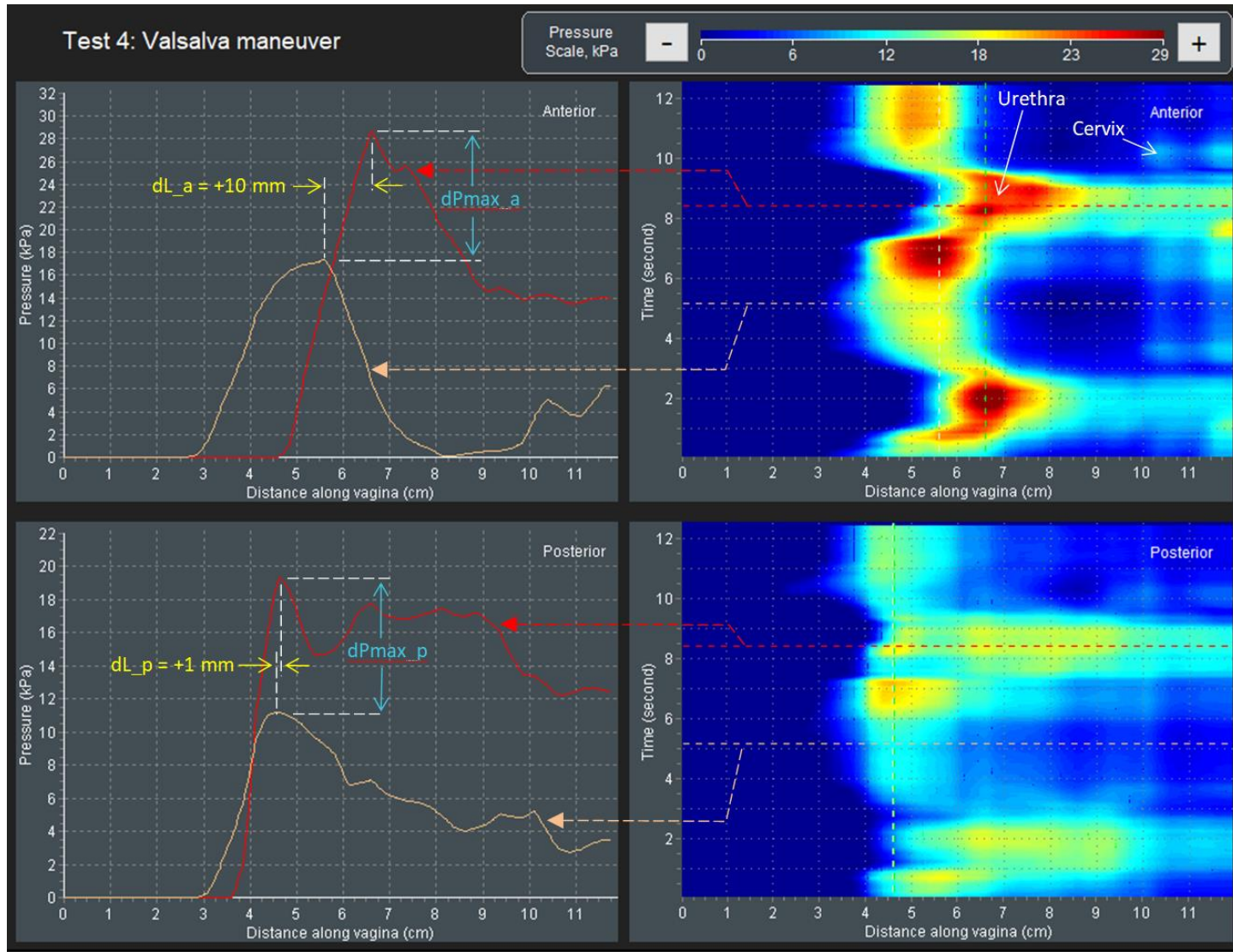
A tactile image acquired during the VTI probe rotation (Test 3) with pressure values at specified locations (see S1 and S2 in Figure 4). The VTI software automatically identified all these 3 locations and shows the pressure values (local maximums) for these locations.

Test 3: Vajen doku elastisitesi ile ilişkili biyomekanik ölçümler

Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Structure
Pmax	kPa	Maximum pressure at vaginal walls deformation by 7 mm [9]	Hard tissue or tight vagina	Vaginal tissue elasticity	Tissues behind the vaginal walls at 5-7 mm depth
Fap	N	Force applied by anterior and posterior compartments to the probe [9].	Integral strength of anterior and posterior compartments	Vaginal tightening	Tissues behind anterior/ posterior vaginal walls.
Fs	N	Force applied by entire left and right sides of vagina to the probe [9].	Integral strength of left and right sides of vagina	Vaginal tightening	Vaginal right/left walls and tissues behind them.
P1_l	kPa	Pressure response from a selected location (irregularity 1) at left side (see S1 in Figure 4)	Hard tissue on left vaginal wall	Irregularity on vaginal wall	Tissue/muscle behind the vaginal walls on left side.
P2_l	kPa	Pressure response from a selected location (irregularity 2) at left side (see S2 in Figure 4)	Hard tissue on left vaginal wall	Irregularity on vaginal wall	Tissue/muscle behind the vaginal walls on left side.
P3_r	kPa	Pressure response from a selected location (irregularity 3) at right side (see S1 in Figure 4)	Hard tissue on right vaginal wall	Irregularity on vaginal wall	Tissue/muscle behind the vaginal walls on right side.

Test 4: Valsalva manevrası

Ön ve arka kompartmanlardan alınan basınçların maksimum değerleri



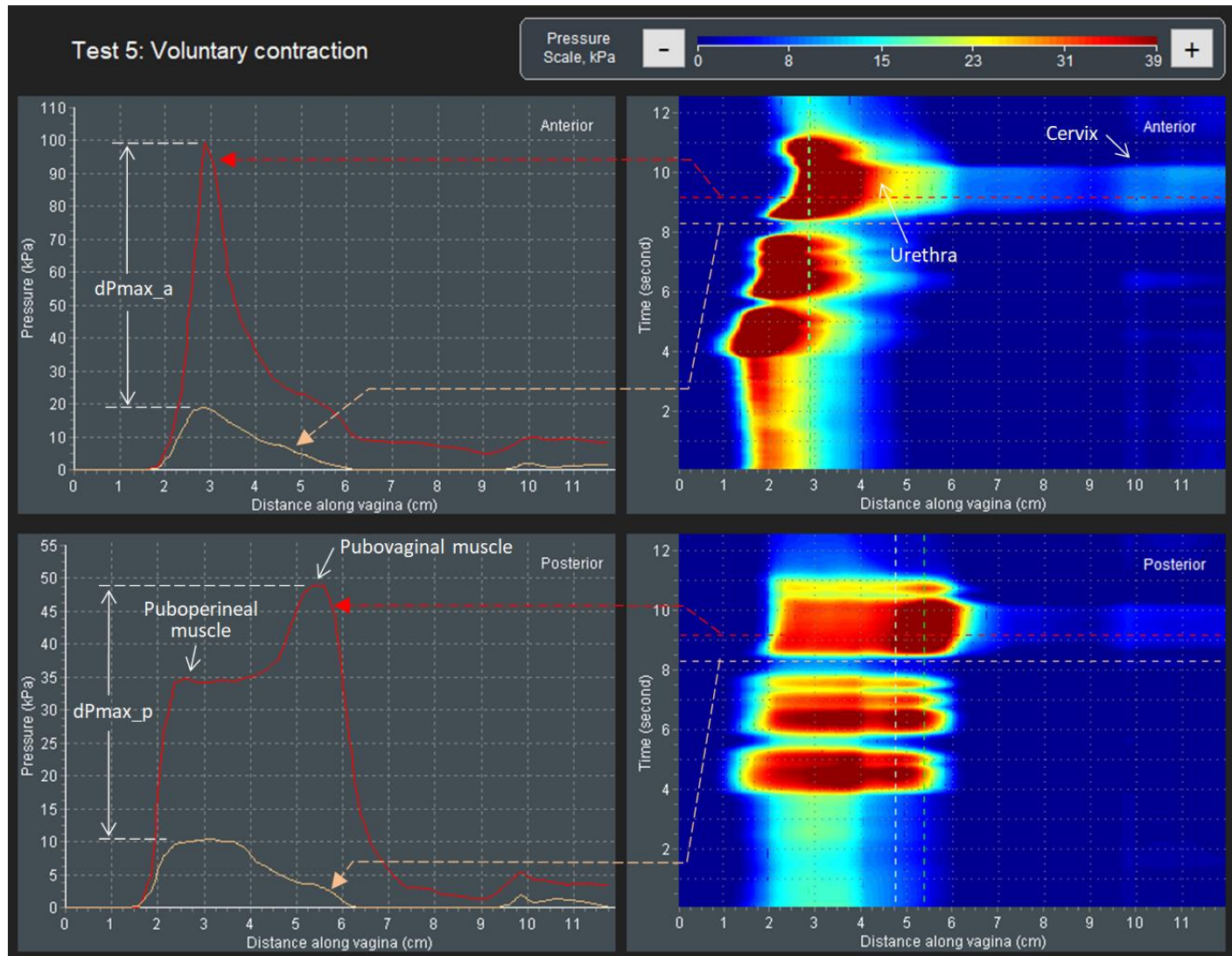
A dynamic pressure patterns acquired during the Valsalva maneuver for anterior and posterior compartments (Test 4).

Test 4: Biomechanical parameters provided by the VTI to characterize pelvic function at Valsalva maneuver

Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Struct
dF_a	N	Integral force change in anterior compartment at Valsalva manoeuvre	Pelvic function* at Valsalva maneuver	Pelvic function	Multiple pelvic muscle*
dPmax_a	kPa	Maximum pressure change in anterior compartment at Valsalva manoeuvre.	Pelvic function* at Valsalva maneuver	Pelvic function	Multiple pelvic muscle*
dL_a	mm	Displacement of the maximum pressure peak in anterior compartment	Mobility of anterior structures* Valsalva maneuver	Pelvic function	Urethra, pubovaginal muscle; ligaments*
dF_p	N	Integral force change in posterior compartment at Valsalva manoeuvre	Pelvic function* at Valsalva manoeuvre	Pelvic function	Multiple pelvic muscle*
dPmax_p	kPa	Maximum pressure change in posterior compartment at Valsalva maneuver.	Pelvic function* at Valsalva manoeuvre	Pelvic function	Multiple pelvic muscle*
dL_p	mm	Displacement of the maximum pressure peak in posterior compartment	Mobility of posterior structures* Valsalva maneuver	Pelvic function	Anorectal, puborectal, pubovaginal muscles; ligaments*

Test 5: İstemli kas kasılmaları

Ön ve arkadan dinamik basınç cevapları.



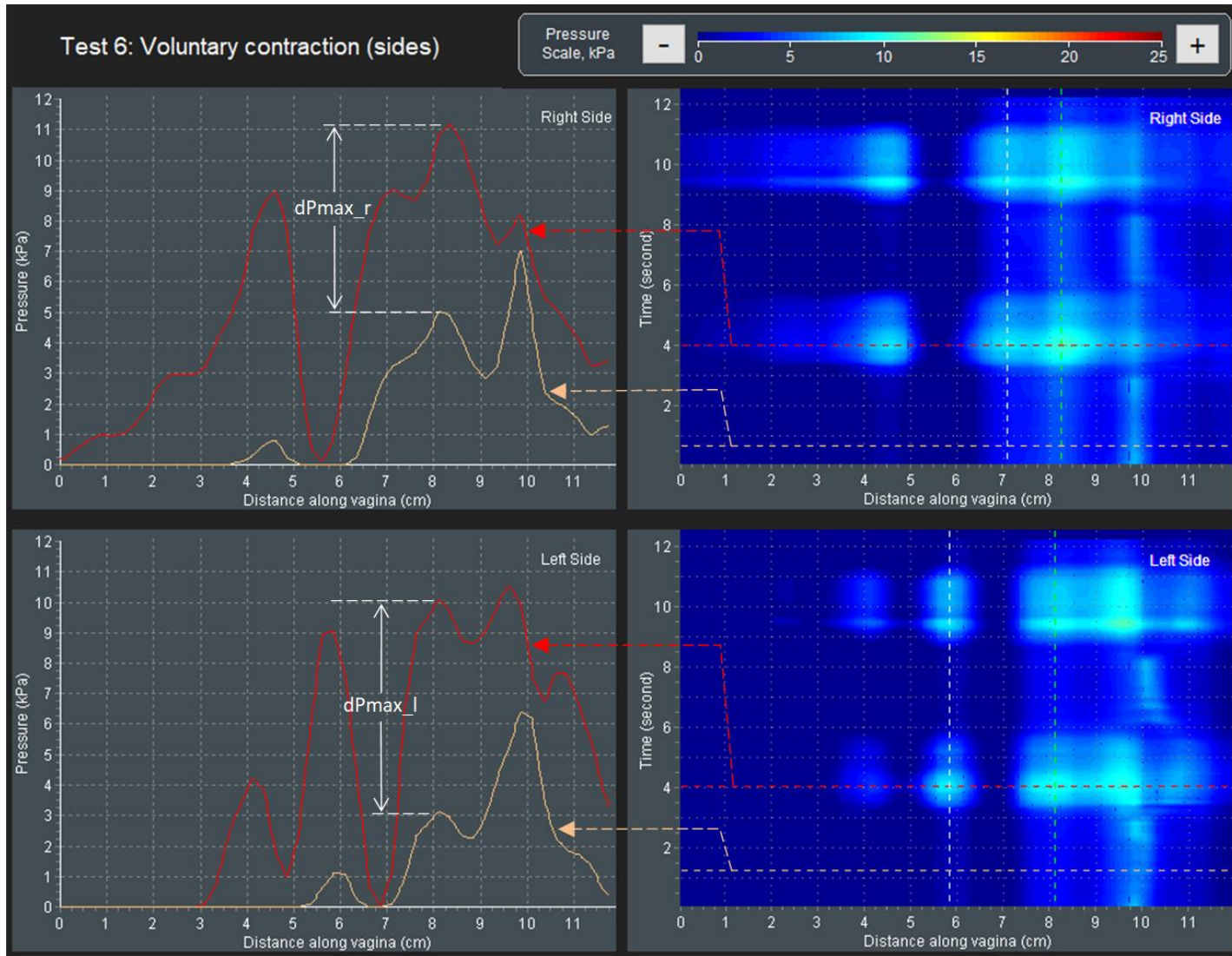
A dynamic pressure patterns acquired during the voluntary muscle contraction for anterior and posterior compartments (Test 5).

Test 5: Biomechanical parameters provided by the VTI to characterize pelvic function at voluntary muscle contraction

Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Structure
dF_a	N	Integral force change in anterior compartment at voluntary muscle contraction	Integral contraction strength of pelvic muscles along the vagina	Pelvic function	Puboperineal, puborectal, pubovaginal and iliococcygeal muscles; uretra
Pmax_a	kPa	Maximum pressure value in anterior compartment at voluntary muscle contraction.	Static and dynamic peak support of the pelvic floor	Pelvic function	Puboperineal and puborectal muscles
dF_p	N	Integral force change in posterior compartment at voluntary muscle contraction	Integral contraction strength of pelvic muscles along the vagina	Pelvic function	Puboperineal, puborectal, pubovaginal and iliococcygeal muscles
dPmax_p	kPa	Maximum pressure change in posterior compartment at voluntary muscle contraction	Contraction strength of pelvic muscles at specified location	Pelvic function	Puboperineal and pubovaginal muscles , puborectal
Pmax_p	kPa	Maximum pressure value in posterior compartment at voluntary muscle contraction.	Static and dynamic peak support of the pelvic floor	Pelvic function	Puboperineal muscles* and puborectal

Test 6: Vajen yan duvarlarında istemli kas kasılmaları

Vajen sağ ve sol yanlarından dinamik basınç cevabı



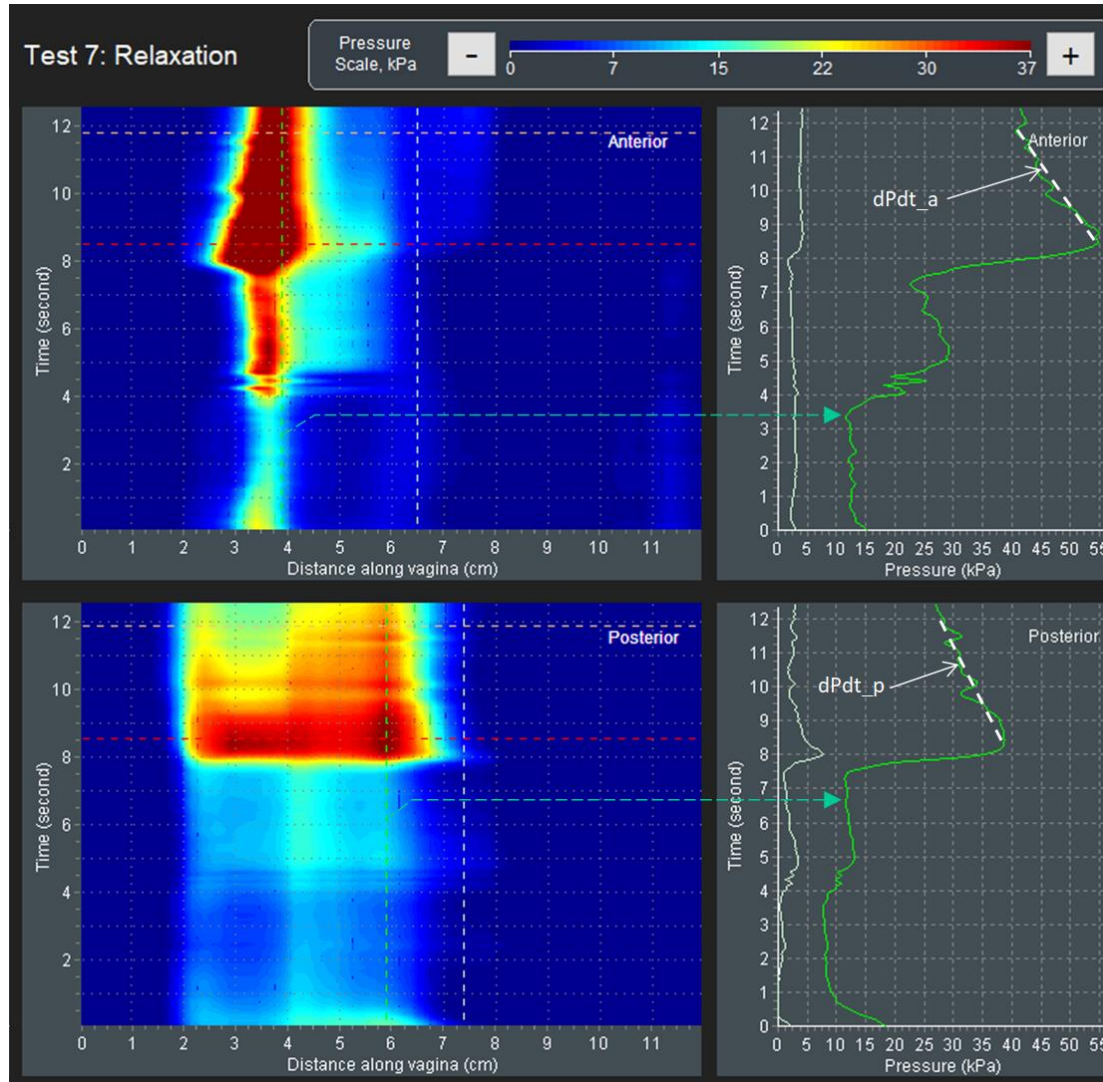
A dynamic pressure patterns acquired during the voluntary muscle contraction for left and right vaginal compartments (Test 6).

Test 6: Vajen yanlarından istemli kas kasılmalarının biyomekanik ölçümü

Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Structure
dF_r	N	Integral force change in right side at voluntary muscle contraction	Integral contraction strength of pelvic muscles along the vagina	Pelvic function	Puboperineal and pubovaginal , puborectal muscles,
dPmax_r	kPa	Maximum pressure change in right side at voluntary muscle contraction	Contraction strength of specific pelvic muscle	Pelvic function	Puboperineal or pubovaginal or puborectal muscles
Pmaxa_r	kPa	Maximum pressure value in right side at voluntary muscle contraction	Specified pelvic muscle contractive capability and integrity	Pelvic function	Puboperineal muscles or puborectal
dF_l	N	Integral force change in left side at voluntary muscle contraction	Integral contraction strength of pelvic muscles along vagina	Pelvic function	Puboperineal and pubovaginal , puborectal muscles,
dPmax_l	kPa	Maximum pressure change in left side at voluntary muscle contraction	Contraction strength of specific pelvic muscle	Pelvic function	Puboperineal or pubovaginal or puborectal muscles
Pmaxa_l	kPa	Maximum pressure value in left side at voluntary muscle contraction	Specified pelvic muscle contractive capability and integrity	Pelvic function	Puboperineal muscles or puborectal

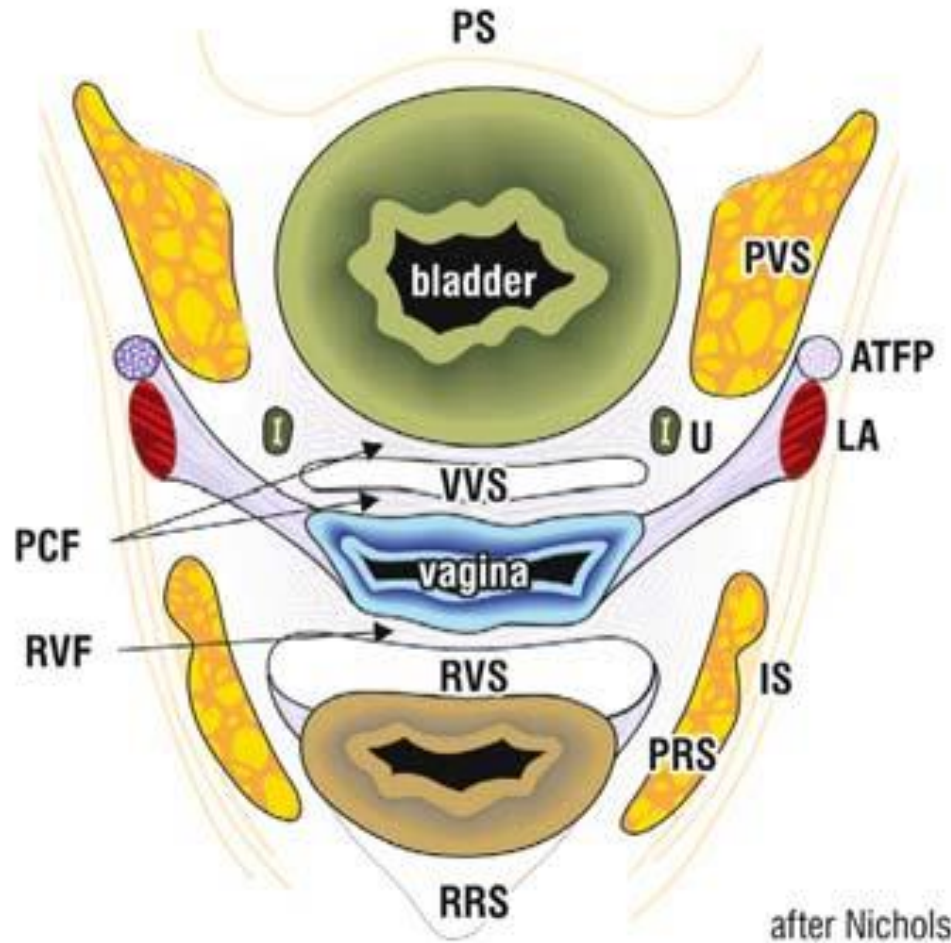
Test 7: İstemsiz gevşeme

Ön ve arkadan dinamik basınç cevaplarının alınması



A dynamic pressure patterns acquired during the involuntary muscle relaxation for interior and posterior compartments (Test 7).

Bağ dokusu alanları



- PVS - paravesical space
- VVS - vesicovaginal space
- RVS - rectovaginal space
- RRS - retrorectal space
- RVF - rectovaginal fascia
- U - ureter
- PCF - pub-ocervical fascia
- ATFP - Arcus tendineus fascia pelvis
- IS - ischial spine
- LA - levator ani

Test 7: İstemsiz kas gevşemeleri ile giden pelvik fonksiyonların biyomekanik ölçümü

Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Structure
dPdt_a	kPa/s	Anterior absolute pressure change per second for maximum pressure at involuntary relaxation	Innervation status of specified pelvic muscles	Innervations status	Levator ani muscles
dpcdt_a	%/s	Anterior relative pressure change per second for maximum pressure at involuntary relaxation	Innervation status of specified pelvic muscles	Innervations status	Levator ani muscles
dPdt_p	kPa/s	Posterior absolute pressure change per second for maximum pressure at involuntary relaxation	Innervation status of specified pelvic muscles	Innervations status	Levator ani muscles
dpcdt_p	%/s	Posterior relative pressure change per second for maximum pressure at involuntary relaxation	Innervation status of specified pelvic muscles	Innervations status	Levator ani muscles

Test 8: Öksürme ile reflex kas kasılmaları

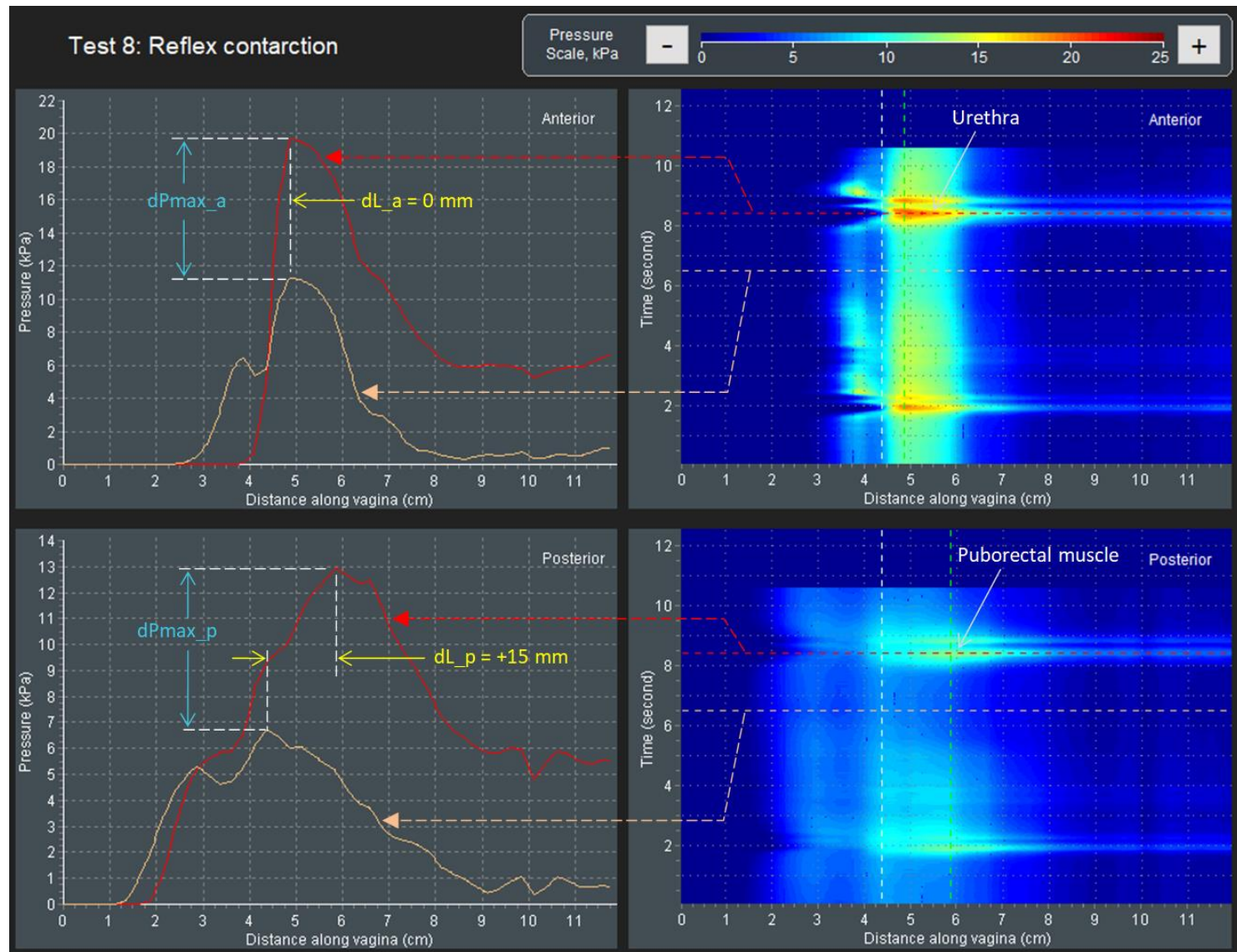


Figure 12. A dynamic pressure patterns acquired during the reflex contraction (cough) for anterior and posterior compartments (Test 8)

Aktif Kapanma

Üretra ve mesane boynunu control eden kasların ortak hareketi

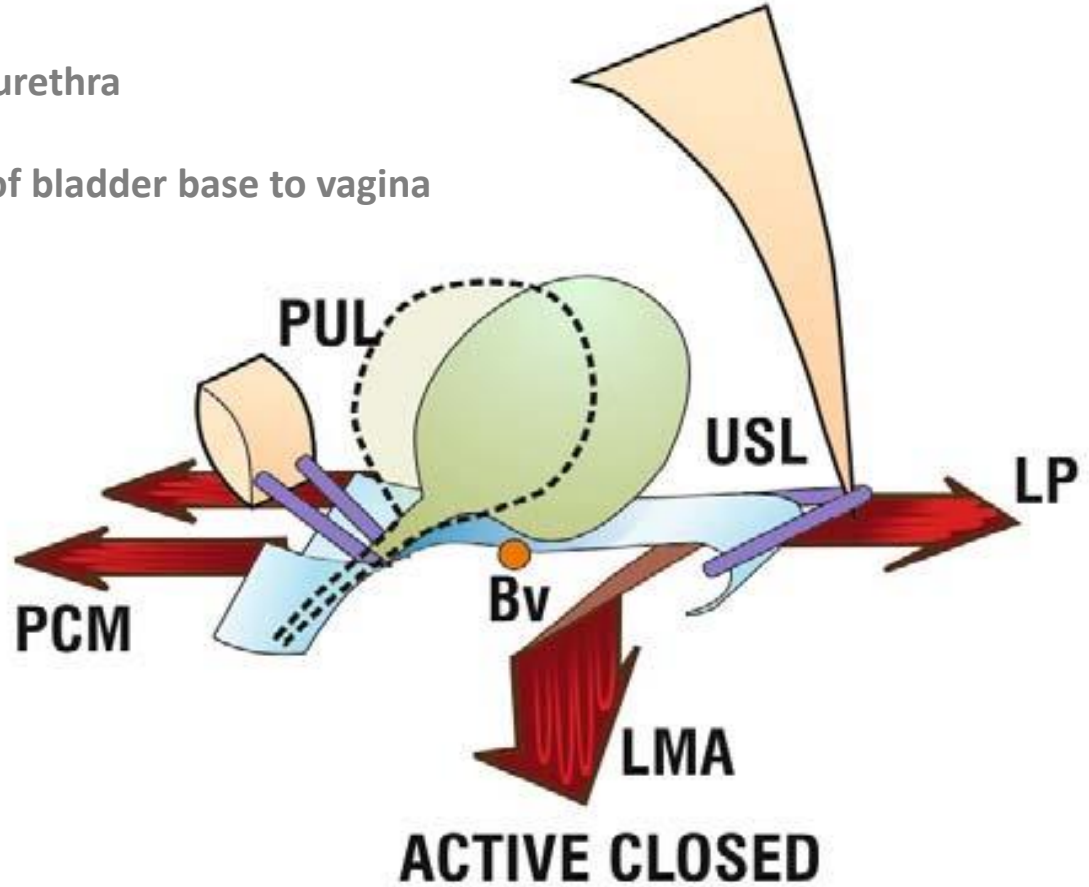
Arrows - muscle forces

Blue - vagina

Green - bladder and urethra

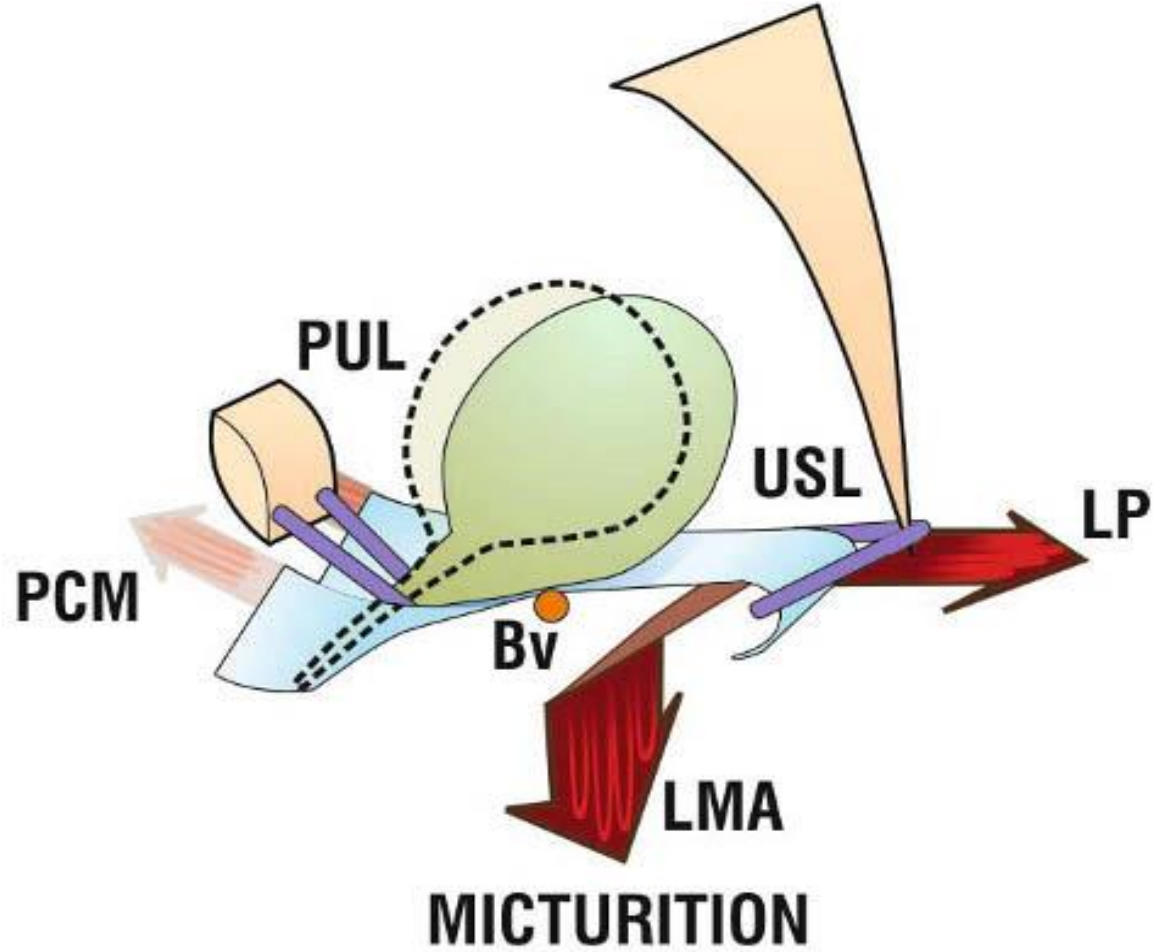
Yellow - bone

Bv - attachment of bladder base to vagina



İşeme

Puboservikal kas gevşemesi sonrası üretra açılmasın



Test 8: Biomechanical parameters provided by the VTI to characterize pelvic function at reflex muscle contraction (cough)

Parameters Abbreviation	Units	Parameter Description	Parameter Interpretation	Parameter Class	Targeting/Contributing Pelvic Struct
dF_a	N	Integral force change in anterior compartment at reflex pelvic muscle contraction (cough)	Integral pelvic function* at reflex muscle contraction	Pelvic function	Multiple pelvic muscle*
dPmax_a	kPa	Maximum pressure change in anterior compartment at reflex pelvic muscle contraction (cough)	Contraction strength of specified pelvic muscles	Pelvic function	Multiple pelvic muscle*
dL_a	mm	Displacement of the maximum pressure peak in anterior compartment	Mobility of anterior structures* at reflex muscle contraction	Pelvic function	Urethra, pubovaginal muscle; ligaments*
dF_p	N	Integral force change in posterior compartment at reflex pelvic muscle contraction (cough)	Integral pelvic function* at reflex muscle contraction	Pelvic function	Multiple pelvic muscle*
dPmax_p	kPa	Maximum pressure change in posterior compartment at reflex pelvic muscle contraction (cough)	Contraction strength of specified pelvic muscles	Pelvic function	Multiple pelvic muscle*
dL_p	mm	Displacement of the maximum pressure peak in posterior compartment	Mobility of anterior structures* at reflex muscle contraction	Pelvic function	Anorectal, puborectal and pubovaginal muscles; ligaments

Equipment cost and tactile imaging strength

Görüntüleme Teknolojisi		Radiation / Emission	Real time imaging	Elastography	Cost, USD	Examination time
MRI		Low	X	X	\$2M – \$3M	20-60 min
Nuclear Medicine		High	X	X	\$1M	45-180 min
X-Ray		Medium	✓	X	\$100k - \$500k	2-15 min
Strain/ Shear Wave Ultrasound		Very low (acoustic energy)	✓	✓	\$100k - \$250k	5-10 min
TACTILE IMAGING		None	✓	✓	\$30k - \$45k	3-5 min

TACTILE IMAGING STRENGTH:

- no radiation and emission
- new diagnostic parameters
- dynamic muscle assessment
- low cost
- shorter examination time
- portability, performance

Ön Kompartman

(External urethral meatus-Bladder neck)

- 1.External urethral ligament
- 2.Suburethral hammock
- 3.Pubourethral ligament

Orta Kompartman

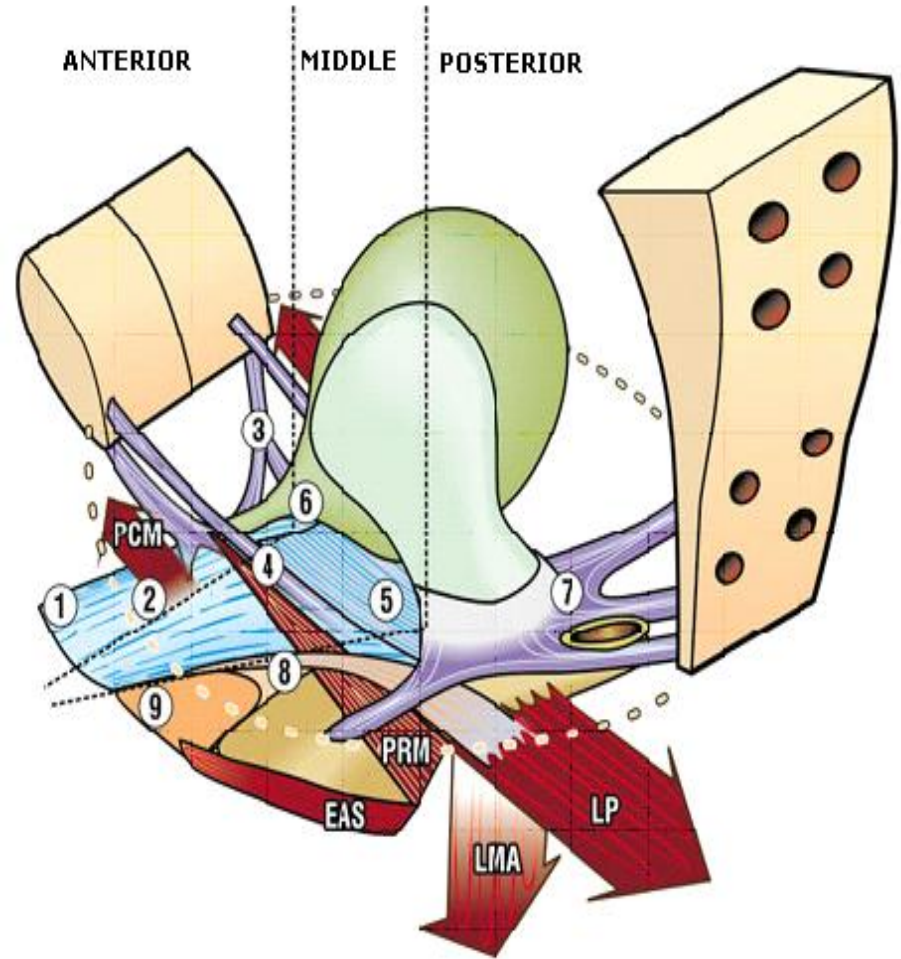
(BN-Cervix/hysterectomy scar)

- 4.ATFP
- 5.Pubocervical fasya defekti
- 6.Critic elastikiyet alanı

Arka Kompartman

(C/HS-Perineal cisim)

- 7.Uterosakral Lig. Defekti
- 8.Retovajinal Fasya Defekti
- 9.Perineal Cisim



Müdahale Seçeneklerinin Değerlendirilmesi

- Vajen elastisite kaybı
 - Lazer ve lokal hormon tedavileri, Hyauronik a, PRP, lipid dolgu
- Ön kompartman defektleri
 - TVT, TOT, Mini askı
- Arka kompartman defektleri
 - Kuldoplasti, sakrouterine plikasyon, post IVS, perineal cisim tamiri
- Ligament defektleri
 - Doku fiksasyon sistemleri, TVT, TOT, mini askı, sakrouterine plikasyon, servikal halka onarımı
- Levator kası felci
 - Nöromodulasyon
- Hiatal açıklık artmış
 - Levator sütürleri, fizyoterapi, feed-back

Teşekkürler...