TÜRK RADYASYON ONKOLOJİSİ DERNEĞİ

REKTUM KANSERİNDE KANITA DAYALI TEDAVİ VE RADYOTERAPİ PLANLAMASI

TROD Gastrointestinal Onkoloji Çalışma Grubu

Oligometastazlarda SBRT doz, planlama

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Başkent Üniversitesi Tıp Fakültesi

Adana Dr Turgut Noyan Uygulama ve Araştırma Merkezi

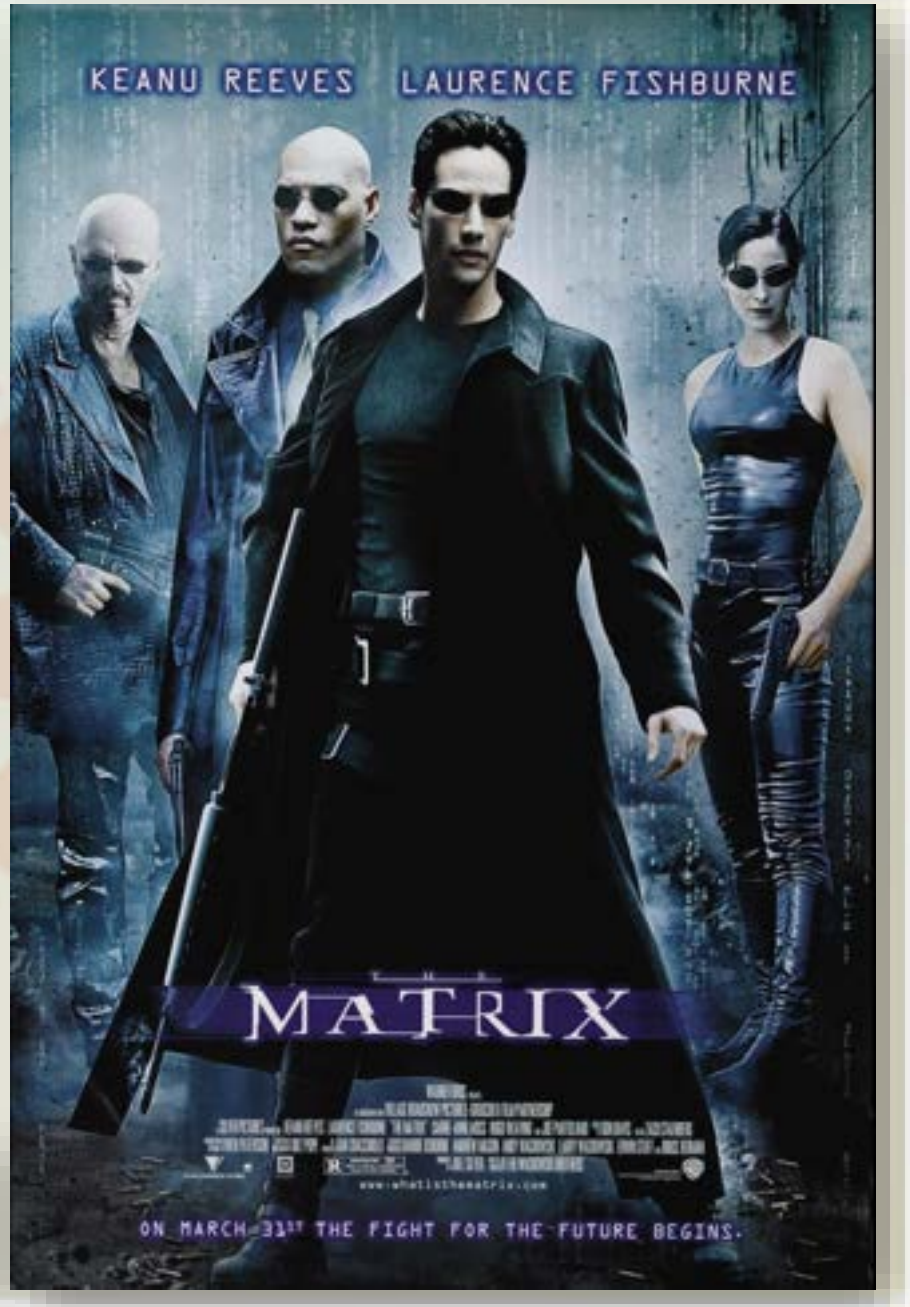
Radyasyon Onkolojisi AD

Sunum Planı

1. Karaciğer SBRT
2. Akciğer SBRT
3. Kemik SBRT

Bölüm 1

Karaciğer SBRT



Karaciğer SBRT

1960 — 1995 — 2019 — 2024

Editorial > J Clin Oncol. 1995 Jan;13(1):8-10. doi: 10.1200/JCO.1995.13.1.8.

Oligometastases

S Hellman, R R Weichselbaum

Clinical Trial > Lancet. 2019 May 18;393(10185):2051-2058. doi: 10.1016/S0140-6736(18)32487-5. Epub 2019 Apr 11.

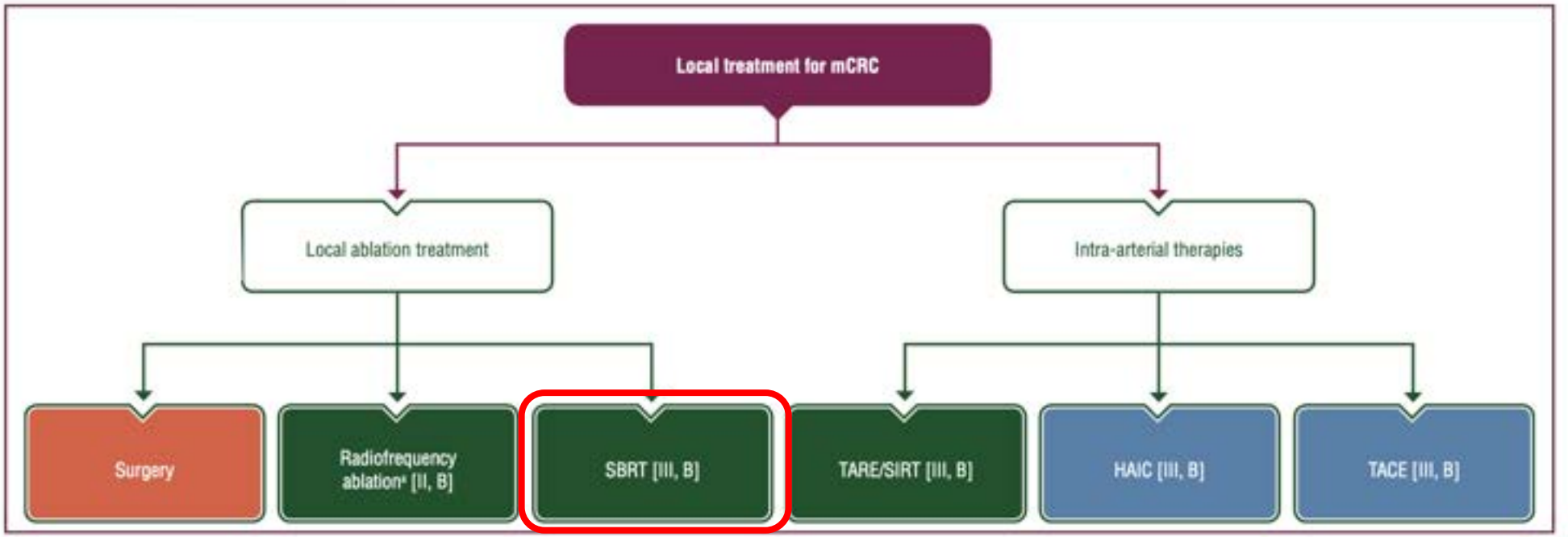
Stereotactic ablative radiotherapy versus standard of care palliative treatment in patients with oligometastatic cancers (SABR-COMET): a randomised, phase 2, open-label trial

Karaciğer SBRT

- **Karaciğer met**
  - **Rezektabl**
    - **Cerrahi**
      - Altın standart
  - **Unrezektabl**
    - **Sistemik tedavi**
      - Sistemik?
    - **Lokal tedavi**
      - **TACE/TARE/SIRT**
      - **RFA**
        - \+
          CLOCC (Cht vs RFA)
      - **SBRT**
        - Retrospektif
          ?
          OLIVER (Cht vs SBRT)

ESMO
GOOD SCIENCE
BETTER MEDICINE
BEST PRACTICE

Metastatic colorectal cancer: ESMO Clinical Practice Guideline for diagnosis, treatment and follow-up☆



- SBRT is a treatment option, although it is yet unclear which patients benefit most [III, B].

Konsey

- Cerrahi altın standart (%20)
- Cerrahi vs. Lokal tedavi (RFA, SBRT, TAKE vs.) --> Karşılaştırma yok
  - (COLLISION: Cerrahi vs. RFA)
- Lokal tedavilerde: RFA vs. SBRT --> Karşılaştırma yok
  - (İnop CRLM: NCT02820194)
- Cerrahi/medikal inop, RFA inop (büyük tm, santral lokalizasyon) --> SBRT için uygun
- Hasta seçimi: DFI, ECOG, etc.
- QoL
- Cost effectiveness
- Treatment interruptions

RFA vs. SBRT

Comparative Study > Int J Radiat Oncol Biol Phys. 2018 Mar 15;100(4):950-958.
doi: 10.1016/j.ijrobp.2017.12.014. Epub 2017 Dec 15.

Comparison of Stereotactic Body Radiation Therapy and Radiofrequency Ablation in the Treatment of Intrahepatic Metastases

Comparative Study > Acta Oncol. 2013 Jun;52(5):971-7.
doi: 10.3109/0284186X.2013.766362. Epub 2013 Feb 14.

Percutaneous radiofrequency ablation (RFA) or robotic radiosurgery (RRS) for salvage treatment of colorectal liver metastases

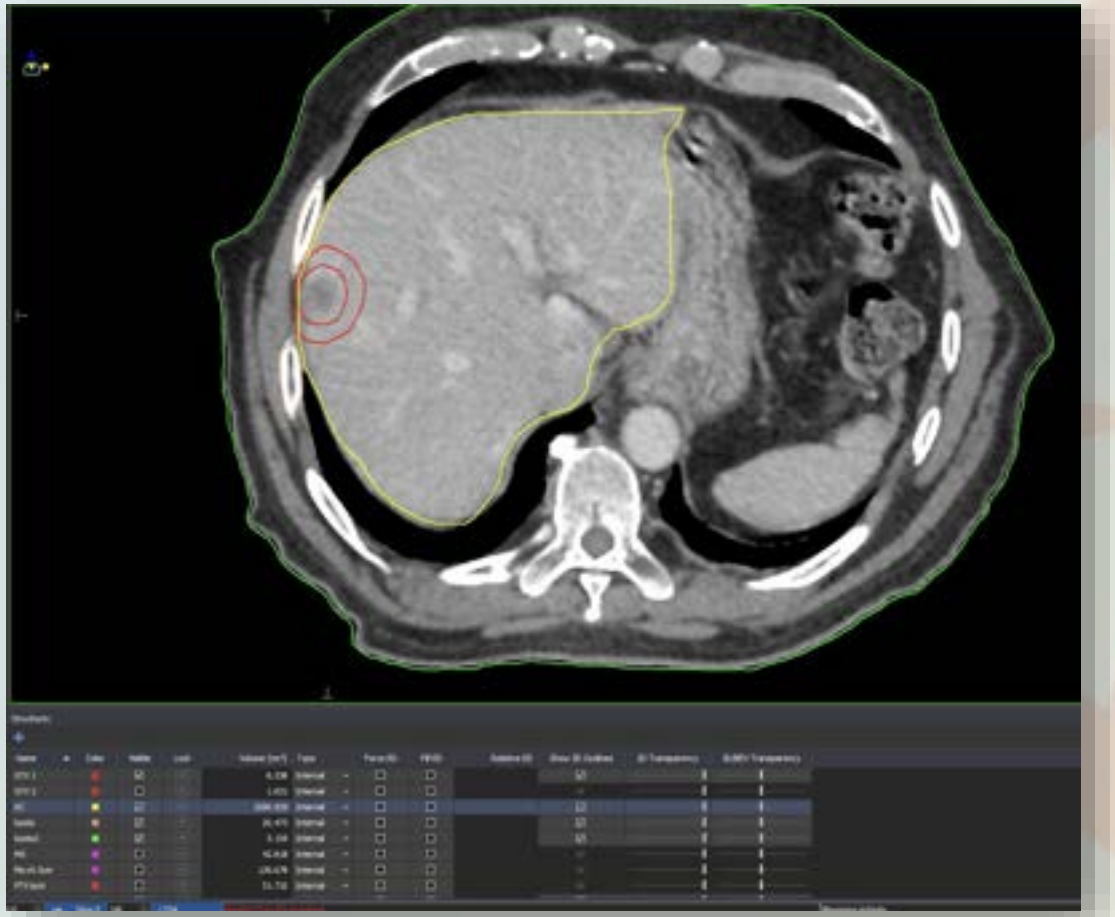
Review > Radiother Oncol. 2020 Apr:145:63-70. doi: 10.1016/j.radonc.2019.12.004.
Epub 2020 Jan 7.

Comparisons between radiofrequency ablation and stereotactic body radiotherapy for liver malignancies: Meta-analyses and a systematic review

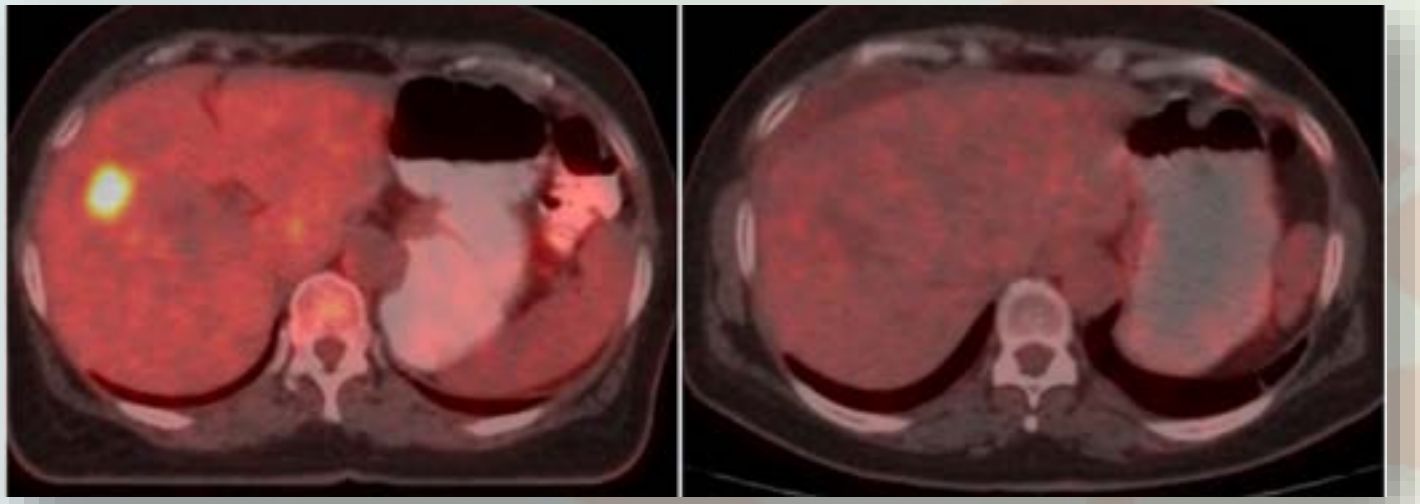
Review > Radiat Oncol. 2017 Jun 29;12(1):110. doi: 10.1186/s13014-017-0818-8.

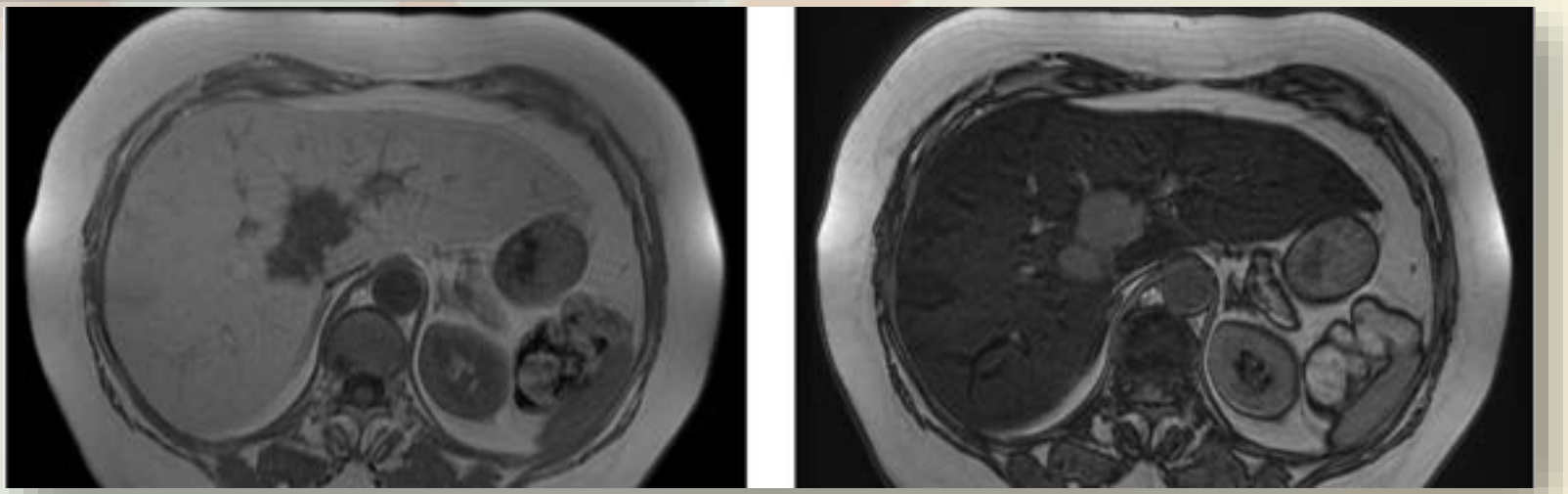
Systematic review of patient reported quality of life following stereotactic ablative radiotherapy for primary and metastatic liver cancer

Planlama – CT simülasyon



Ek görüntüleme - Yanıt





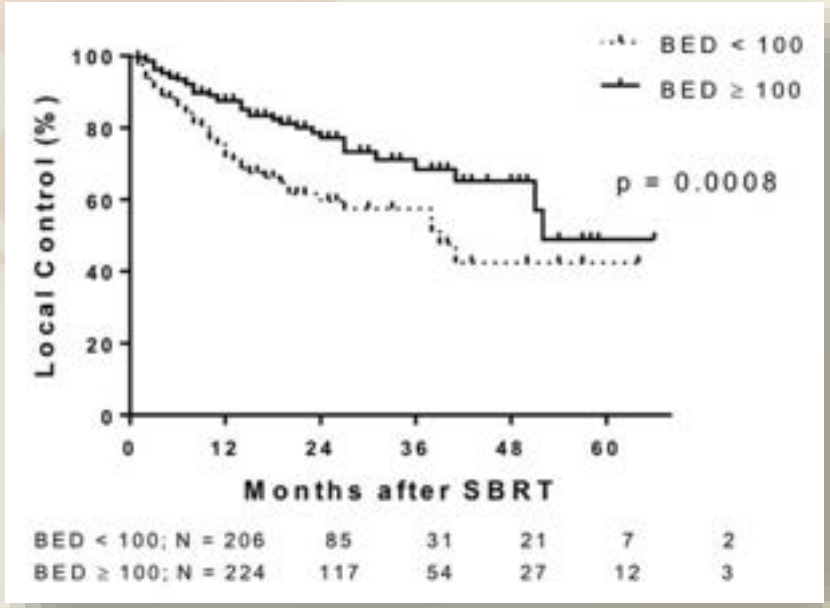
Planlama – Motion management

SBRT doz

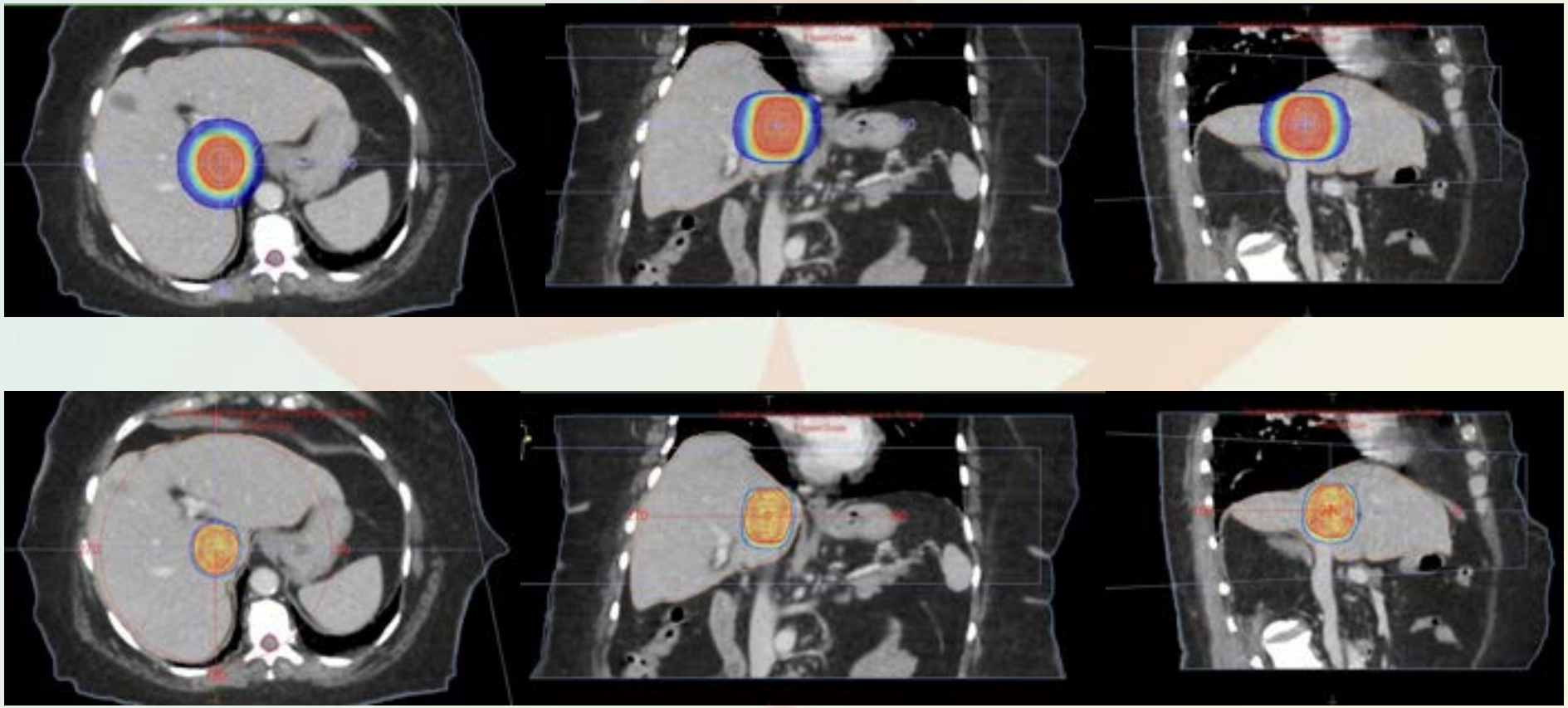
- 3 x 18 Gy
- 4 x 12.5 Gy
- 4 x 10 Gy
- 5 x 8 Gy

Stereotactic Body Radiotherapy (SBRT) for liver metastasis – clinical outcomes from the international multi-institutional RSSearch® Patient Registry

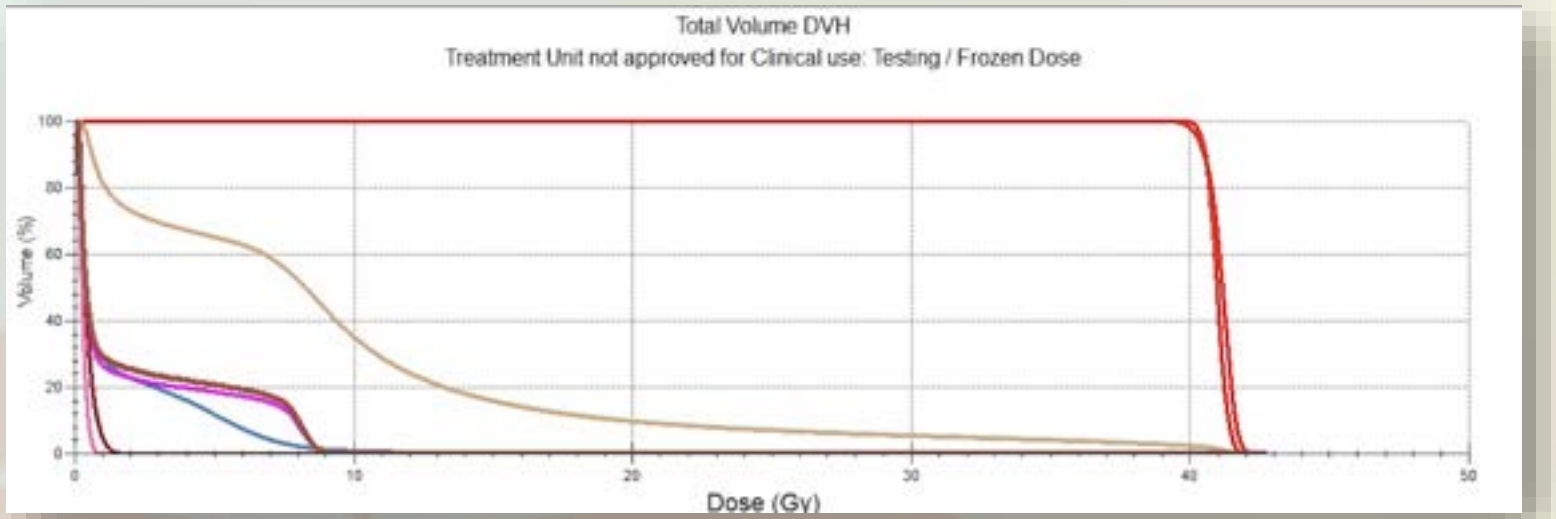
BED_{10} > 100 Gy --> LC/OS avantajı var



KC SBRT



KC SBRT



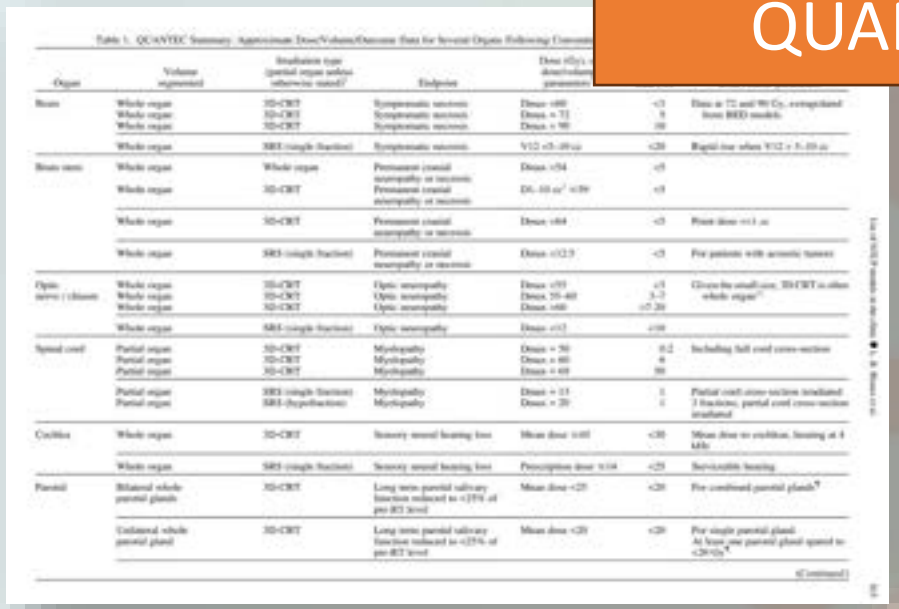
DVH Statistics

Dosimetric Criteria | Statistics | Display

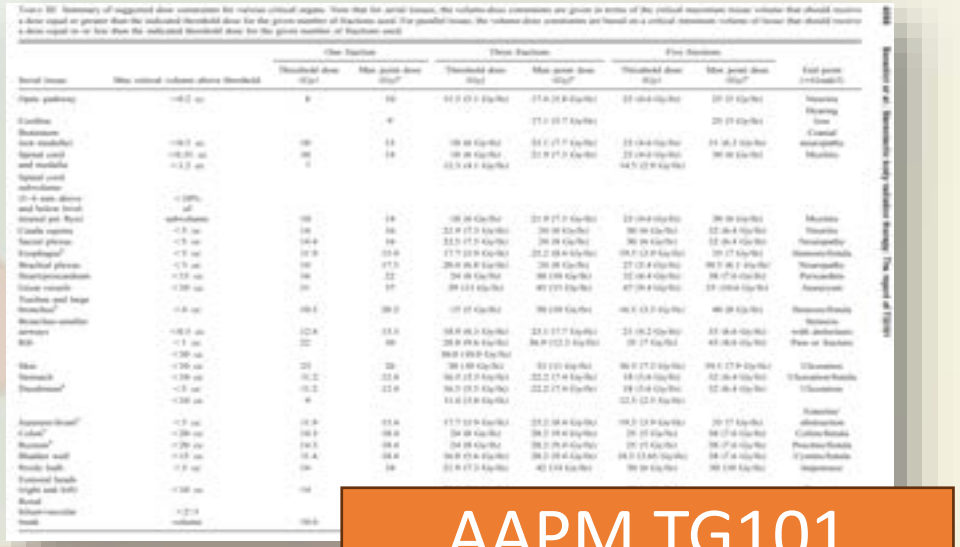
Structure	Volume (cm³)	Min. Dose (Gy)	Max. Dose (Gy)	Mean Dose (Gy)	Ref. Vol. (cm³)	Ref. Vol. (%)	Ref. Dose (Gy)	Dosimetric Criterion	% in Volume	Is in SS	Heterogeneity Index	Conformity Index
PTV	28.915	38.860	42.708	41.104	28.330	97.98	40.000		100.00	yes	1.04	
Spinal_Canal	30.152	0.093	9.275	1.877					99.01	no	59.15	
External_Contour(Un	14728.305	0.015	21.604	1.503					98.84	no	83.14	0.92
20.000Gy	142.347	17.767	42.708	30.960					100.00	yes	2.01	
38.000Gy	41.160	37.097	42.708	40.575					100.00	yes	1.08	
GTV	3.372	39.674	42.037	40.957					100.00	yes	1.03	
Kidney_L	95.561	0.060	0.935	0.269					99.39	no	4.88	
Kidney_R	95.539	0.102	2.231	0.438					100.00	yes	5.92	
Liver	1200.823	0.118	42.708	9.440	215.750	17.97	14.105		100.00	yes	72.67	
Saglam#C	1197.451	0.118	42.708	9.351	700.000	58.46	7.090		100.00	yes	70.50	
Spinal_Cord	21.472	0.094	9.275	2.052					99.01	no	59.26	

OAR – Dose constraints

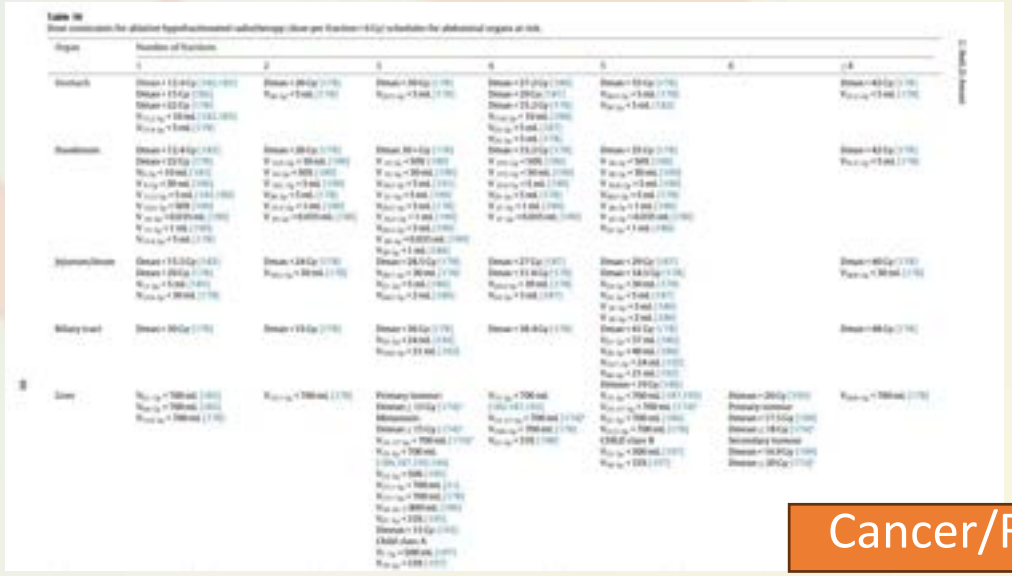
QUANTEC



AAPM TG101



Sağlam KC V14<700 cc



Cancer/Radiothérapie

Plan değerlendirme kriterleri

$$HI = \frac{D_{2\,\%} - D_{98\,\%}}{D_{50\,\%}}.$$

Homojenite indeksi

$$CI = \frac{(TV_{PIV})^2}{TV * PIV}$$

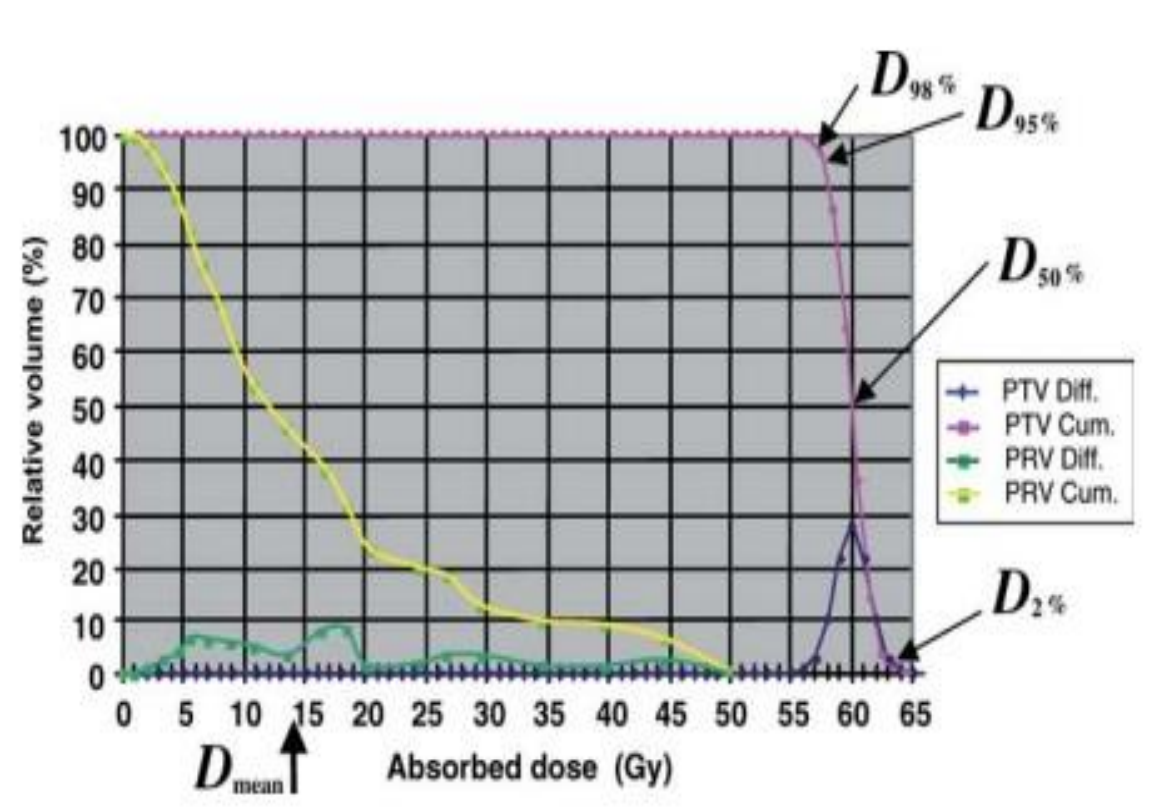
Conformity indeks

$$GI = \frac{PTV_{half}}{PTV}$$

Gradient indeks

Homojenite indeksi = HI

$$HI = \frac{D_{2\,\%} - D_{98\,\%}}{D_{50\,\%}}.$$



- H= 0 mükemmel

- PTV Maksimum doz D%2
- Minimum doz D%98
- Median doz ,D%50 tanımlanan doza yakındır.

ICRU Report 83, Prescribing, Recording, and Reporting Intensity-Modulated Photon-Beam Therapy (IMRT)

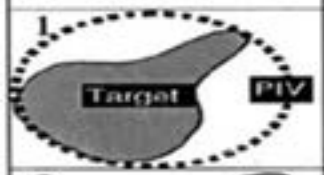
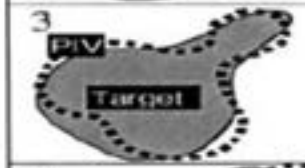
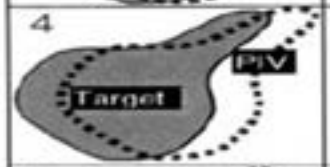
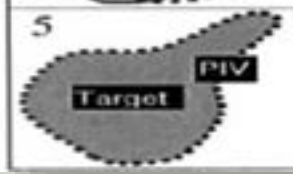
Konformite indeksi = CI

$$CI = \frac{(TV_{PIV})^2}{TV * PIV}$$

~~$$CI = \frac{TV}{PIV}$$~~

- CI= 1 mükemmel

- TV = Hedef Hacim
- PIV = Seçilen İzodoz Hacmi
- TV_{PIV} = Seçilen İzodozun PTV deki Hacmi

Isodose Plan	Parameters	CI (Paddick)	
		$\frac{TV_{PIV}^2}{TV \times PIV}$	$\frac{TV}{PIV}$
1 	$TV = 5cm^3$ $TV_{PIV} = 5cm^3$ $PIV = 10cm^3$	0.50	0.50
2 	$TV = 5cm^3$ $TV_{PIV} = 3cm^3$ $PIV = 3cm^3$	0.60	1.66
3 	$TV = 5cm^3$ $TV_{PIV} = 4cm^3$ $PIV = 5cm^3$	0.64	1.00
4 	$TV = 5cm^3$ $TV_{PIV} = 3cm^3$ $PIV = 5cm^3$	0.36	1.00
5 	$TV = 5cm^3$ $TV_{PIV} = 5cm^3$ $PIV = 5cm^3$	1.00	1.00

Gradient indeks = GI

$$GI = \frac{PTV_{half}}{PTV}$$

PTV Volume (cc)	Ratio of Prescription Isodose Volume to the PTV Volume		Ratio of 50% Prescription Isodose Volume to the PTV Volume, $R_{50\%}$		Maximum Dose (in % of dose prescribed) @ 2 cm from PTV in Any Direction, D_{2cm} (%)	
	Deviation		Deviation		Deviation	
	None	Minor	None	Minor	None	Minor
1.8	<1.2	<1.5	<5.9	<7.5	<50.0	<57.0
3.8	<1.2	.<1.5	<5.5	<6.5	<50.0	<57.0
7.4	<1.2	<1.5	<5.1	<6.0	<50.0	<58.0
13.2	<1.2	<1.5	<4.7	<5.8	<50.0	<58.0
22.0	<1.2	<1.5	<4.5	<5.5	<54.0	<63.0
34.0	<1.2	<1.5	<4.3	<5.3	<58.0	<68.0
50.0	<1.2	<1.5	<4.0	<5.0	<62.0	<77.0
70.0	<1.2	<1.5	<3.5	<4.8	<66.0	<86.0
95.0	<1.2	<1.5	<3.3	<4.4	<70.0	<89.0
126.0	<1.2	<1.5	<3.1	<4.0	<73.0	<91.0
163.0	<1.2	<1.5	<2.9	<3.7	<77.0	<94.0

RTOG 0813

Bölüm 2

Akciğer SBRT

Akciğer SBRT

- AC metastazı KC metastazından daha iyi prognozlu.
- Metastazektomi sağkalım katkısı var

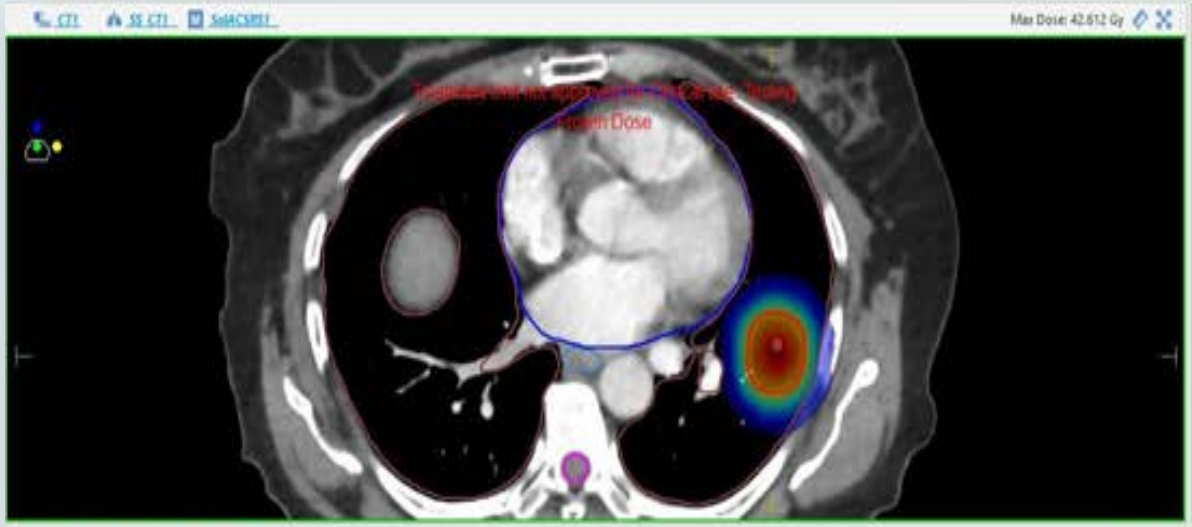
- ≈ KC SBRT
  - Cerrahi komorbiditeler
  - Endikasyonlar
  - Pozisyonlama, simülasyon vs.

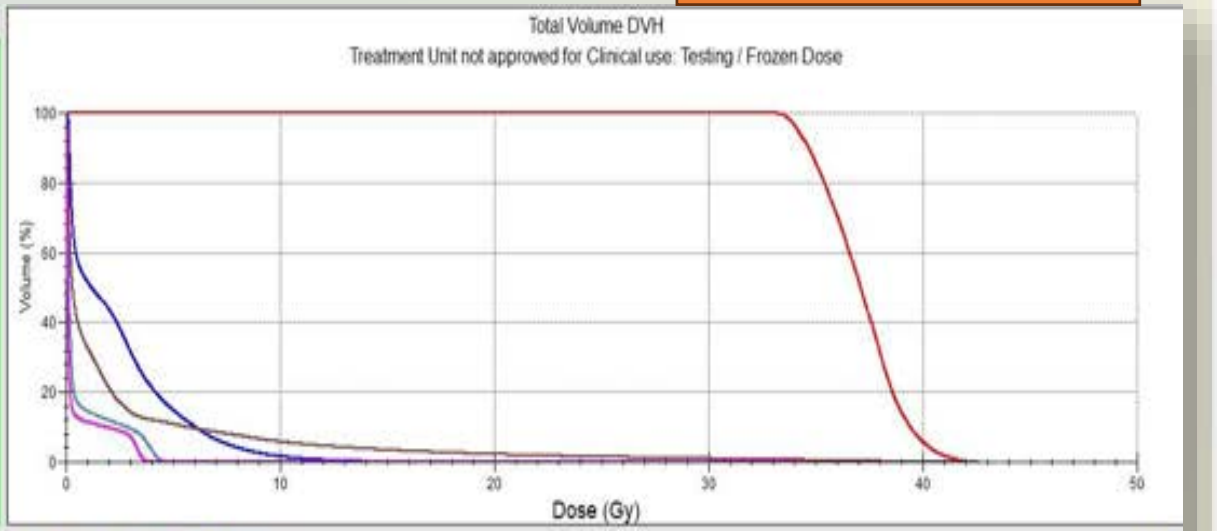
SBRT doz

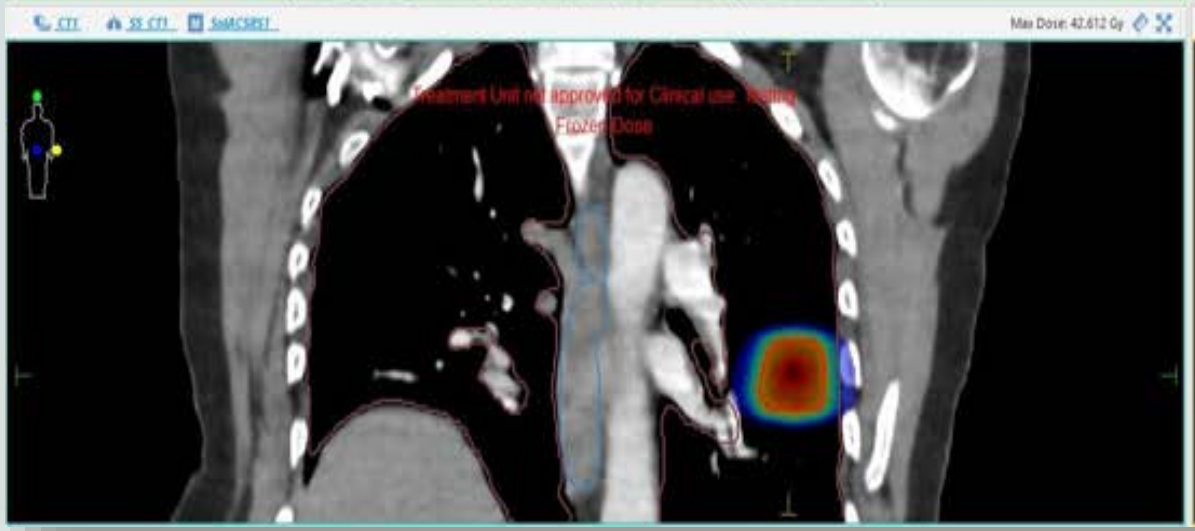
Table 2. Commonly Used Doses for SABR

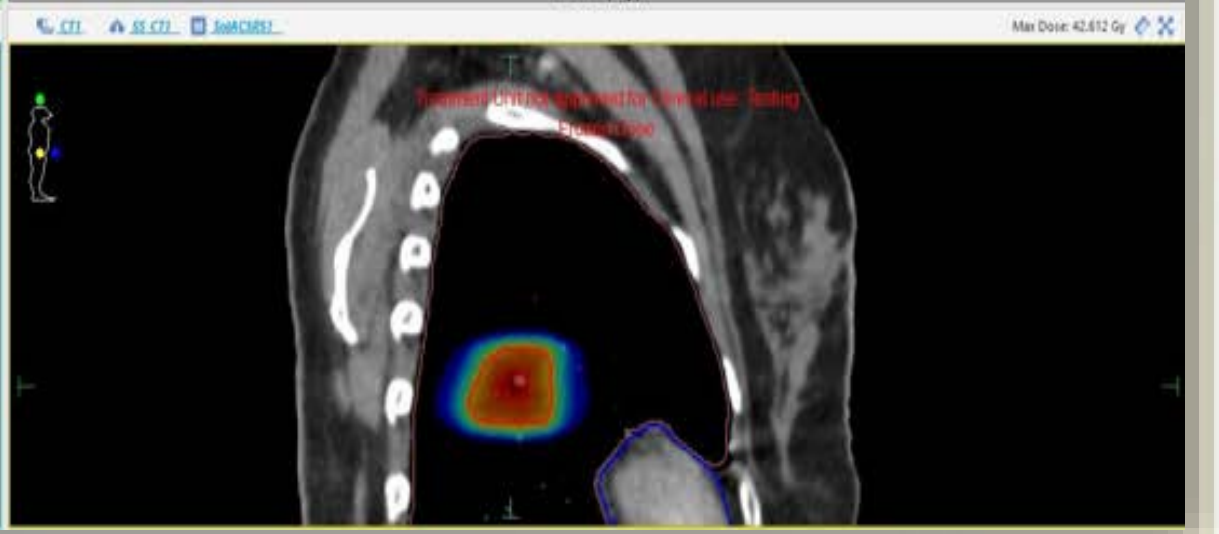
Total Dose	# Fractions	Example Indications
25–34 Gy	1	Peripheral, small
45–60 Gy	3	Peripheral tumors
48–50 Gy	4	Central or peripheral tumors <4–5 cm
50–55 Gy	5	Central tumors
50–60 Gy	5	Peripheral tumors
60–70 Gy	8–10	Central tumors

1 x 34 Gy


Max Dose: 42.612 Gy


Total Volume DVH
Treatment Unit not approved for Clinical use: Testing / Frozen Dose
Volume (%)
Dose (Gy)
0
20
40
60
80
100
0
10
20
30
40
50


Max Dose: 42.612 Gy


Max Dose: 42.612 Gy

DVH Statistics

Dosimetric Criteria | Statistics | Display

Structure	Volume (cm³)	Min. Dose (Gy)	Max. Dose (Gy)	Mean Dose (Gy)	Ref. Vol. (cm³)	Ref. Vol. (%)	Ref. Dose (Gy)	Dosimetric Criterion	% in Volume	Is in SS	Heterogeneity Index	Conformity Index
PTV SOL AC 34Gy	13.208	32.637	42.437	37.067	12.741	96.46	34.000		100.00	yes	1.18	
					13.208	100.00	32.300					
Spinal_Cord	35.611	0.009	3.895	0.411	0.000	0.00	10.000	V10Gy < 0.35 cm³	99.67	no	168.61	
					0.000	0.00	7.000	V7Gy < 1.2 cm³				
					0.000	0.00	3.895	Dmax < 14 Gy				
Heart	677.975	0.078	17.336	2.291	0.000	0.00	17.336	Dmax < 22 Gy	100.00	yes	55.98	0.00
					0.142	0.02	16.000	V16Gy < 15 cm³				
Esophagus	30.486	0.021	4.713	0.597	0.000	0.00	11.900	V11.9Gy < 5 cm³	100.00	yes	100.98	0.00
					0.000	0.00	4.713	Dmax < 15.4 Gy				
PTV SAG AC 40Gy	3.643	0.198	1.182	0.411					100.00	yes	3.85	0.00
BODY(Unsp.Tiss.)	15000.647	0.000	13.655	0.390					99.69	no	145.33	0.70
TAC	2241.160	0.028	42.439	2.137	49.066	2.19	20.000		100.00	yes	163.36	

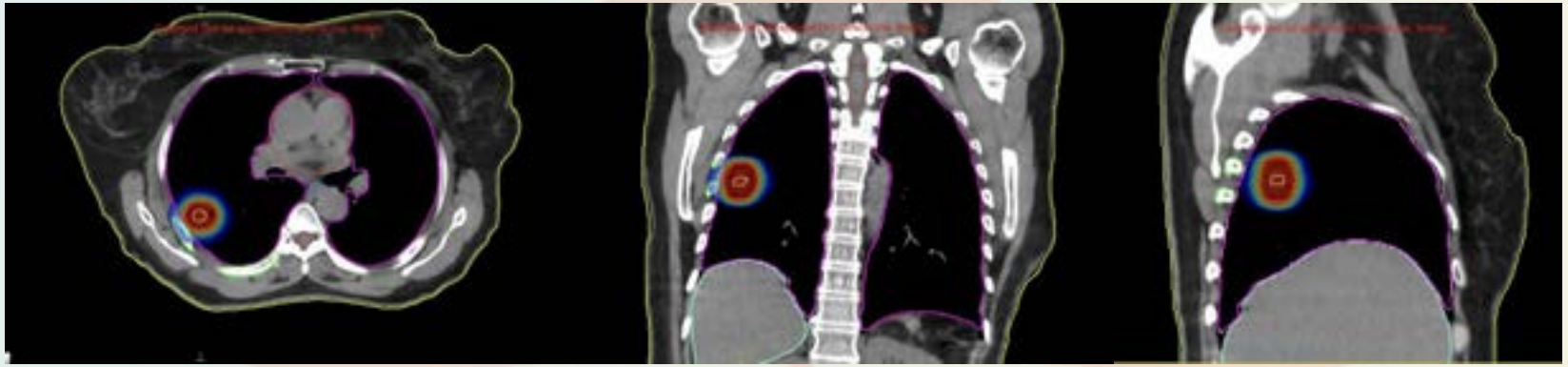
PTV Volume (cc)	Ratio of Prescription Isodose Volume to the PTV Volume		Ratio of 50% Prescription Isodose Volume to the PTV Volume, $R_{50\%}$		Maximum Dose (in % of dose prescribed) @ 2 cm from PTV in Any Direction, D_{2cm} (%)		Percent of Lung Receiving 20 Gy Total or More, V_{20} (%)	
	Deviation		Deviation		Deviation		Deviation	
	None	Minor	None	Minor	None	Minor	None	Minor
13.2	<1.2	<1.5	<4.7	<5.8	<50.0	<58.0	<10	<15

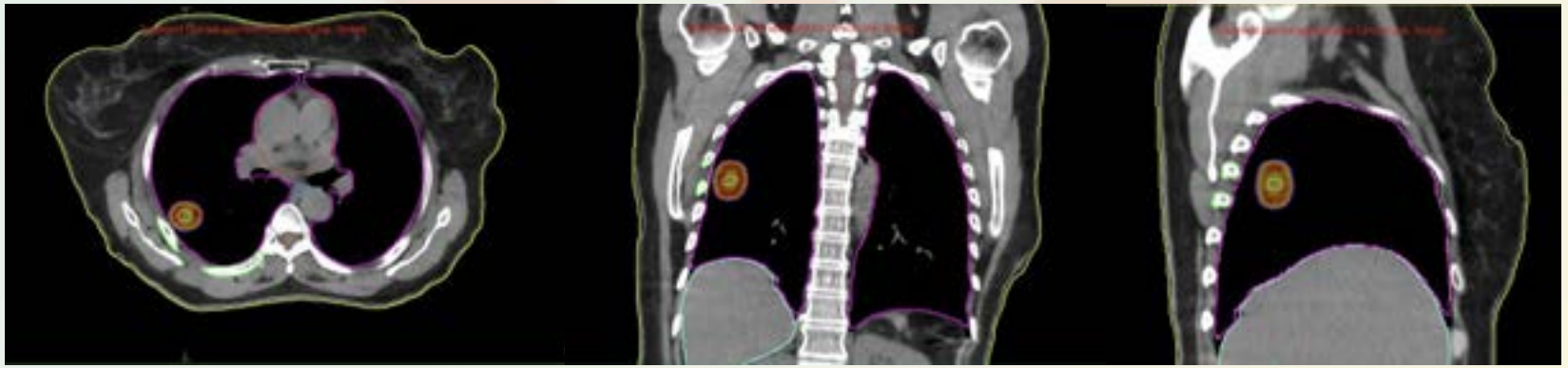
13,208cc 1,03 5,33 %45 %2,2

V34Gy=13,64cc

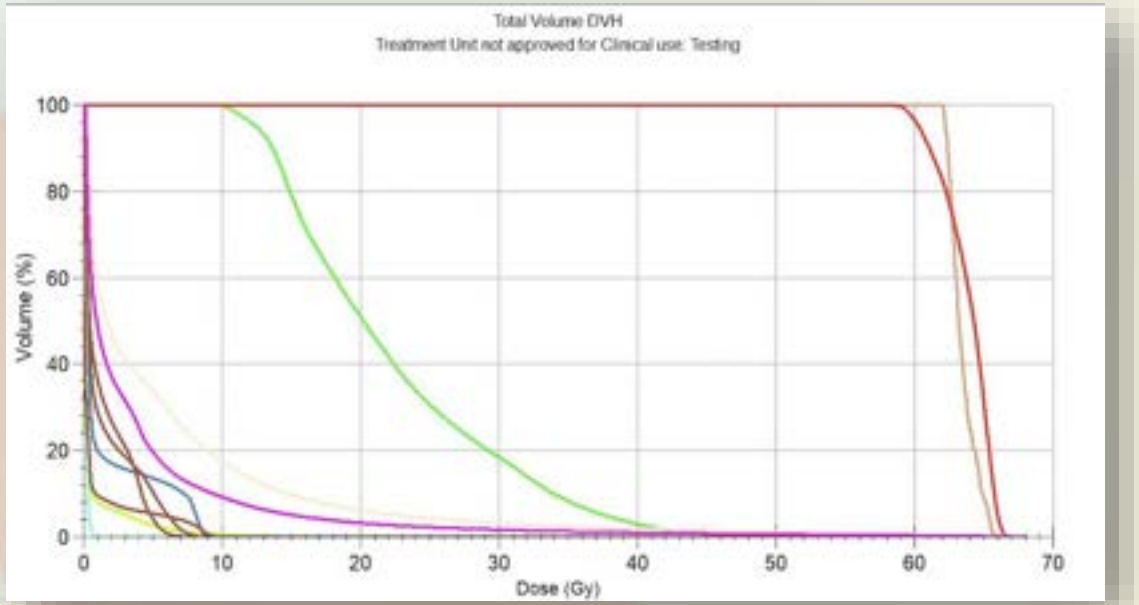
V17Gy=70,45cc

AC SBRT 3 fr x 20 Gy





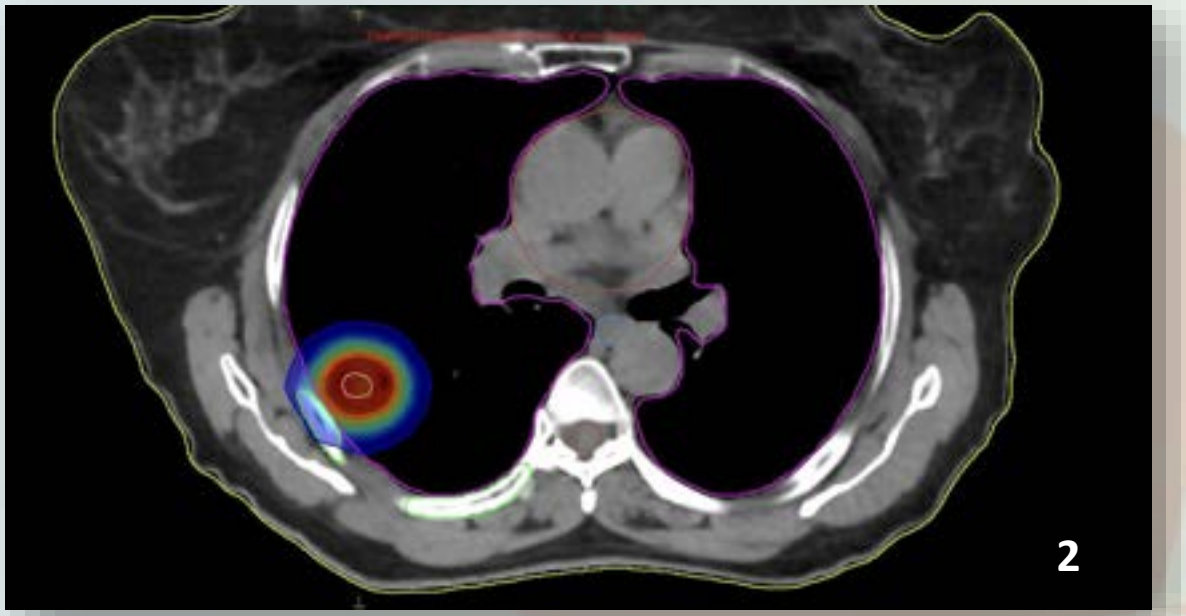
AC SBRT 3 fr x 20 Gy



DVH Statistics

Dosimetric Criteria | Statistics | Display

Structure	Volume (cm³)	Min. Dose (Gy)	Max. Dose (Gy)	Mean Dose (Gy)	Ref. Vol. (cm³)	Ref. Vol. (%)	Ref. Dose (Gy)	Dosimetric Criterion	% in Volume	Is in SS	Heterogeneity Index	Conformity Index
PTV	10.781	57.993	67.254	63.809	10.405	96.51	60.000		100.00	yes	1.09	0.54
					10.781	100.00	57.000	V57Gy > 10.681 cm³				
kosta	13.097	9.793	52.440	22.057	4.000	30.54	25.027		100.00	yes	3.02	0.00
Spinal_Cord	54.070	0.000	9.692	0.634					100.00	no	785.79	
Esophagus	25.004	0.053	8.916	1.446					100.00	yes	72.20	0.00
Heart	558.293	0.099	9.016	1.401					100.00	yes	38.74	0.03
BODY(Unsp.Tiss.)	28204.161	0.000	20.147	0.455					99.60	no	477.31	0.53
30.000Gy	59.697	28.068	67.449	45.111					100.00	yes	2.11	
60.000Gy	10.683	59.030	67.327	63.877					100.00	yes	1.09	
TAC	3041.802	0.068	67.205	3.684	98.768	3.25	20.000		100.00	yes	93.79	0.05
ptv 2cm	191.664	0.713	25.963	10.684					100.00	yes	14.55	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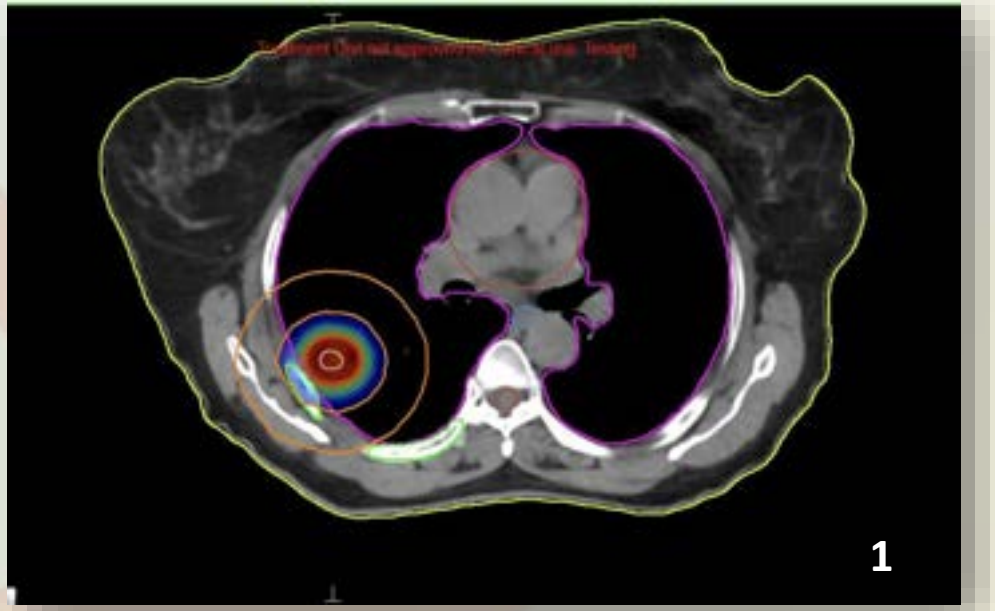
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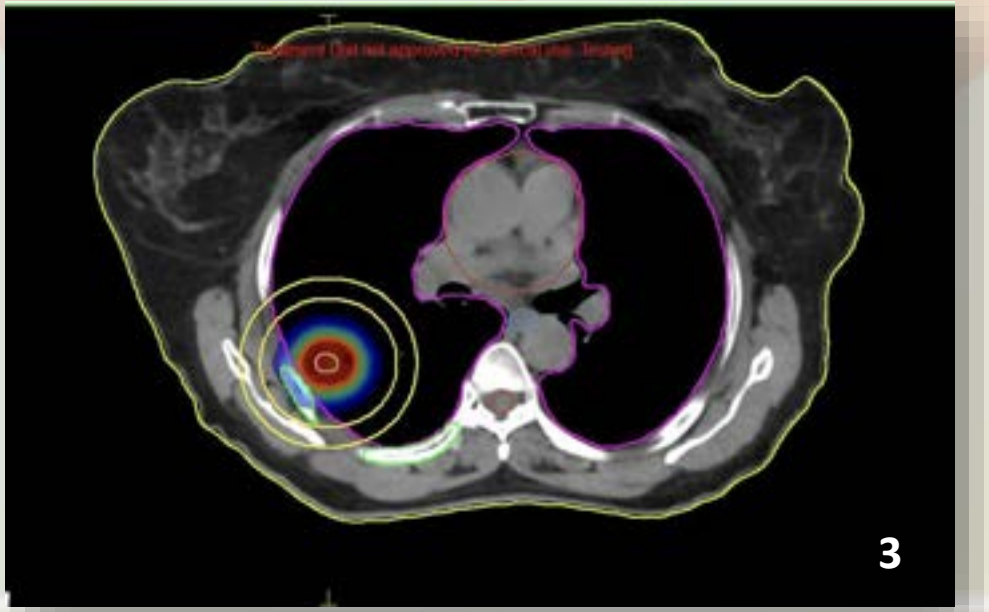

3

Bölüm 3

Kemik SBRT

IMDb RATING
6.7/10
542K

Kemik SBRT

RADIATION THERAPY ONCOLOGY GROUP

RTOG 0631

PHASE II/III STUDY OF IMAGE-GUIDED RADIOSURGERY/SBRT FOR LOCALIZED SPINE METASTASIS

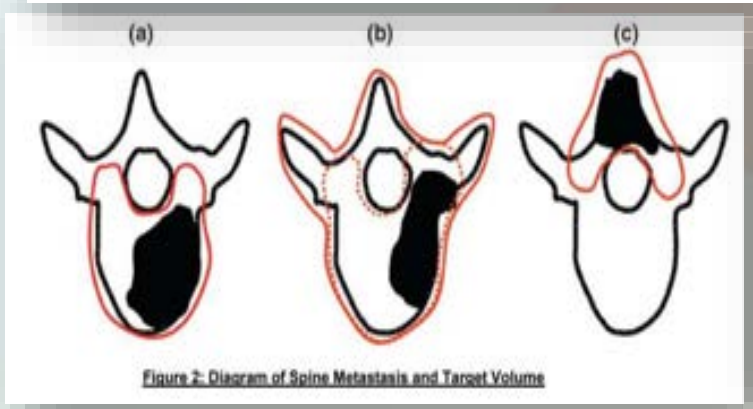
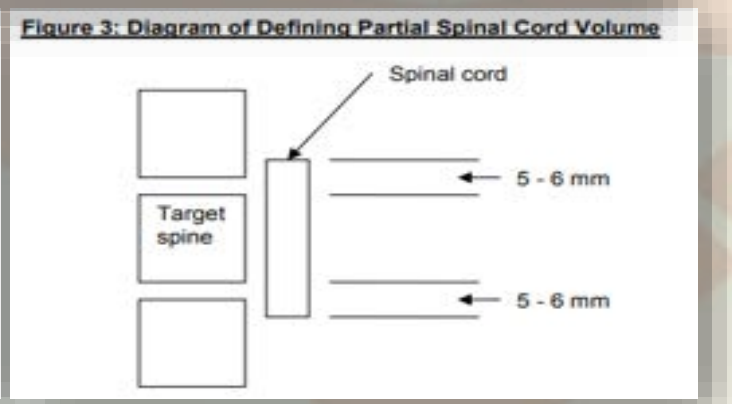
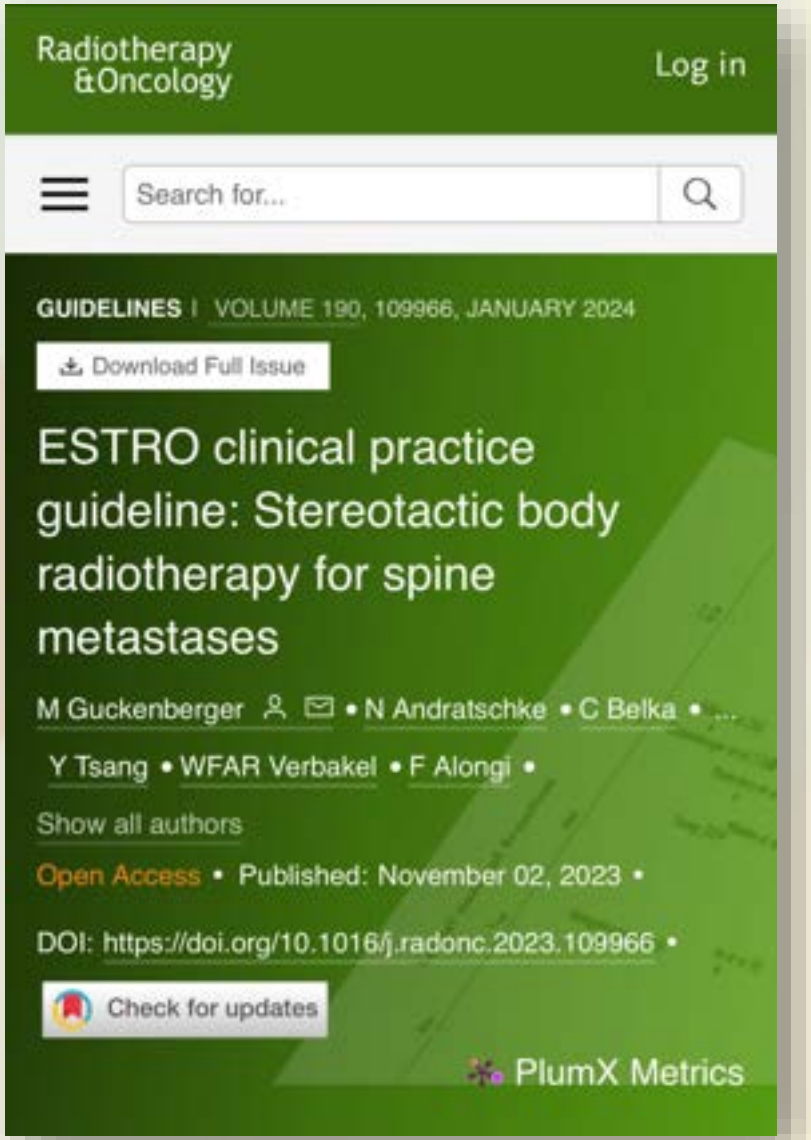
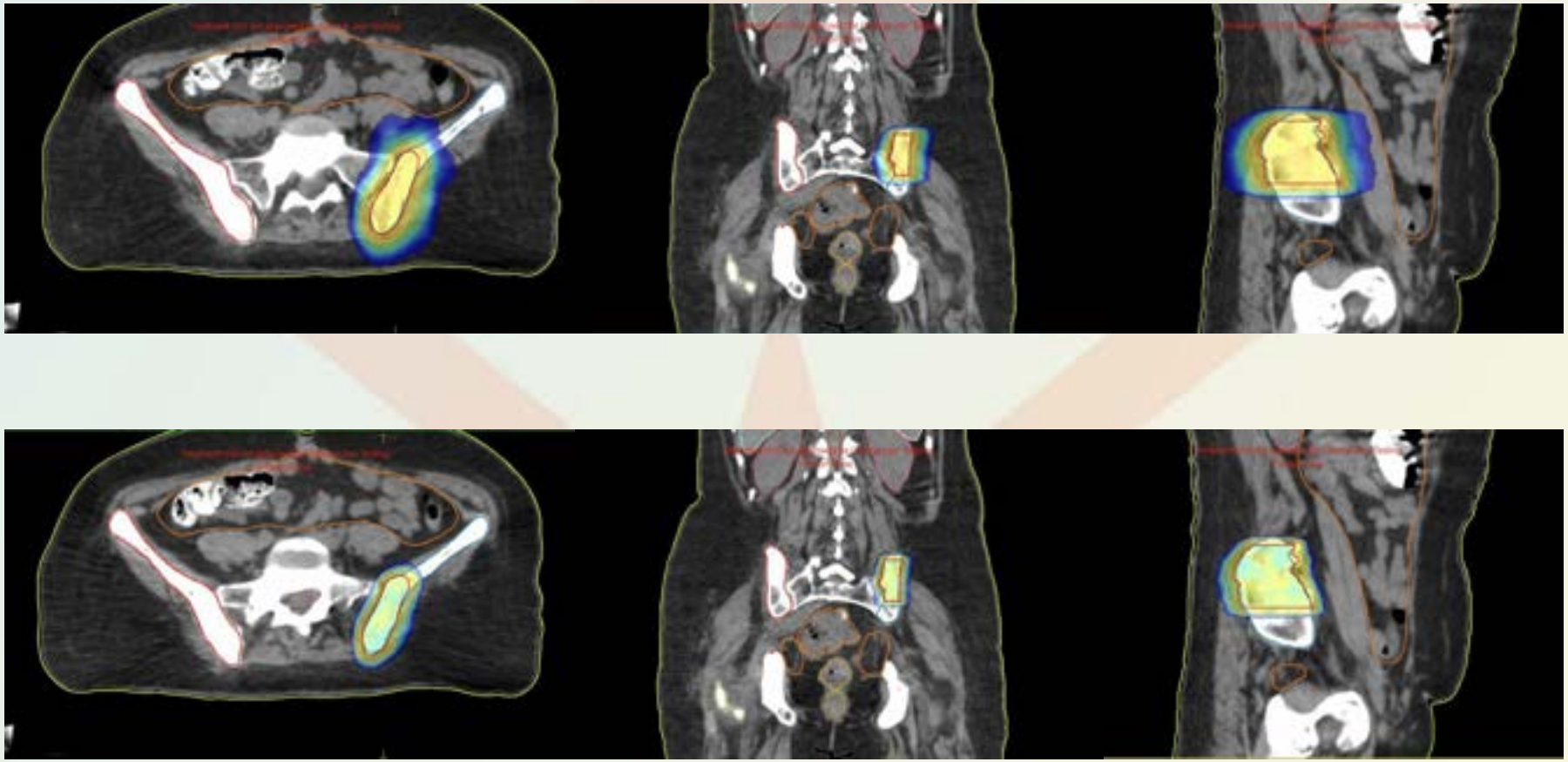


Figure 2: Diagram of Spine Metastasis and Target Volume

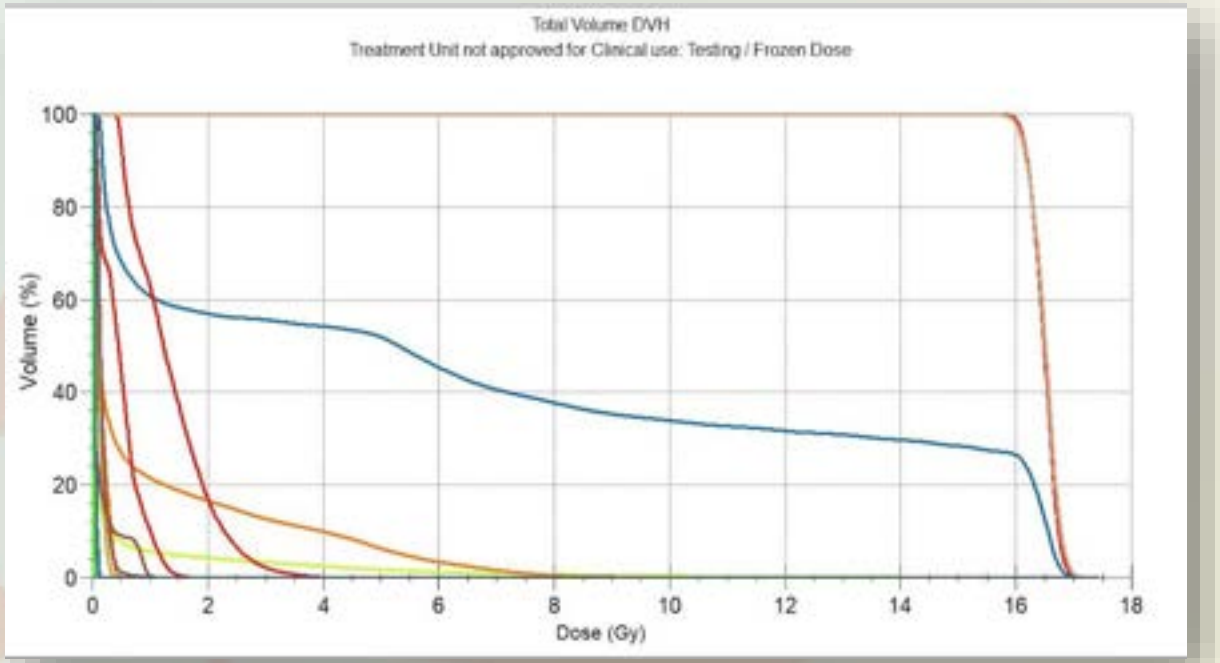




Sol iliak SBRT



Sol iliak SBRT

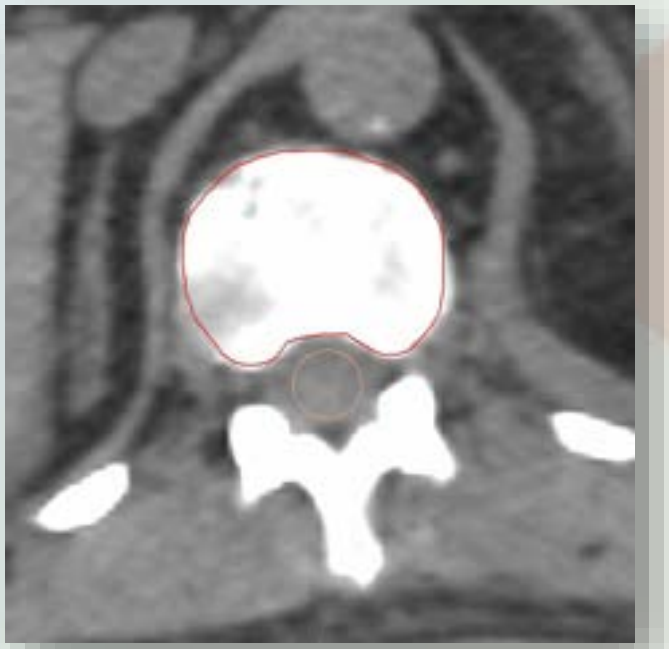


DVH Statistics

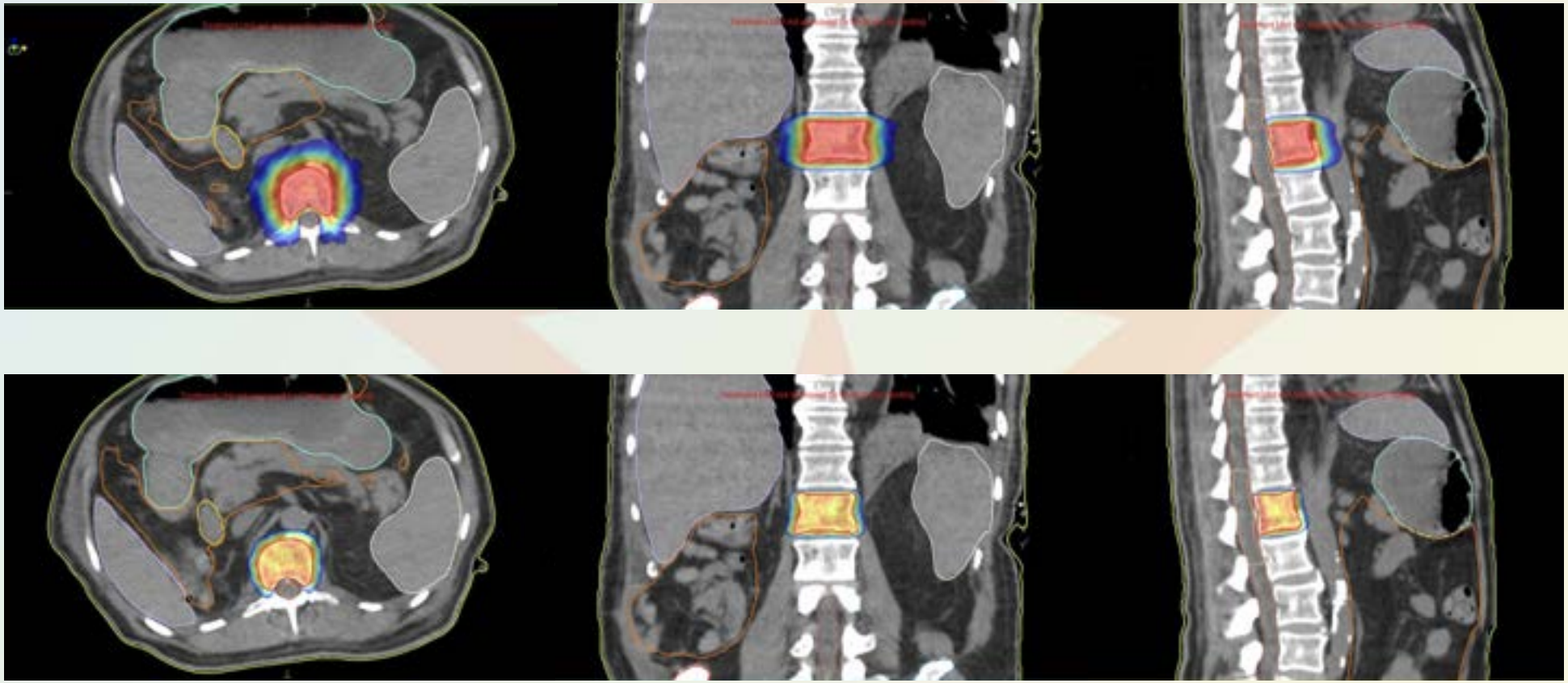
Dosimetric Criteria | Statistics | Display

Structure	Volume (cm³)	Min. Dose (Gy)	Max. Dose (Gy)	Mean Dose (Gy)	Ref. Vol. (cm³)	Ref. Vol. (%)	Ref. Dose (Gy)	Dosimetric Criterion	% in Volume	Is in SS	Heterogeneity Index	Conformity Index
PTV 16	96.167	15.397	17.428	16.488	94.250	98.01	16.000		100.00	yes	1.05	0.94
9.000Gy_1	72.284	0.313	14.011	1.836					100.00	yes	12.99	0.00
Spinal_Cord	57.617	0.000	1.218	0.118					100.00	yes	139.11	0.00
BODY(Unsp.Tiss.)	38658.936	0.000	16.782	0.298					100.00	no	235.53	0.39
Bowel_Bag	2583.011	0.011	11.660	0.946					100.00	yes	186.69	
Femur_Head_L	115.063	0.016	0.138	0.051					100.00	yes	3.72	
Femur_Head_R	122.089	0.011	0.084	0.035					100.00	yes	3.49	
Rectum	38.865	0.036	0.385	0.113					100.00	yes	5.38	
Urinary_Bladder	435.701	0.041	1.460	0.160					100.00	yes	5.10	
Vagina	13.295	0.032	0.100	0.055					100.00	yes	2.19	

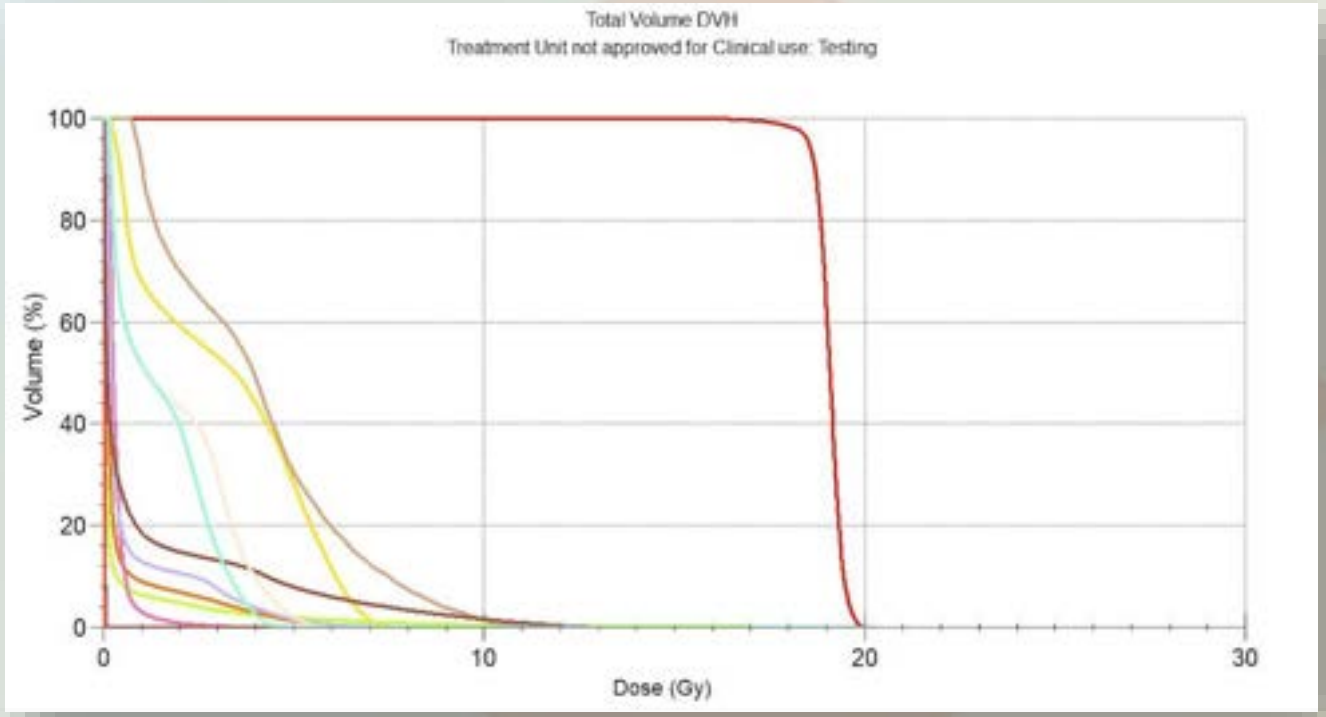
Konturlama - GTV/OAR



Planlama – plan değerlendirme (Basic)



Planlama – plan değerlendirme (Basic)

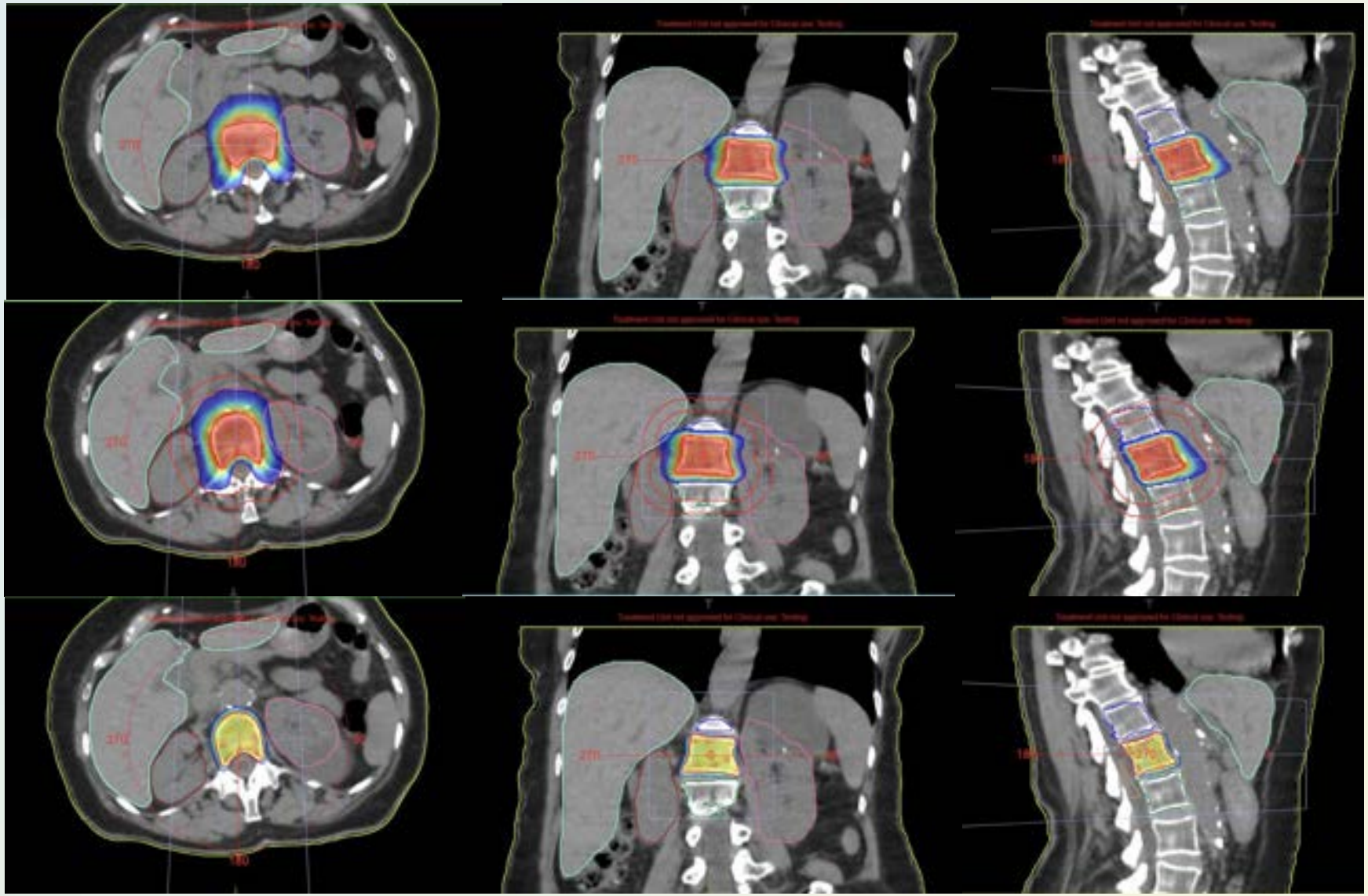


DVH Statistics

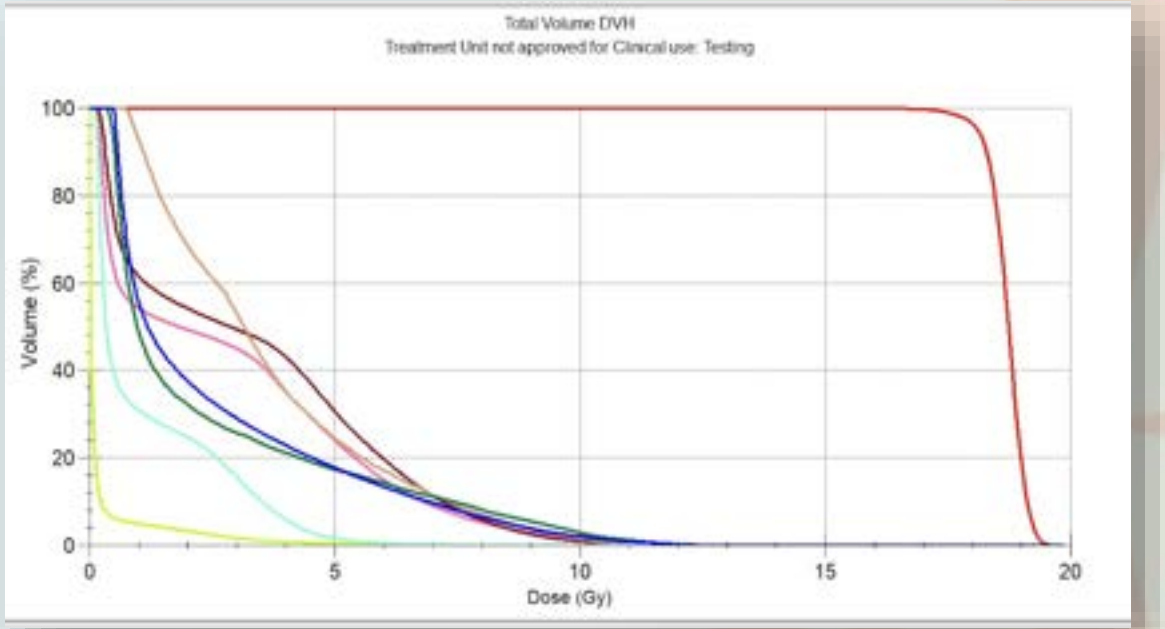
Dosimetric Criteria | Statistics | Display

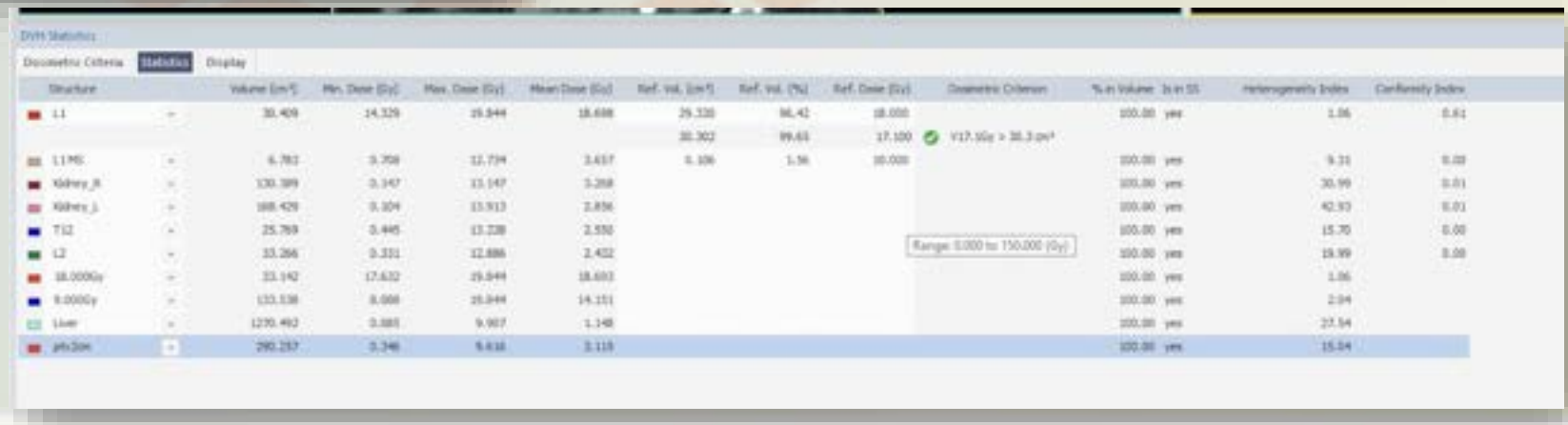
Structure	Volume (cm³)	Min. Dose (Gy)	Max. Dose (Gy)	Mean Dose (Gy)	Ref. Vol. (cm³)	Ref. Vol. (%)	Ref. Dose (Gy)	Dosimetric Criterion	% in Volume	Is in SS	Heterogeneity Index	Conformity Index
L1	40.050	14.960	20.283	19.056	39.449	98.50	18.000		100.00	yes	1.06	0.48
l1 ms	8.176	0.690	11.692	3.967	0.121	1.48	10.000		100.00	yes	9.57	0.00
BODY(Unsp.Tiss.)	28190.724	0.000	19.760	0.347					99.79	no	287.24	0.45

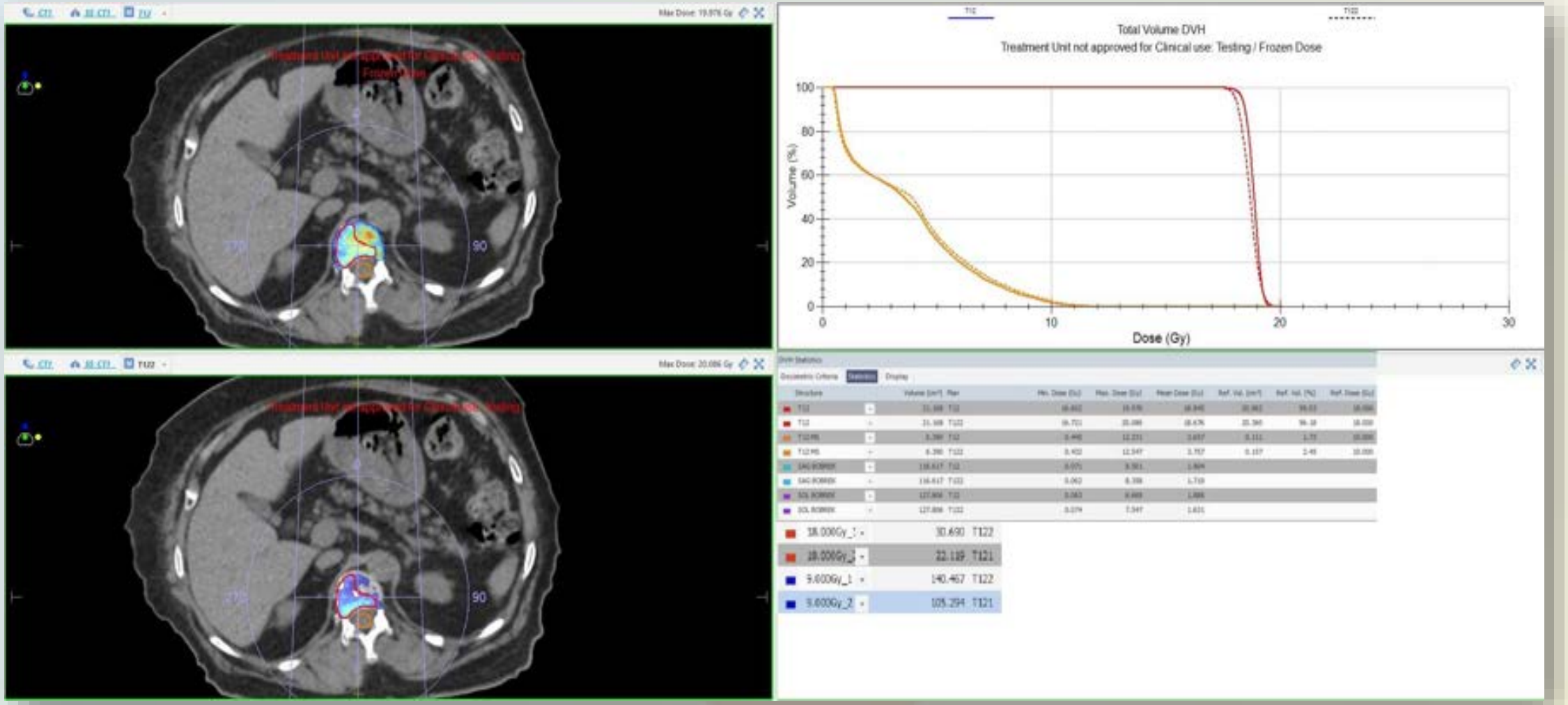
Detailed



Planlama – plan değerlendirme (Detaylı)



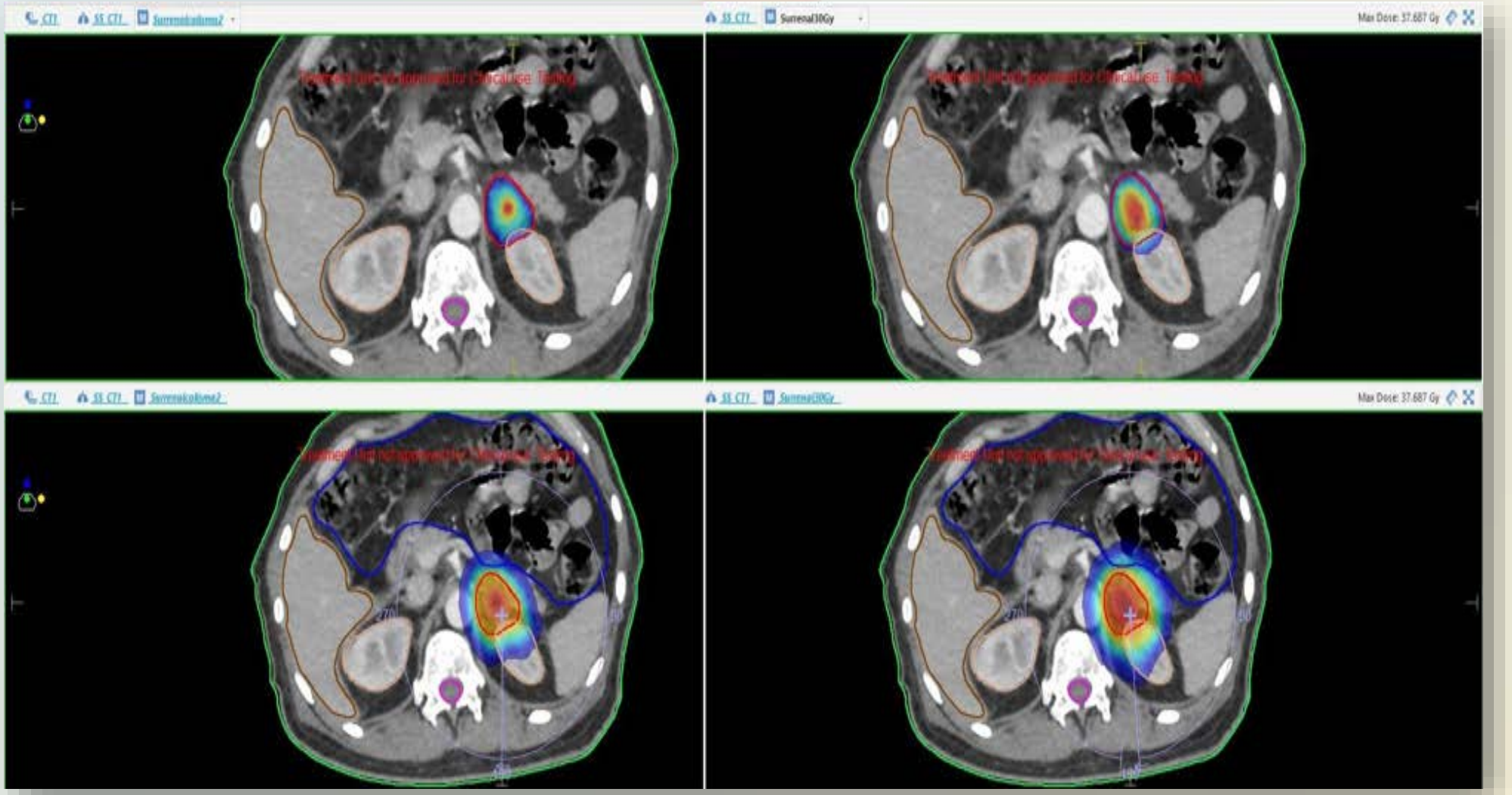




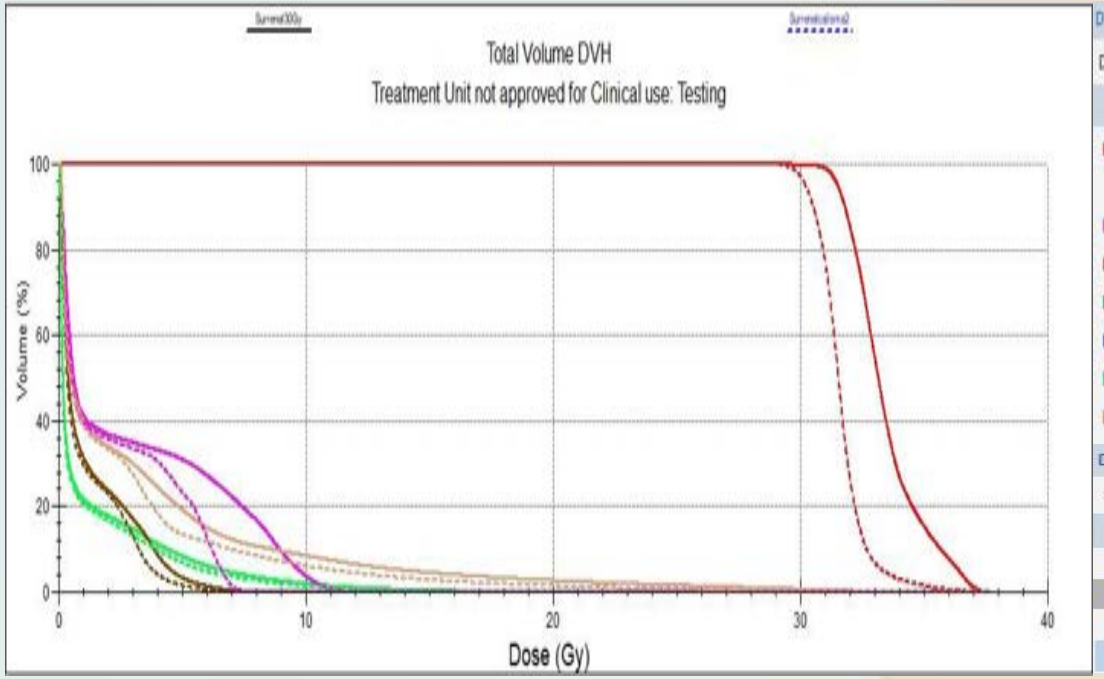
CI= 0,84 ≈ 1 HI= 0,09 ≈ 0 GI= 6.6 (< 5,5)

CI= 0,89 ≈ 1 HI= 0,08 ≈ 0 GI= 4.97 (< 5,5)

Kötü örnek



Kötü örnek



DVH Statistics

Dosimetric Criteria | Statistics | Display

Structure	Volume (cm³)	Min. Dose (Gy)	Max. Dose (Gy)	Mean Dose (Gy)	Ref. Vol. (cm³)	Ref. Vol. (%)	Ref. Dose (Gy)	Dosimetric Criterion
PTV	38.117	28.350	37.608	31.620	37.012	97.10	30.000	
					38.115	99.99	28.500	V28.5Gy > 38.017 ...
MS	25.239	0.075	7.768	2.163				
KC	1404.699	0.046	8.841	1.059				
SOL BOBREK	224.401	0.092	32.978	3.515				
SAG BOBREK	226.300	0.062	5.576	1.426				
BODY(Unsp.Tiss.)	12087.902	0.005	16.743	1.064				
T_Bobrek	450.701	0.062	32.978	2.467	32.132	7.13	9.000	

DVH Statistics

Dosimetric Criteria | Statistics | Display

Structure	Volume (cm³)
15.000Gy	168.959
15.000Gy_k	224.637
30.000Gy	39.132
30.000Gy_k	52.819

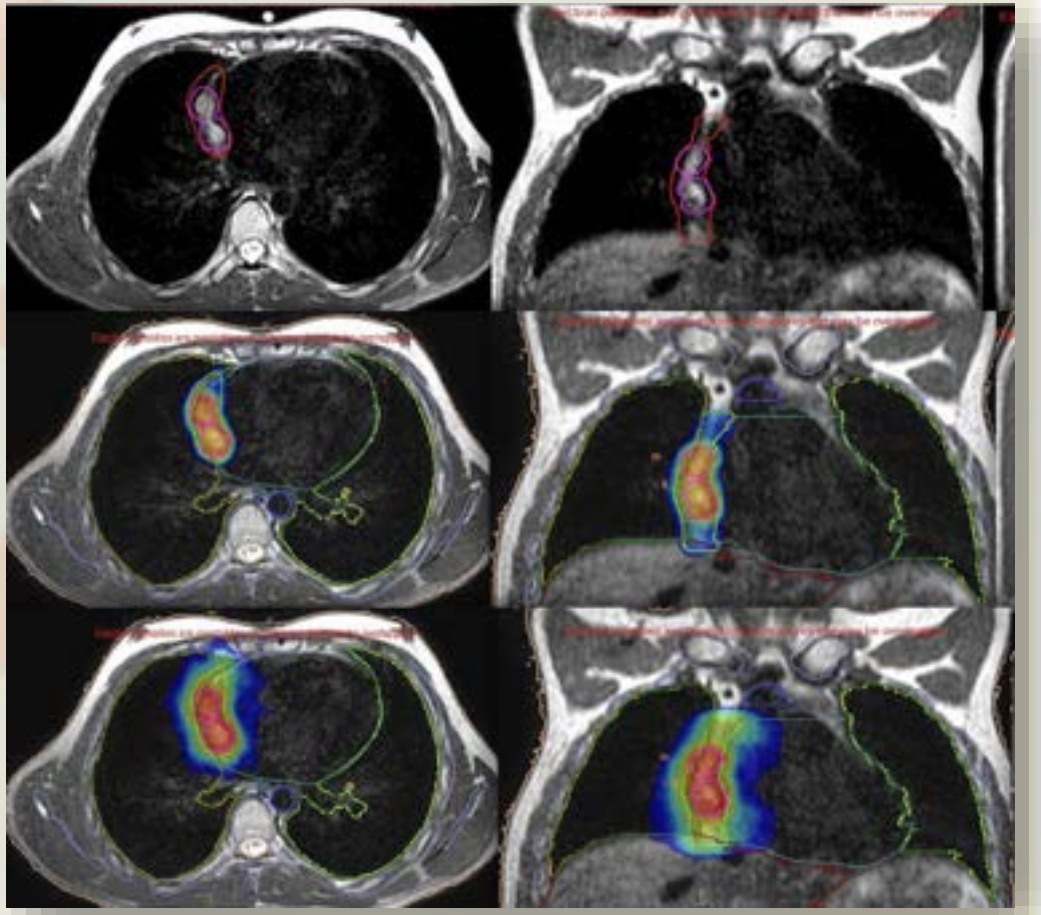
CI= 0,71 ≈ 1 HI= 0,17 ≈ 0 GI= 5,9 <5

CI= 0,96 ≈ 1 HI= 0,14 ≈ 0 GI=4,4 < 5

Current & Future Perspectives

MR-Linac

MR-Linac



Sonuç

- IMRT vs. SBRT
  - Yüksek doz
  - Hedef tanımlamaları
  - İmmobilizasyon
  - Detaylı Plan değerlendirme
  - Klinik tecrübe (Tekniker --> Fiz. Müh. --> Dr.)

Teşekkürler…

ocguler@gmail.com