Thyroid Uptake & Nodule ablation

Mohammad Abuqbeitah

PhD candidate

Istanbul University-Cerrahpaşa

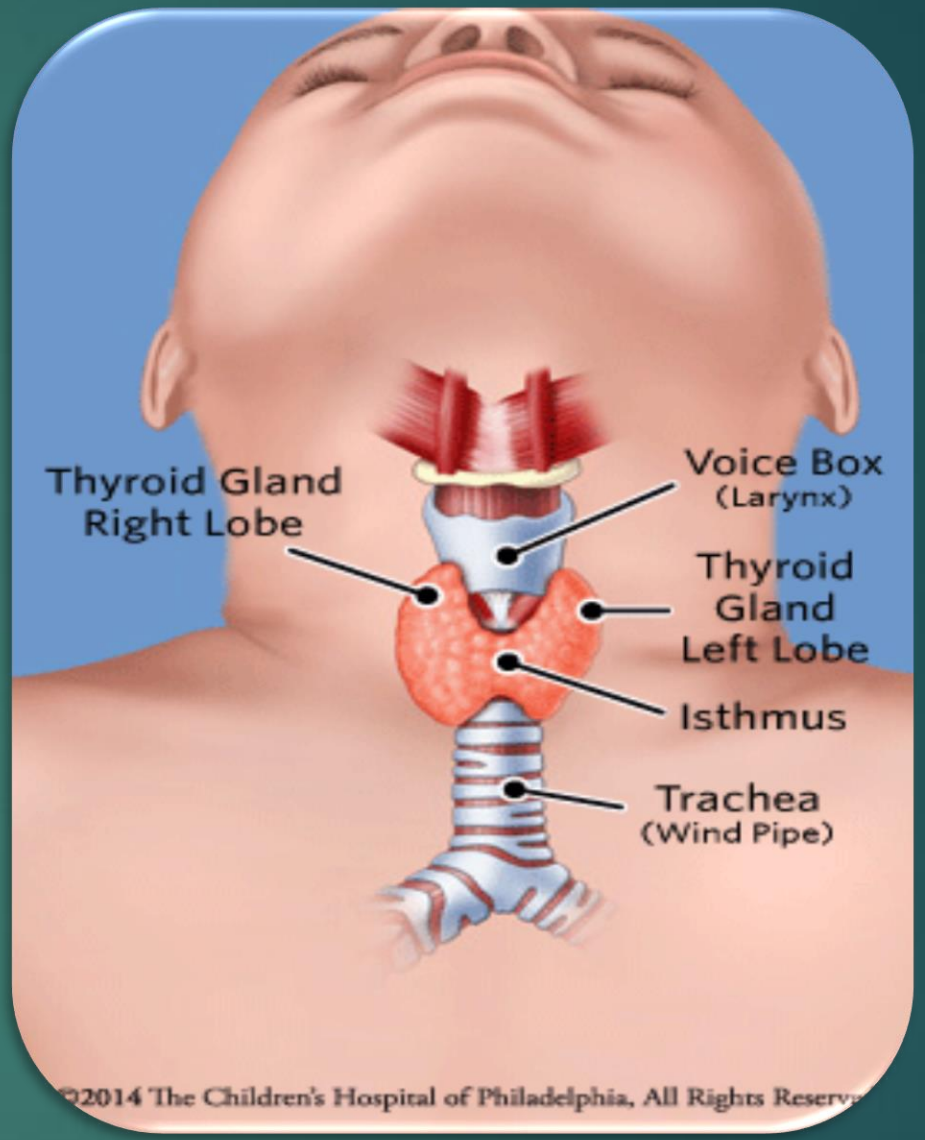
Nuclear Medicine Dept.

17. ULUSAL
MEDİKAL FİZİK KONGRESİ
18-19 Ekim 2019

- **Thyroid gland** secretes three hormones, namely (thyroxine/T_4 and triiodothyronine/T_3), and calcitonin.

- **TG** controls many parts of human's metabolism, (heart beats and burning calories.

- **TSH** is released by the anterior pituitary and stimulates the thyroid follicular cells to release thyroxine, T4 (80%) and triiodothyronine, or T3 (20%)



Thyroid diseases

Hyper-thyroidisim

- when it makes too many hormones.
- 1- Greaves
- 2- Toxic Adenoma

Overactive nodule in th thyroid

Hypo-thyroidisim

- when the gland doesn't make enough hormones.
- Causes: insufficient iodine, thyroiditis, radiaiton exposure

….Thyroid cancer

Benign Cancer

- Greaves
- Toxic adenoma

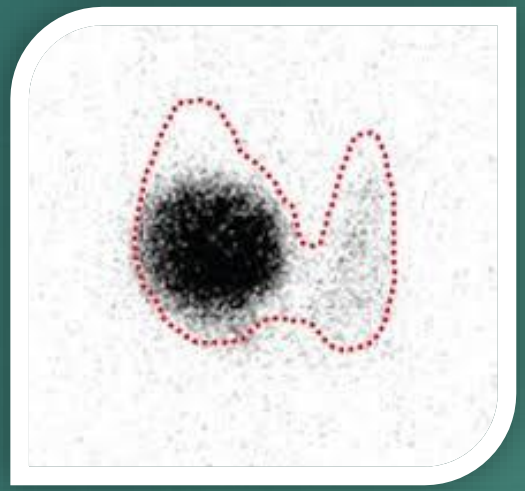
Malignant Cancer

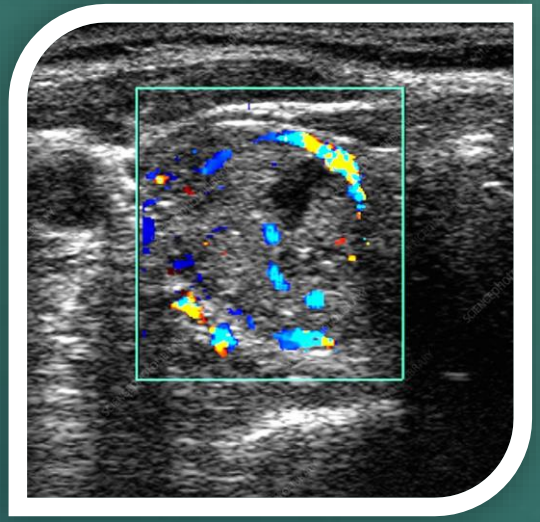
- Well-Differentiated group
  - Papillary adencarcinoma
  - Follicular
  - H- cell cancer
- Medullary
- Anaplasmatic Cancer

Thyroid Diseases Treatment

- Medication: Thyroiditis
- Surgery: Goiter, hyperthyroidisim and cancer
- Radiation therapy: Medullary and anaplastic cancers
- **Radiofreuency: Nodular thyroid**
- **Radioactive 131I: benign cancer and post-thyroidectomy**

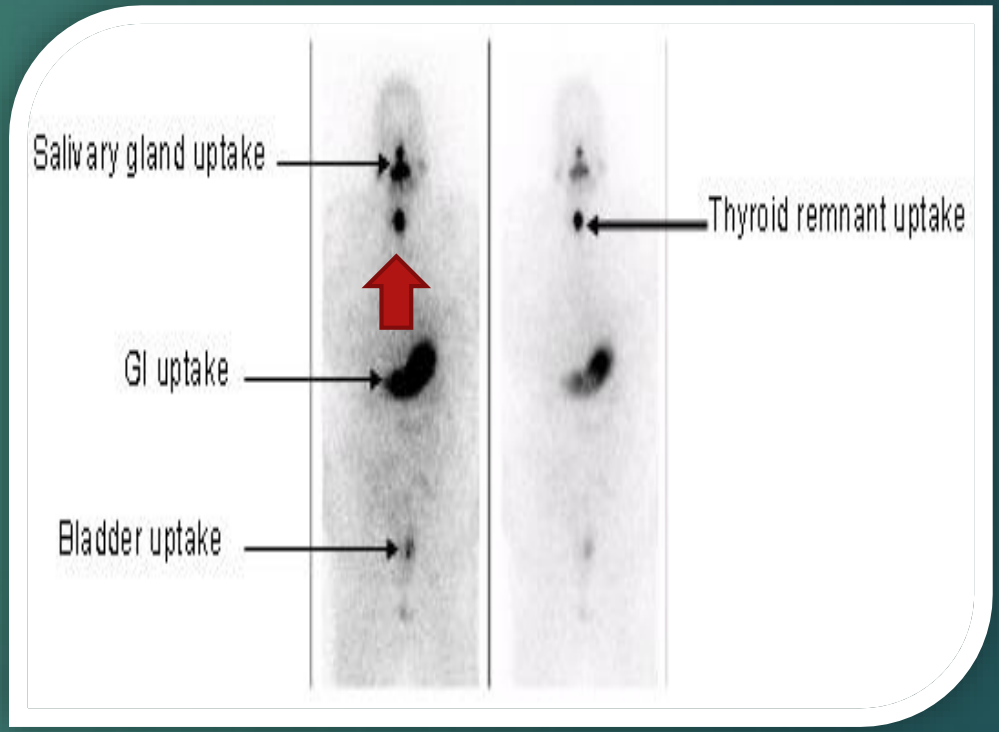
Toxic adenoma



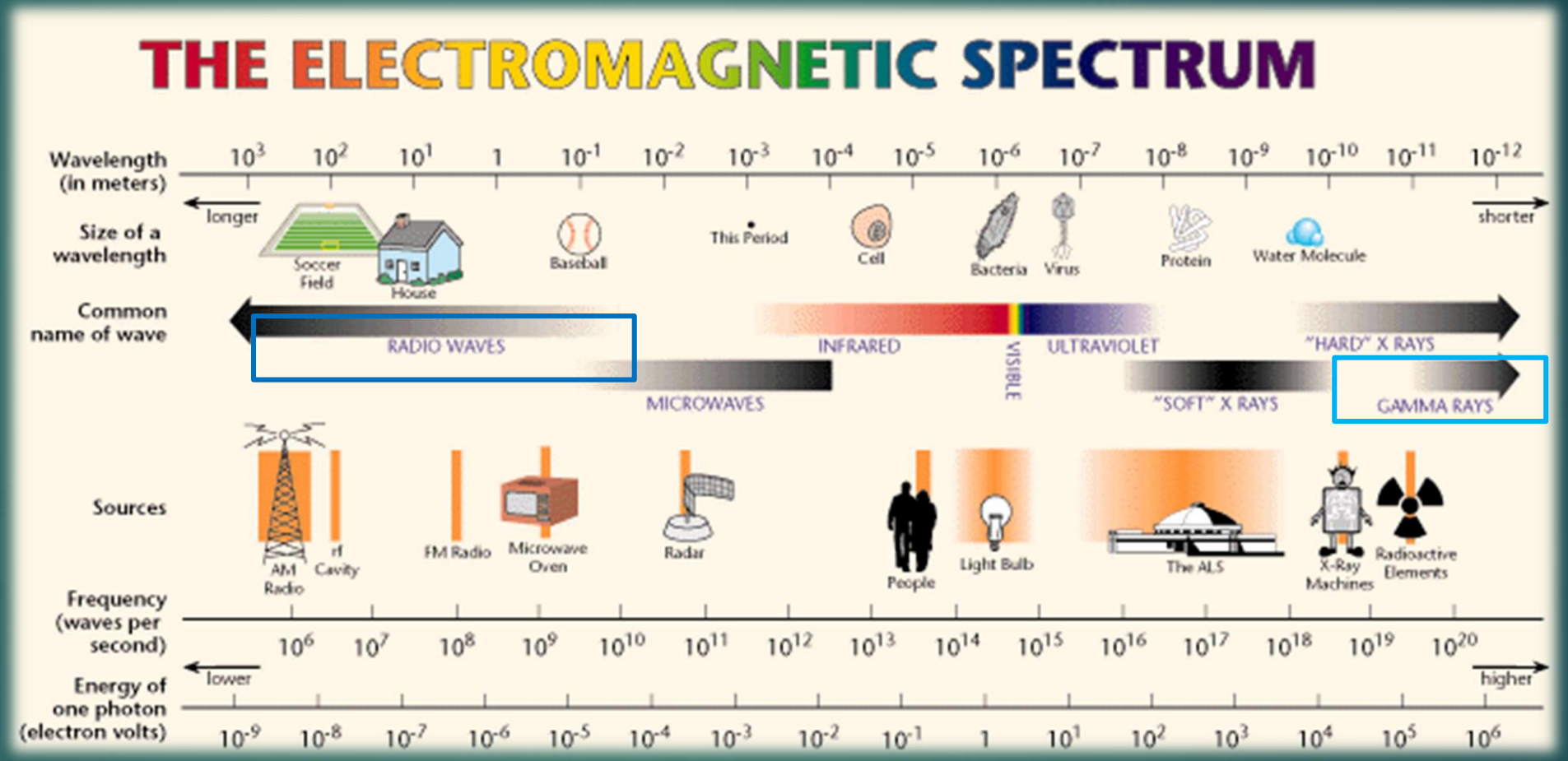


Thyroid Residues

(Post-thyroidectomy)

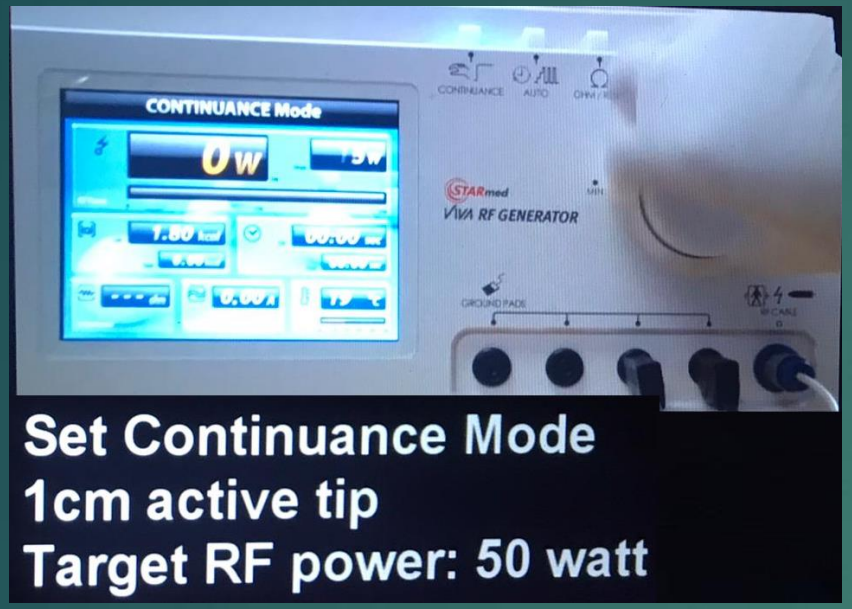


Nodular Therapy



Radiofrequency

- RF ablation uses the heat generated from high-frequency alternating electric current oscillating between 200 and 1200 kHz.
- RF power is 30–120 W depending on the size of the active tip and the internal characteristics of the nodules
- Active tips of various lengths, for example, 0.5, 0.7, 1.0, or 1.5 cm
- The RF waves passing through the electrode agitate tissue ions around the electrode, and they increase the temperature (by frictional heat) within the tumour tissue.
- At temperatures between 60 and 100°C, nearly immediate tissue coagulation is induced with irreversible damage caused to tumour tissue,
- while temperatures greater than 100–110°C result in tissue vaporization and carbonization.
- Ground pads (dispersive electrodes) applied to the skin are connected to the radiofrequency generator, and the generator is connected to the RF needle electrode


CONTINUANCE Mode
0w
STARmed
VIVA RF GENERATOR
Set Continuance Mode
1cm active tip
Target RF power: 50 watt

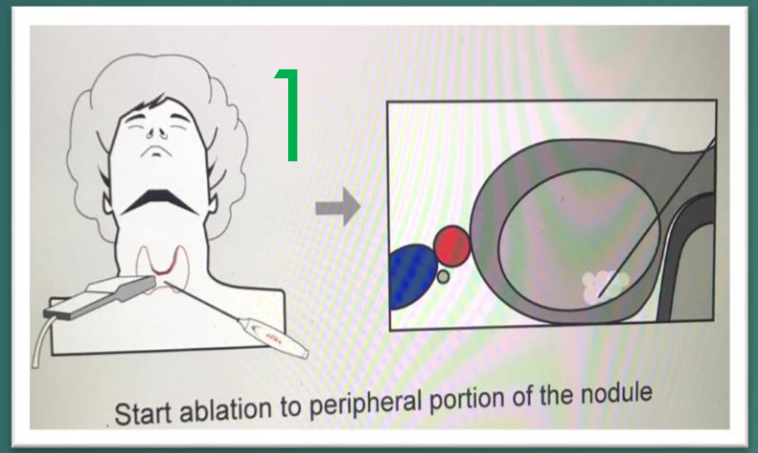

GENERATORE RF
POMPA
PEDALE
RF generator - peristaltic pump - foot pedal

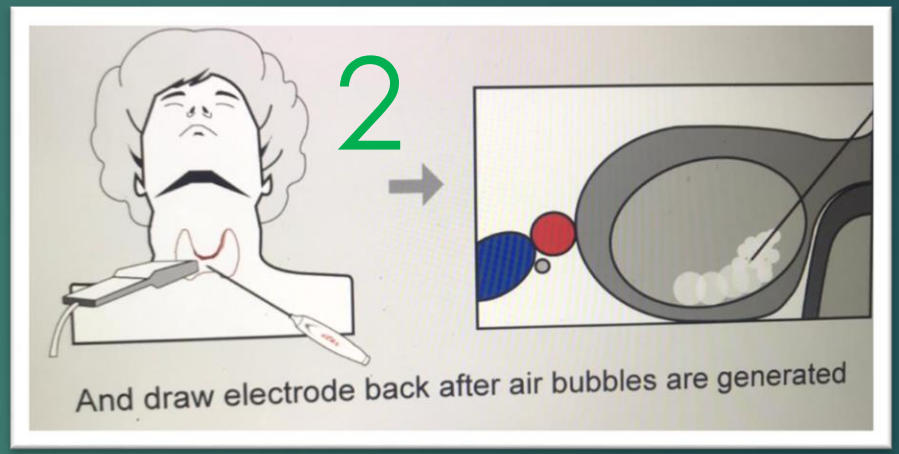

SOLUZIONE FISIOLOGICA
GENERATORE RF
POMPA

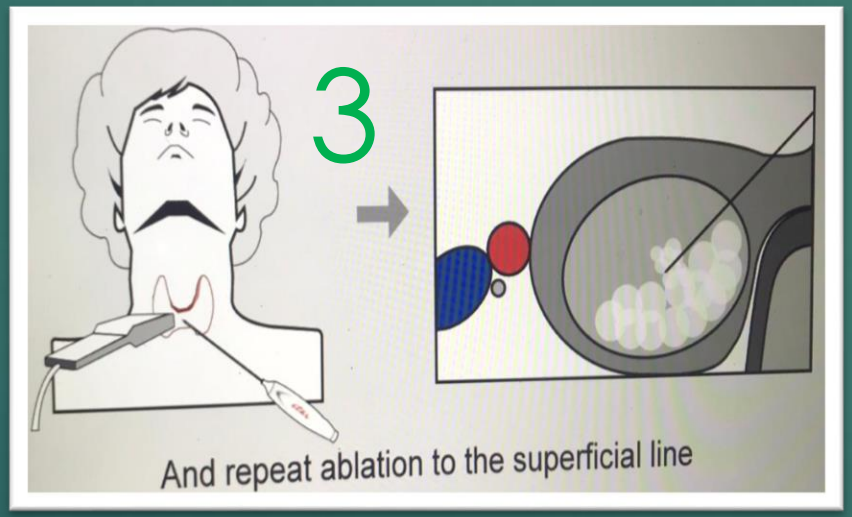

STARmed
18-07s10F
RFA ELECTRODE NEEDLE (FIXED)
DIAMETER 18 GAUGE, SHAFT LENGTH 7 CM, ACTIVE TIP 10 MM

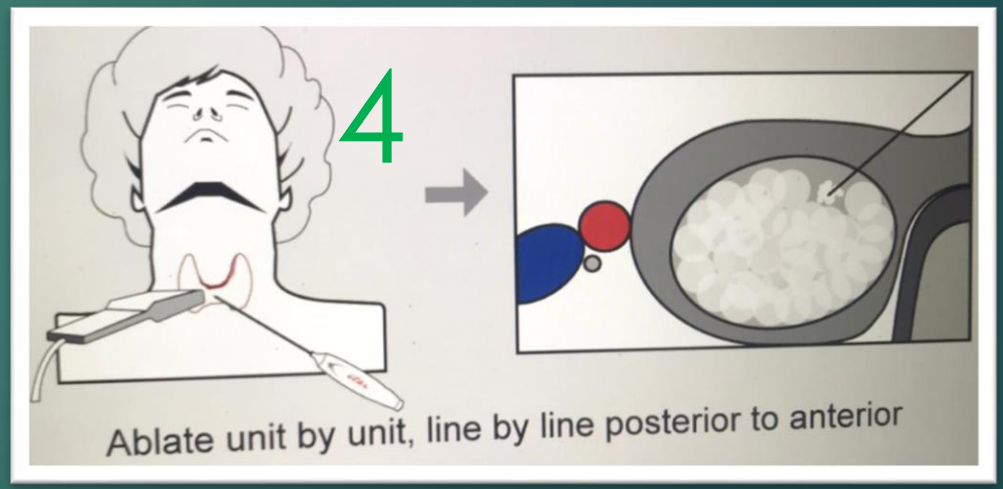

MONOPOLAR RFA
ground pads are placed
at both patient's thighs
in order to create a
closed-loop circuit

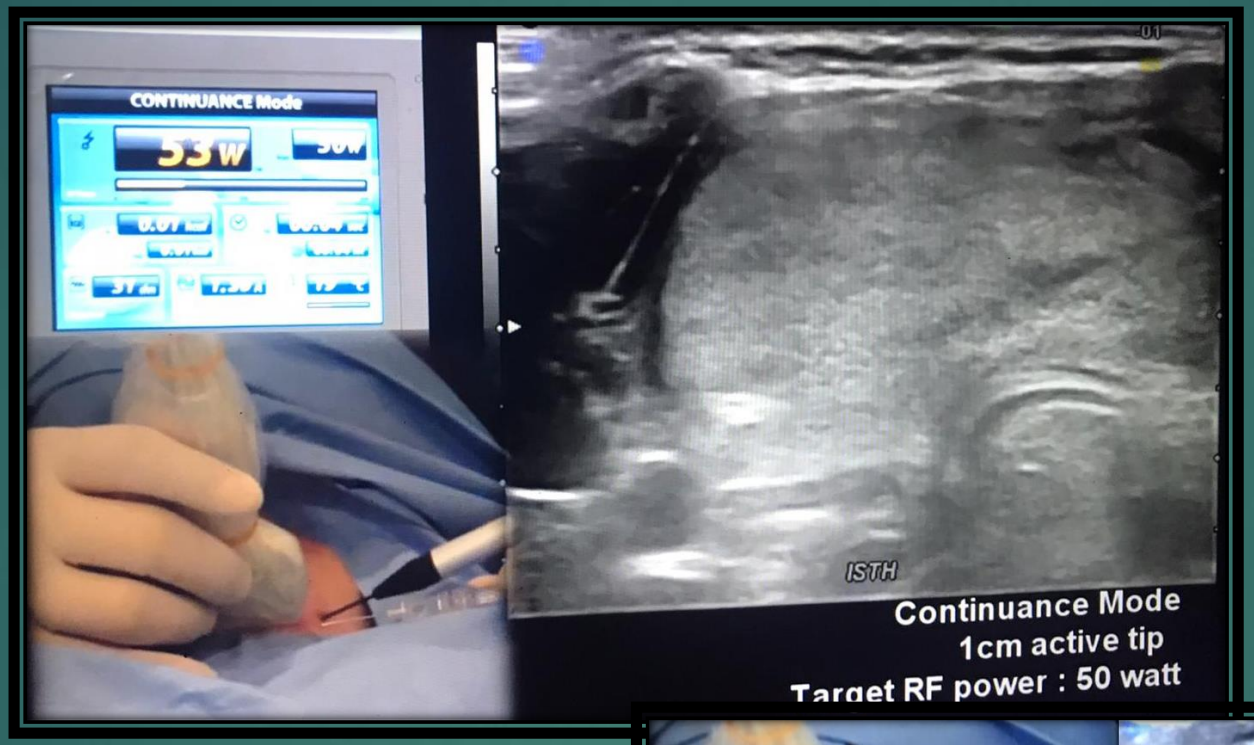
Moving shot technique

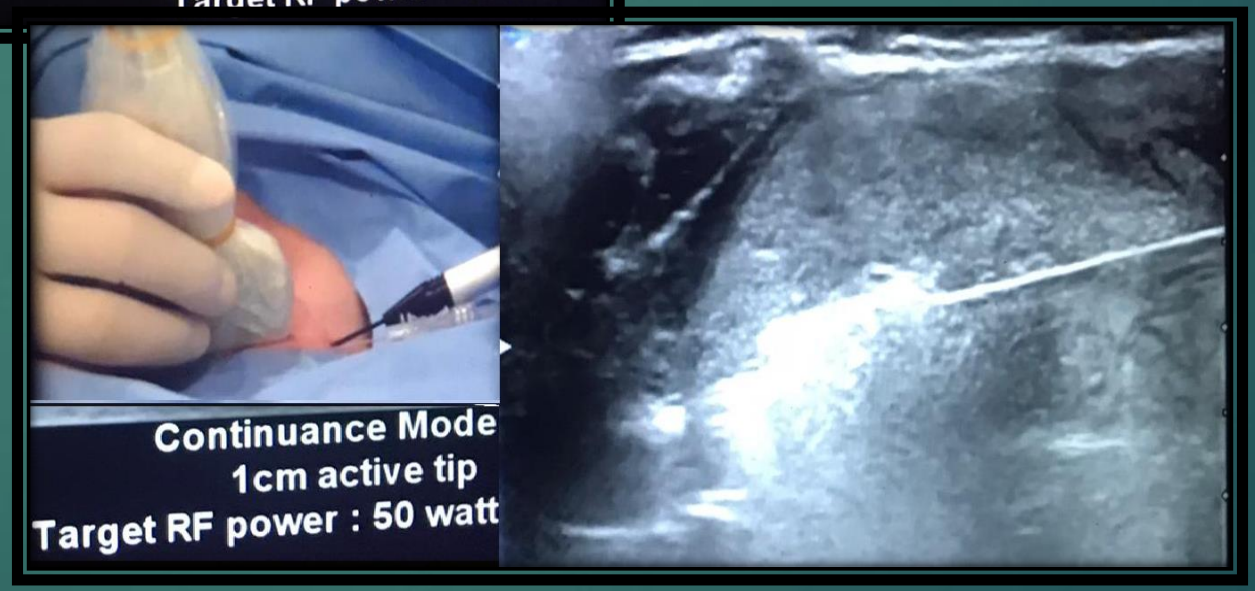








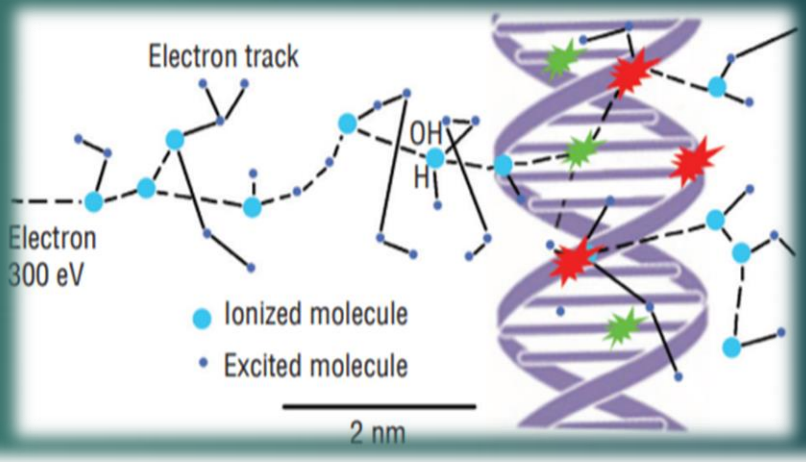

CONTINUANCE Mode
55W
ISTH
Continuance Mode
1cm active tip
Target RF power : 50 watt


Continuance Mode
1cm active tip
Target RF power : 50 watt

Radioiodine (131I) therapy

Table 1. Physical properties of iodine-131 [2]

Type of radiation emitted	Energy	Percentage
Beta minus (electrons)	248 keV	2.1
	334 keV	7.4
	606 keV	89.3
	812 keV	0.7
Gamma	723 keV	1.8
	637 keV	7.3
	364 keV	81.2
	284 keV	6.1
	80 keV	2.6



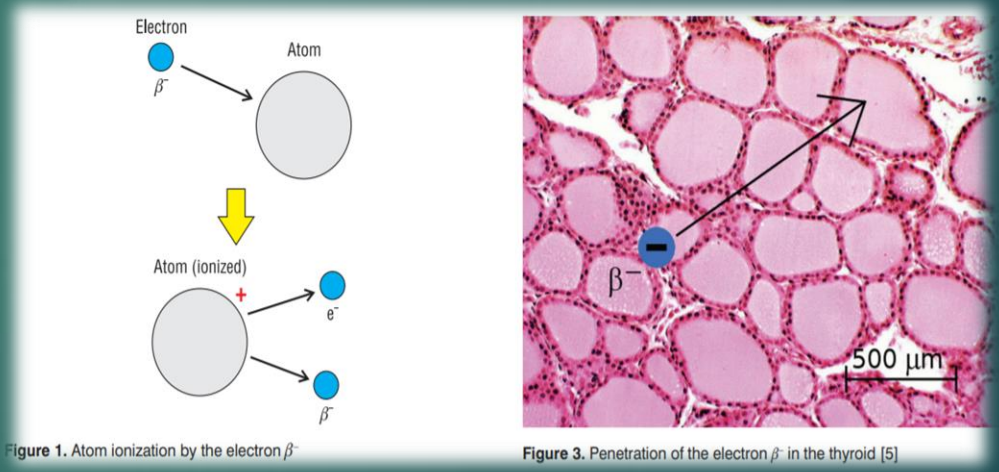
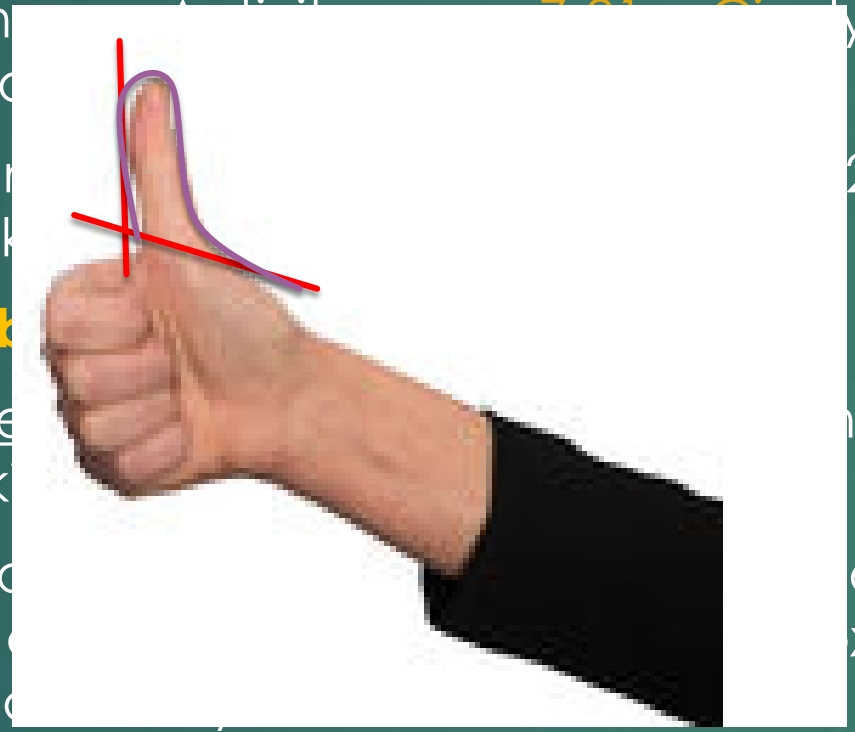


Figure 1. Atom ionization by the electron β^-

Figure 3. Penetration of the electron β^- in the thyroid [5]

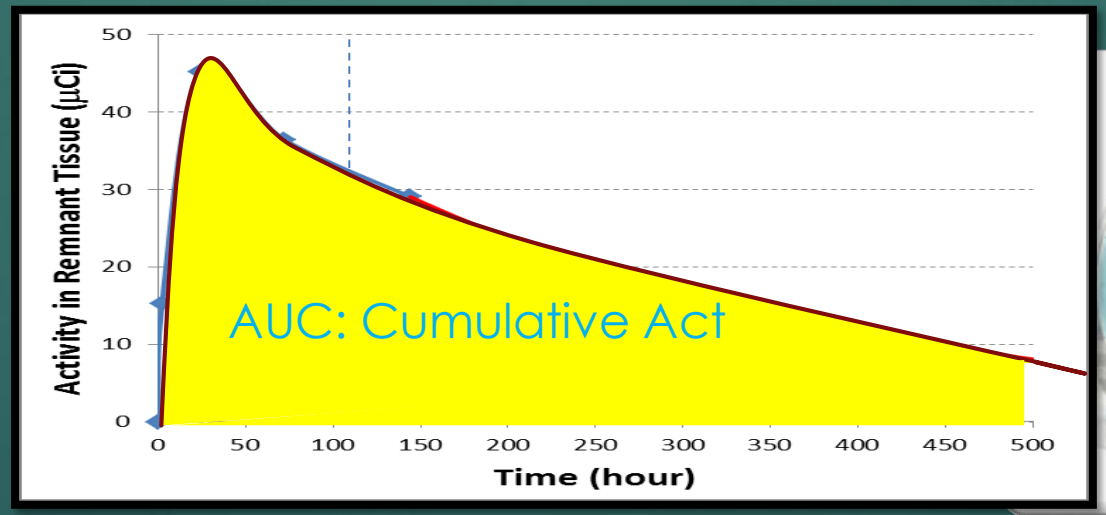
131I treatment routes

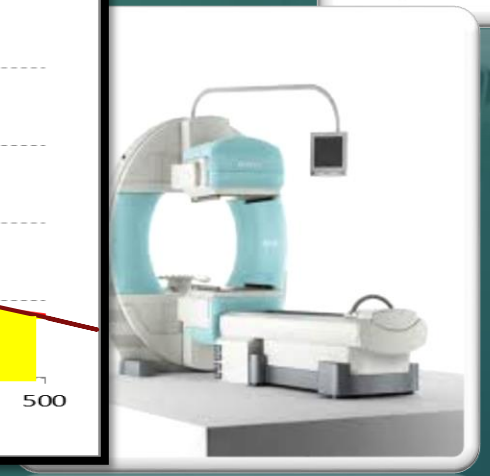
- **Fixed dose (empirical):-**
  - Toxic Aden… …ying on the 2 and 24 ho…
  - Thyroid Car… …2 and 24 hours uptak…
- **Dosimetry b…**
  - Patient spe… …t the iodine biok…
  - Absorbed d… …d as adequate … …xic adenoma …



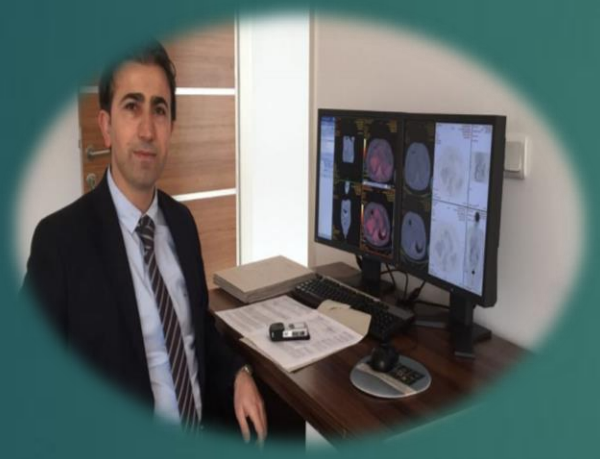
Thyroid Dosimetry Headlines…

- *Tracer administration:* 10-20 µCi 131I for TA, 100-200 µCi for Thyroid ablation
- Deriving *time –Activity Curve* by acquiring subsequent uptake values along 96-168 hours.
- *Cumulative Activity* calculation
- *Dose calculation*
- **Estimating the activity that will deliver desired** dose e.g 300 Gy





Clinical Study

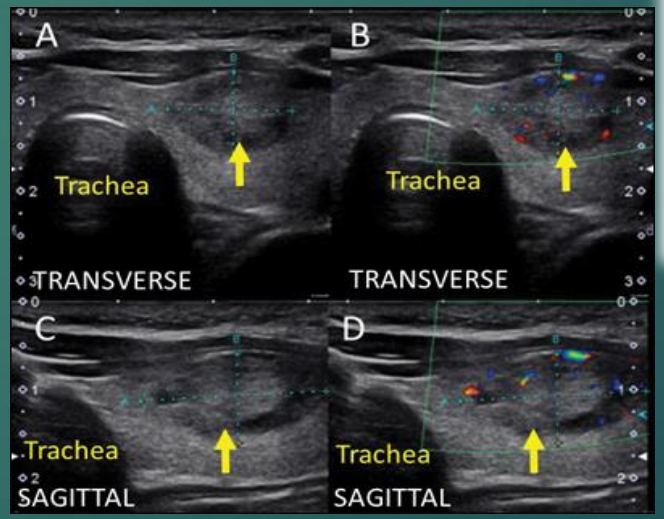


Inclusion Criteria

- Our study comprised patients of Greaves (n=18), and Toxic Adenoma (n=10)

Test	FT3 (pg/ml)	FT4 (ng/dl)	TSH (µIU/mL)
Reference values	2-4.4	0.93-1.7	0.27-4.2

- A Properly calibrated thyroid uptake probe with NaI(Tl) was employed to acquire uptake measures.
- Energy photopeak was set as 364 Kev with 20% window width
- U.S was used for volume determination
- $V = 4/3 \times (xyz/2)^3 \times \pi$



Nodule Uptake

- $(\mathbf{RIU})\ \% = \frac{Nc-Fc}{Sc-BG} \times 100$

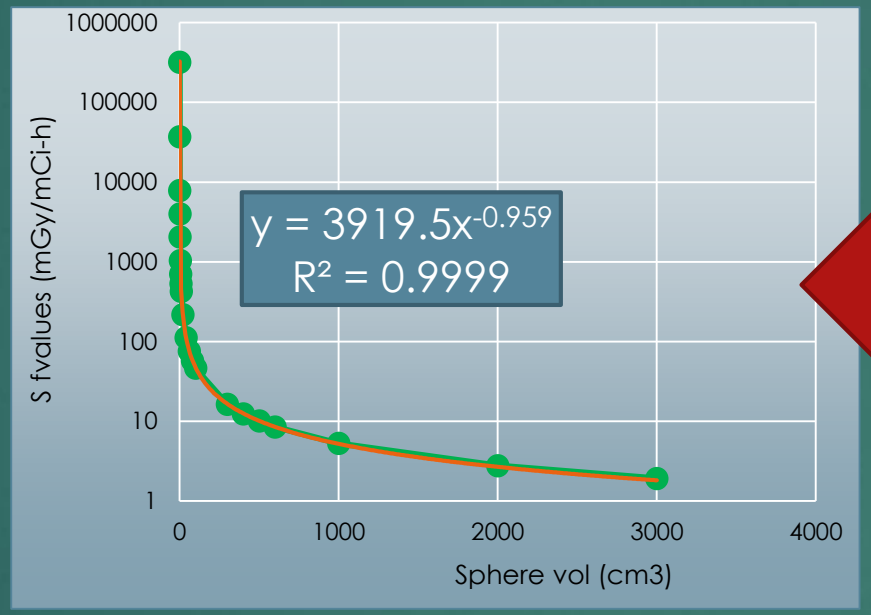
Nc: Neck counts
Fc: Femure counts
BG: background counts

Conversion Factor

To convert the counts into Activity as c/MBq.

✓ Absorbed Dose Calculation

1- *MIRD method*



Doses from Nuclide: I-131 in Spheres:

Sphere Mass (g)	Dose (mGy/MBq)
0.01	3,87E004
0.1	4,18E003
0.5	8,55E002
1.0	4,45E002
2.0	2,25E002
4.0	1,14E002
6.0	7,69E001
8.0	5,79E001
10.0	4,67E001
20.0	2,38E001
40.0	1,21E001
60.0	8,19E000
80.0	6,22E000
100.0	5,03E000

- Dose= $\bar{A} \times S$

mass= $V \times D$

2- Time effective based model

$$A = \frac{0.714}{\bar{E}} \times \frac{M \ . \ D}{\mathrm{RIU}_{(t1)} \, . \, 2^{(t_1/T_{eff})} \, . \mathrm{T}_{(eff)}}$$

$$T_{eff} = \frac{(\mathrm{t}_1 - \mathrm{t}_{max}) \cdot \ln(2)}{\ln RIU_{\max} - \ln RIU_{\mathrm{t1}}}$$

Hänscheid et al. (2013)

3- The ellipsoidal thyroid

$$A = \frac{D \cdot M}{RIU_{max} \cdot T_{eff}} \cdot \frac{32.31\rho + 1}{\rho(0.2625\rho + 5.1819)}$$

$$\rho = \frac{3v}{s}$$

$$V = \frac{4}{3} \cdot abc \cdot \pi, \quad S = 4\pi \left(\frac{(ab)^p (bc)^p (ac)^p}{3} \right)^{1/p}$$

Amato et al. (2011)

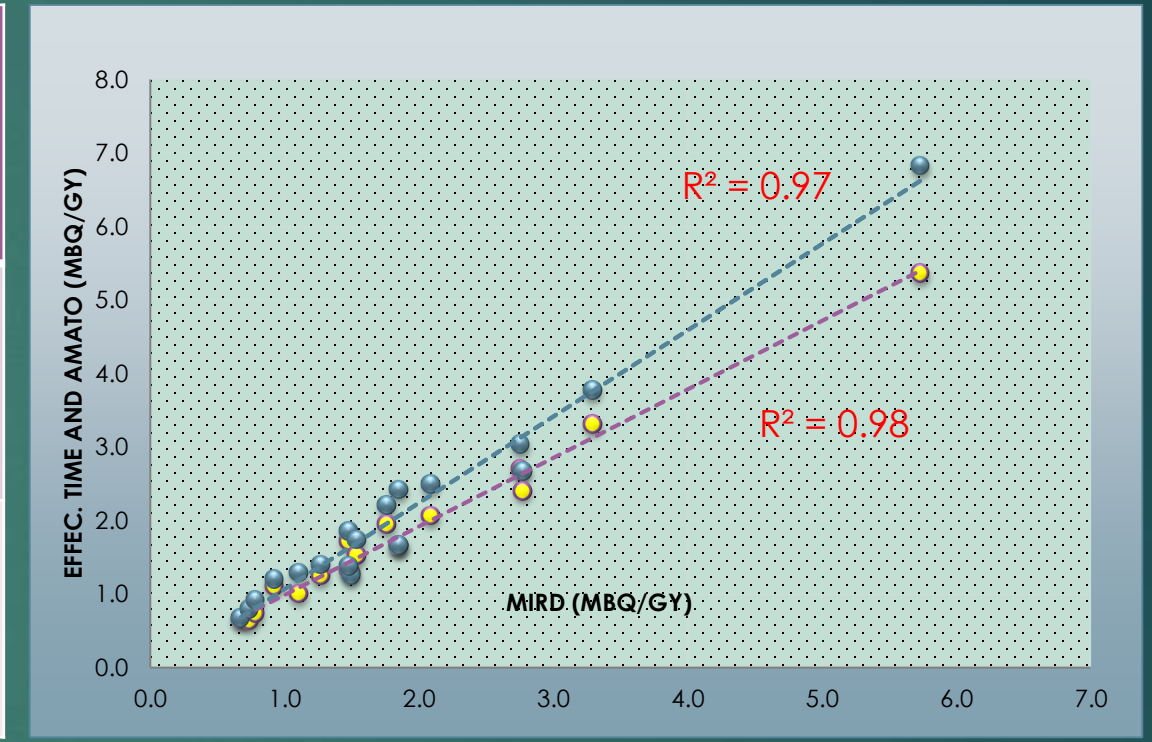
Findings….

Physical parameters following 131I tracer

Parameter	Graves (n=15)	Toxic adenoma (n=10)
Thyroid volume (m±sd cm3)	22±10	45±36
Effective half life (m±sd h)	128±40	95±43
Residence time (m±sd h)	116±45	106±63

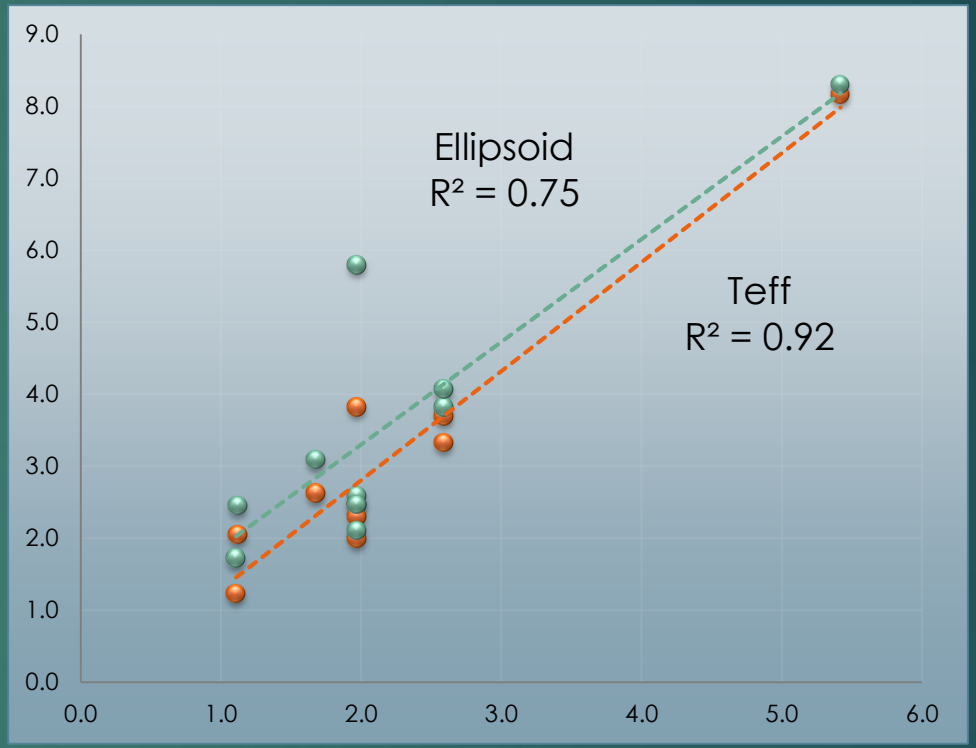
Teff and Ellipsoid Deviation to MIRD for GRAVES patients

Method	Min %	Mean %	Max %	P_{value}
Teff	-14	-3	20	0.74
Ellipsoid	1	15	28	0.76



Teffand Ellipsoid Deviation to Unite density model for *TOXIC ADENOMA Patients*

Method	Min %	Mean %	Max %	P_{value}
Teff	1.2	41	94	0.09
Ellipsoid	6.5	65	194	0.03



Clinical outcome

Toxic Adenoma

- *100%* of the patients showed Authyroid status after receiving 360±66 Gy.

Graves

- 13 patients received 240±55 Gy following dosimetry showed authyroid or minimum hypothyroidism during 3-6 months.
- 5 patients who were emprically treated recieved ≥ 385 Gy and portrated HYPOTHYROIDISM

No patient underwent further dose during 2 years

Before therapy

TSH 0.005	FT3 32.55	FT4 7.24
Max/Min uptake Nodule vol (cm3)	86/57% 163	
E.H.T(h)	122	
Rt (h)	243	
A_0 (MBq)	1591	
AD (Gy)	300	

6 months after therapy

- ✓ **Normal** hormone levels
  TSH(0.27)/FT3(3.3)/FT4:(1.59)
- ✓ **Authyroid** status
- ✓ **98%** nodule shrinkage

To this end…

- Evidence based therapy is more realistic and effective in retriving AUTHYROID status in RIT of benign cancer.
- empirical regime lacks the turn over phase that justify the common failure in restoring authyroid status.
- The formula with 3 uptake measures and effective half life seems appropriate and cost effective in the daily practice .
- Unit density sphere model is pretty successive in Toxic Adenoma with 250-300 GY
- The ellipsoidal shape of the thyroid or nodule is irrelevant in the dosimetry of benign cancer owing to the obtained clinical outcomes.

Thank you

Doğuş kilisesi

- Doğuş Kilisesi, Filistin'de Batı Şeria'daki Beytüllahim'de bulunan bir bazilikadır.
- Kilise ilk olarak 327 yılında I. Konstantin ve annesi Helena tarafından, İsa'nın doğum yerini olarak bilinen mağaranın üzerine inşa edildi

Hz.İsa'nın doğum yeri