



**NTRK**  
connect<sup>®</sup>

---

POWERED BY **COR2ED**

# ***NTRK* GENE FUSION IN THYROID TUMOURS: DIAGNOSIS AND TREATMENT UPDATE**

**Prof. Ezra Cohen**

**Moore's Cancer Center, San Diego, CA, USA**

**DECEMBER 2022**

# ENTRECTINIB & LAROTRECTINIB: TRK INHIBITORS

- The discovery of *NTRK* gene fusions led to the recent development of therapeutic agents that inhibit TRK fusion proteins<sup>1</sup>
- Two TRK inhibitors are approved by the US FDA (larotrectinib is approved globally in 48 countries) for use in patients with unresectable or metastatic *NTRK* gene fusion-positive cancers, agnostic of tumour type<sup>1</sup>

## ENTRECTINIB<sup>2</sup>

### INDICATION FOR USE:

Adult and paediatric patients 12 years of age and older with solid tumours that:

- have an *NTRK* gene fusion as detected by an FDA-approved test without a known acquired resistance mutation,
- are metastatic or where surgical resection is likely to result in severe morbidity, and
- have either progressed following treatment or have no satisfactory alternative therapy.

## LAROTRECTINIB<sup>3</sup>

### INDICATION FOR USE:

Adult and paediatric patients with solid tumours that:

- have an *NTRK* gene fusion without a known acquired resistance mutation,
- are metastatic or where surgical resection is likely to result in severe morbidity, and
- have no satisfactory alternative treatments or that have progressed following treatment.

# ESMO-MCBS NEW THERAPIES/INDICATIONS IN THYROID CANCER

Therapy	Disease setting	Trial	Control	Absolute survival gain	ESMO-MCBS score <sup>1</sup>
Entrectinib	Adult and paediatric patients 12 years of age and older with solid tumours expressing an <i>NTRK</i> gene fusion, who have disease that is locally advanced, metastatic or where surgical resection is likely to result in severe morbidity, and who have not received a prior TRK inhibitor, and who have no satisfactory treatment options	Phase ½: <ul style="list-style-type: none"> <li>• STARTRK-1 (NCT02097810)</li> <li>• STARTRK-2 (NCT02568267)</li> <li>• ALKA-372-001 (EudraCT 2012-000148-88)</li> </ul>	Single arm	ORR: 57% Median DoR: 10.4 months Median PFS: 11.2 months	3 (Form 3)
Larotrectinib	Adult and paediatric patients with solid tumours that display an <i>NTRK</i> gene fusion, who have disease that is locally advanced, metastatic or where surgical resection is likely to result in severe morbidity, and who have no satisfactory treatment options	Phase 1/2: <ul style="list-style-type: none"> <li>• Phase 1 study of the oral</li> <li>• TRK inhibitor larotrectinib</li> <li>• in adult patients with solid Tumours (NCT02122913)</li> <li>• SCOUT (NCT02637687)</li> <li>• NAVIGATE (NCT02576431)</li> </ul>	Single arm	ORR: 79% Median DoR: 35.2 months Median PFS: 28.3 months	3 (Form 3)

<sup>1</sup> ESMO-MCBS v1.116 was used to calculate scores (<https://www.esmo.org/guidelines/esmo-mcbs/esmo-mcbs-evaluationforms>)

DoR, duration of response; ESMO, European Society for Medical Oncology; ESMO-MCBS, ESMO-Magnitude of Clinical Benefit Scale; NTRK, neurotrophic tyrosine receptor kinase; ORR, objective response rate; PFS, progression-free survival; TRK, tropomyosin receptor kinase

## American Thyroid Association 2022 Annual Meeting:

- Cabanillas ME, Lin JJ, Brose MS, McDermott R, Almubarak M, Bauman J, Casanova M, Krishnamurthy A, Kummar S, Lee S-H, Leyvraz S, Oh D-Y, Shen L, Norenberg R, Dima L, Mussi CE, Hong DS, Drilon A, Waguespack SG. Updated Efficacy and Safety of Larotrectinib in Patients With Advanced Tropomyosin Receptor Kinase (TRK) Fusion-Positive Thyroid Carcinoma. *Thyroid*. 2022; 32, Supplement 1:P-1-A-135 (highlighted poster 108; presented at ATA 2022)

## Recent Publications review:

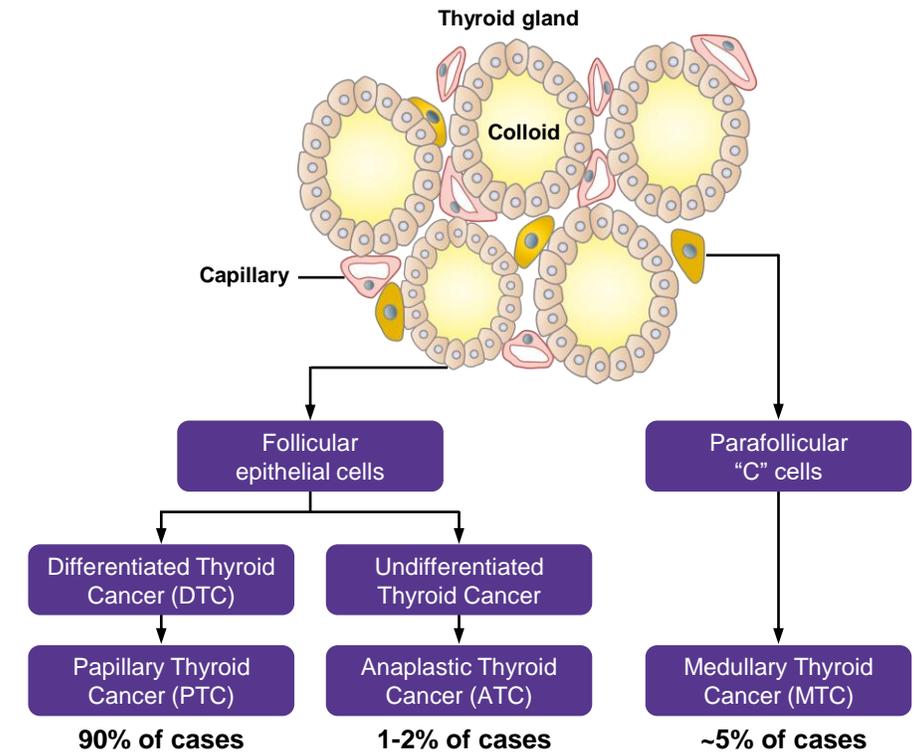
- Vuong HG, Le HT, Le TTB, Le T, Hassell L, Kakudo K. Clinicopathological significance of major fusion oncogenes in papillary thyroid carcinoma: An individual patient data meta-analysis. *Pathol Res Pract*. 2022;240:154180

## Latest US, UK and EU guidelines:

- NCCN Clinical Practice Guidelines in Oncology: Thyroid Carcinoma / Version 3.2022 — November 1, 2022
- Wadsley J, Beasley M, Garcez K, Hoy S, Newbold K, Boelaert K. Guidelines on the Use of Systemic Therapy in Patients with Advanced Thyroid Cancer. *Clin Oncol (R Coll Radiol)*. 2022 Nov 3:S0936-6555(22)00493-9
- Filetti S, Durante C, Hartl DM, Leboulleux S, Locati LD, Newbold K, Papotti MG, Berruti A; ESMO Guidelines Committee. ESMO Clinical Practice Guideline update on the use of systemic therapy in advanced thyroid cancer. *Ann Oncol*. 2022;33(7):674-684
- OncologyPRO: <https://oncologypro.esmo.org/oncology-in-practice/anti-cancer-agents-and-biological-therapy/targeting-ntrk-gene-fusions/overview-of-ntrk-gene-fusion-in-specific-tumours>

# THYROID CANCER OVERVIEW

- In 2020, the International Agency for Research on Cancer estimated the worldwide incidence of thyroid cancer to be 586,202 cases with 43,646 deaths and a 5-year prevalence of 1,984,927
- Thyroid cancers account for approximately 4% of malignancies in children
- The most common type of adult thyroid cancer, PTC, accounts for 90% of all thyroid cancer cases, whereas ATC accounts for only 1-2% of cases
- The majority (~93%) of thyroid carcinomas in children are Differentiated Thyroid Cancers - DTC (papillary and follicular), ~5% of cases are medullary (MTC), and ~2% are a mix or rare forms



ATC, anaplastic thyroid cancer; DTC, differentiated thyroid cancer; MTC, medullary thyroid cancer; PTC; papillary thyroid cancer

Available from: <https://oncologypro.esmo.org/oncology-in-practice/anti-cancer-agents-and-biological-therapy/targeting-ntrk-gene-fusions/overview-of-ntrk-gene-fusion-in-specific-tumours/thyroid-cancer>. Last accessed: November 23, 2022

# PREVALENCE OF *NTRK* GENE FUSIONS IN THYROID TUMOURS

Tumour type	Frequency of <i>NTRK</i> gene fusions ( <i>NTRK</i> <sup>+</sup> /total)	<i>NTRK</i> gene affected	Partner gene	Related reference
Thyroid	2.2% (10/451)	<i>NTRK1/3</i>	Information not available per tumour type. Overall, in 26,312 tumours, <i>NTRK1/2</i> had no preferred upstream fusion partner, and the most common partner for <i>NTRK3</i> was <i>ETV6</i>	Rosen et al. 2020
Thyroid	2.28% (13/571)	<i>NTRK1/3</i>	<i>NTRK1</i> : <i>IRF2BP2</i> , <i>TPM3</i> , <i>TPR</i> , <i>DIAPH1</i> (each n=1) <i>NTRK3</i> : <i>ETV6</i> (n=6) <i>RBPMS</i> , <i>SQSTM1</i> , <i>EML4</i> (each n=1)	Solomon et al. 2020
Thyroid	2.3% (12/513)	<i>NTRK1/3</i>	Not described	Okamura et al. 2018
Thyroid	5.7% (4/70)	<i>NTRK3</i>	<i>NTRK3</i> : <i>ETV6</i> (n=3), <i>VIM</i> (n=1)	Gatalica et al. 2019
PTC	5.3% (2/38)	Not reported	Not reported	Wajjwalku et al. 1992
Thyroid	2.9% (2/68)	<i>NTRK1</i>	<i>TPM3</i>	Said et al. 1994
Paediatric PTC	26% (7/27)	<i>NTRK1/3</i>	<i>NTRK1</i> : <i>TPR</i> (n=1) <i>NTRK3</i> : <i>ETV6</i> (n=5) Unknown (n=1)	Prasad et al. 2016
Paediatric thyroid cancer	7.7% (2/26)	<i>NTRK3</i>	<i>NTRK3</i> : <i>ETV6</i> (n=6) <i>NTRK3</i> : <i>TPR</i> (n=1)	Ricarte-Filho et al. 2013
PTC • Sporadic • Post-Chernobyl	2.9% (7/243) 14.5 (9/62)	<i>NTRK3</i>	<i>NTRK3</i> : <i>ETV6</i>	Leeman-Neill et al. 2014
Primary thyroid tumours	3.1% (11/351 <sup>a</sup> )	<i>NTRK1/3</i>	<i>NTRK1</i> : <i>TPR</i> (n=2), <i>SQSTM1</i> (n=1) <i>NTRK3</i> : <i>ETV6</i> (n=4), <i>RBPMS</i> (n=2), <i>SQSTM1</i> (n=1), and <i>EML4</i> (n=1)	Chu et al. 2020
PTC	5.9% (11/186)			

- Among PTCs with *NTRK* gene fusion, fusions involving *NTRK3* were the most frequent (64.5%) with *ETV6-NTRK3* being the most common fusion type, followed by *SQSTM1-NTRK3*, *EML4-NTRK3*, and *RBMPS-NTRK3*
- *NTRK1*-fused PTCs accounted for 35.5% of PTCs, with *NTRK* gene fusions with *TPM3-NTRK1* being the most common genotype
- No *NTRK2* fusions have been reported to date
- *ETV6-NTRK3* is the most common rearrangement in PTC. While the prevalence of this rearrangement in adults with PTC is very low (<1%), it is the second most common rearrangement seen in radiation-associated PTC

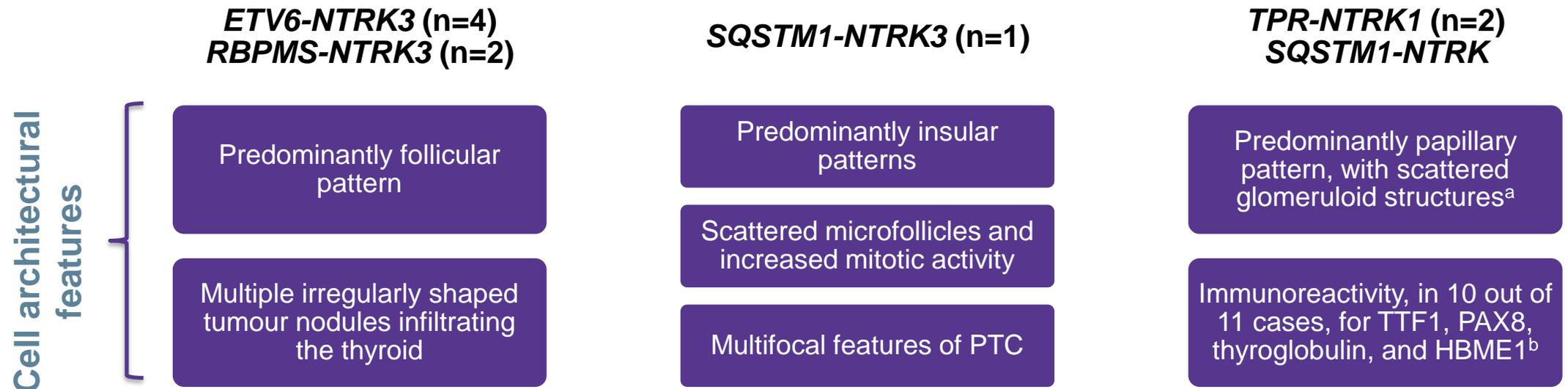
<sup>a</sup> One 14-year-old adolescent and 10 adults. All cases were radiation-naïve. One patient with brain metastases.

DIAPH1, diaphanous related formin 1; NTRK, neurotrophic tyrosine receptor kinase; PTC, papillary thyroid cancer; SQSTM1, sequestosome 1; TPM3, tropomyosin 3; TPR, translocated promoter region

1. Available from: <https://oncologypro.esmo.org/oncology-in-practice/anti-cancer-agents-and-biological-therapy/targeting-ntrk-gene-fusions/overview-of-ntrk-gene-fusion-in-specific-tumours/thyroid-cancer>. Last accessed: November 23, 2022. 2. Vuong HG, et al. *Pathol Res Pract*. 2022;240:154180

# HISTOPATHOLOGY AND CHARACTERISTICS OF *NTRK* GENE FUSION THYROID TUMOURS

- Multiple infiltrative tumour nodules and extensive lymphovascular spread within intrathyroidal and extrathyroidal vessels of variable calibre (n=11). Direct extrathyroidal extension, at least microscopic (n=9)
- Similar cellular architectural properties in cases with the same gene fusion:



<sup>a</sup> *TPR-NTRK1* fusion-positive tumours also showing multiple nodules of packeted papillae divided by fibrotic septa; for *SQSTM1-NTRK1*, numerous psammomatous calcifications

<sup>b</sup> The other case only expressed low levels of TTF1; final diagnosis was primary thyroid secretory carcinoma of the salivary type

# HISTOPATHOLOGICAL/CLINICAL PROFILES OF PTCs WITH DIFFERENT ONCOGENE FUSION TYPES

Variables	<i>ALK</i> (N=47)	<i>BRAF</i> (N=25)	<i>NTRK</i> (N=225)	<i>RET</i> (N=143)	p value
<b>Age</b>					<b>&lt;0.001</b>
Mean (SD)	35.9 (18.1)	22.8 (23.1)	32.5 (17.3)	25.7 (15.3)	
Median (min, max)	33.0 (4.50, 69.0)	13.0 (5.00, 76.0)	31.0 (4.30, 74.0)	19.5 (5.10, 69.0)	
<b>Age group</b>					<b>&lt;0.001</b>
Adult	37 (78.7)	6 (24.0)	149 (69.6)	74 (52.9)	
Paediatric	19 (21.3)	19 (76.0)	65 (30.4)	66 (47.1)	
<b>Gender</b>					<b>0.028</b>
Female	38 (80.9)	12 (48.0)	156 (72.6)	104 (73.0)	
Male	9 (19.1)	13 (52.0)	59 (27.4)	39 (27.0)	
<b>FNA diagnosis</b>					<b>0.004</b>
Benign	0 (0)	NA	1 (3.6)	0 (0)	
Indeterminate	4 (44.4)	NA	4 (14.3)	1 (20.0)	
Suspicious for malignant	5 (55.6)	NA	6 (21.4)	0 (0)	
Malignant	0 (0)	NA	17 (60.7)	4 (80.0)	
<b>Growth pattern</b>					<b>&lt;0.001</b>
Classic	20 (44.4)	15 (62.5)	59 (33.9)	62 (54.1)	
Follicular variant	12 (26.7)	5 (20.8)	69 (39.7)	10 (9.0)	
Diffuse sclerosing variant	1 (2.2)	1 (4.2)	4 (2.3)	35 (31.5)	
Solid variant	2 (4.4)	2 (8.3)	11 (6.3)	6 (5.4)	
Other variants	10 (22.2)	1 (4.2)	31 (17.8)	0 (0)	
<b>Psammoma</b>					<b>0.006</b>
No	NA	NA	65 (75.6)	1 (16.7)	
Yes	NA	NA	21 (24.4)	5 (83.3)	
<b>Lymph node metastasis</b>					<b>&lt;0.001</b>
No	7 (41.2)	5 (20.8)	42 (36.5)	20 (17.1)	
Yes	10 (58.8)	19 (79.2)	73 (63.5)	97 (82.9)	
<b>Extrathyroidal extension</b>					<b>0.001</b>
No	5 (33.3)	2 (25.0)	56 (56.0)	15 (25.9)	
Yes	10 (66.7)	6 (75.0)	44 (44.0)	43 (74.1)	
<b>Radioactive iodine</b>					<b>&lt;0.001</b>
No	9 (52.9)	0 (0)	17 (32.1)	4 (7.7)	
Yes	8 (47.1)	7 (100)	36 (67.9)	48 (92.3)	

ALK, anaplastic lymphoma kinase; BRAF, B-Raf; FNA, fine-needle aspiration; NA, not available; NTRK, neurotrophic tyrosine receptor kinase; PTC; papillary thyroid cancer; RET, ret proto-oncogene; SD, standard deviation

# CLINICOPATHOLOGICAL FEATURES OF *NTRK1* VS *NTRK3*-REARRANGED PTC

Variables	<i>NTRK1</i> (N=80)	<i>NTRK3</i> (N=145)	p value
<b>Age</b>			0.139
Mean (SD)	35.3 (19.1)	31.0 (16.1)	
Median (min, max)	36.0 (4.30, 74.0)	29.0 (5.20, 74.0)	
<b>Gender</b>			<0.001
Female	43 (56.6)	113 (81.3)	
Male	33 (43.4)	26 (18.7)	
<b>Histologic variants</b>			<0.001
Classic	30 (56.6)	29 (24.0)	
Follicular variant	10 (18.9)	59 (48.8)	
Diffuse sclerosing variant	4 (7.5)	0 (0)	
Solid variant	1 (1.9)	10 (8.3)	
Other variants	8 (15.1)	23 (19.0)	
<b>Psammoma</b>			0.508
No	55 (77.5)	65 (75.6)	
Yes	16 (22.5)	21 (24.4)	
<b>Focality</b>			0.011
Multifocal	26 (78.8)	50 (53.8)	
Unifocal	7 (21.2)	43 (46.2)	
<b>Vascular invasion</b>			0.048
No	4 (44.4)	46 (78.0)	
Yes	5 (55.6)	13 (22.0)	
<b>Lymph node metastasis</b>			0.065
No	8 (22.2)	34 (43.0)	
Yes	28 (77.8)	45 (57.0)	
<b>Extrathyroidal extension</b>			0.036
No	8 (36.4)	48 (61.5)	
Yes	14 (63.6)	30 (38.5)	
<b>Distant metastasis</b>			0.061
No	13 (48.1)	27 (71.1)	
Yes	14 (51.9)	11 (28.9)	

NTRK, neurotrophic tyrosine receptor kinase; PTC, papillary thyroid cancer; SD, standard deviation

# TREATMENT RECOMMENDATIONS FOR LAROTRECTINIB AND ENTRECTINIB

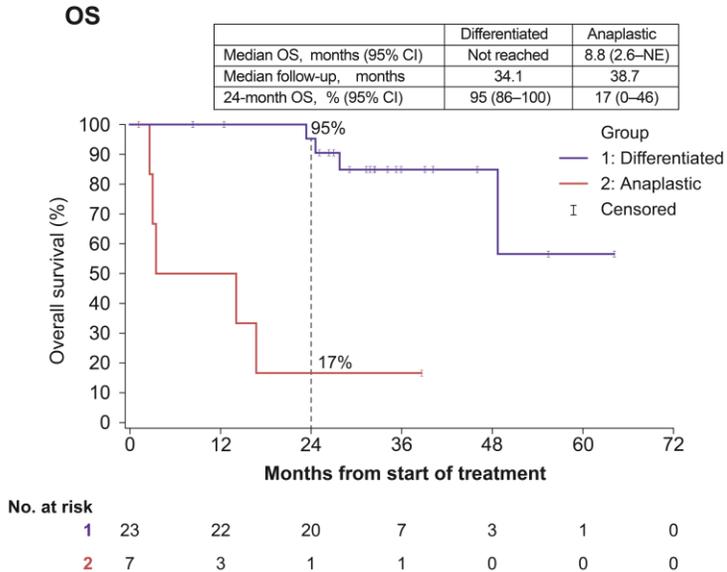
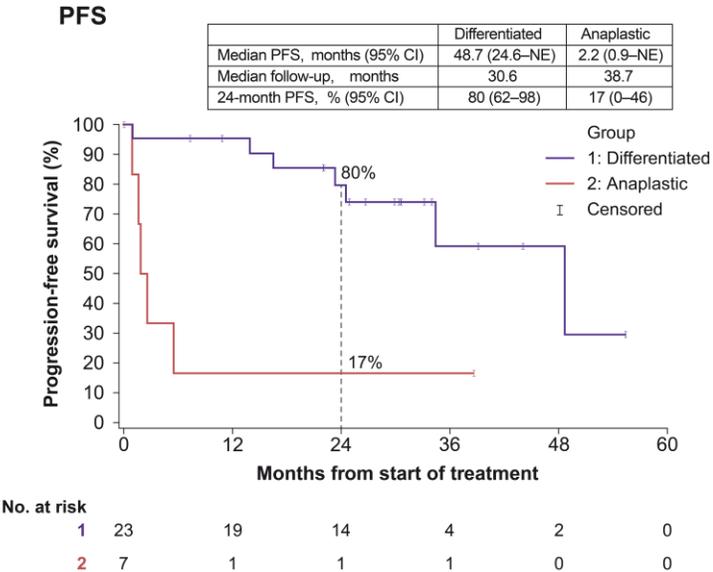
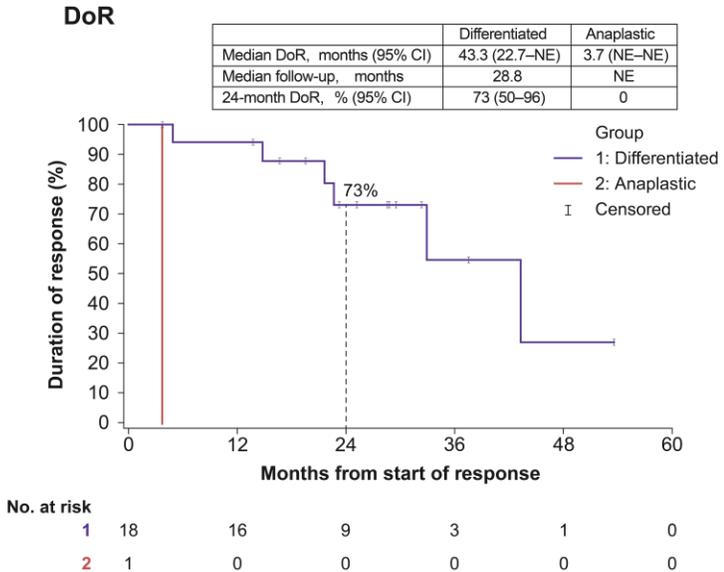
- EU guidelines:
  - **Larotrectinib** is an option for the treatment of **adults and paediatric patients** with metastatic *NTRK* gene fusion-positive solid tumours, **not amenable to surgery**, that have **no satisfactory treatment options** [V, B; ESMO-MCBS v1.1 score: 3; ESCAT score: I-C]<sup>1</sup>
  - **Entrectinib** is an option for treating **adults and adolescents aged ≥12 years** with metastatic or unresectable *NTRK* gene fusion-positive solid tumours that **have progressed in spite of standard-of-care treatment** [V, B; ESMO-MCBS v1.1 score: 3; ESCAT score: I-C]<sup>1</sup>
- US guidelines (NCCN guidelines):
  - **Larotrectinib** or **entrectinib** for patients with *NTRK* gene fusion-positive advanced solid tumours<sup>2</sup>
- UK guidelines:
  - **Larotrectinib** and **entrectinib** are *NTRK* gene fusion inhibitors approved by NICE for the treatment of patients with solid tumours that display a *NTRK* gene fusion who have locally advanced or metastatic disease and who have no satisfactory alternative treatment options<sup>3</sup>

# UPDATED EFFICACY: LAROTRECTINIB IN ADVANCED TRK FUSION-POSITIVE THYROID CARCINOMA



## Cut off date: July 2021

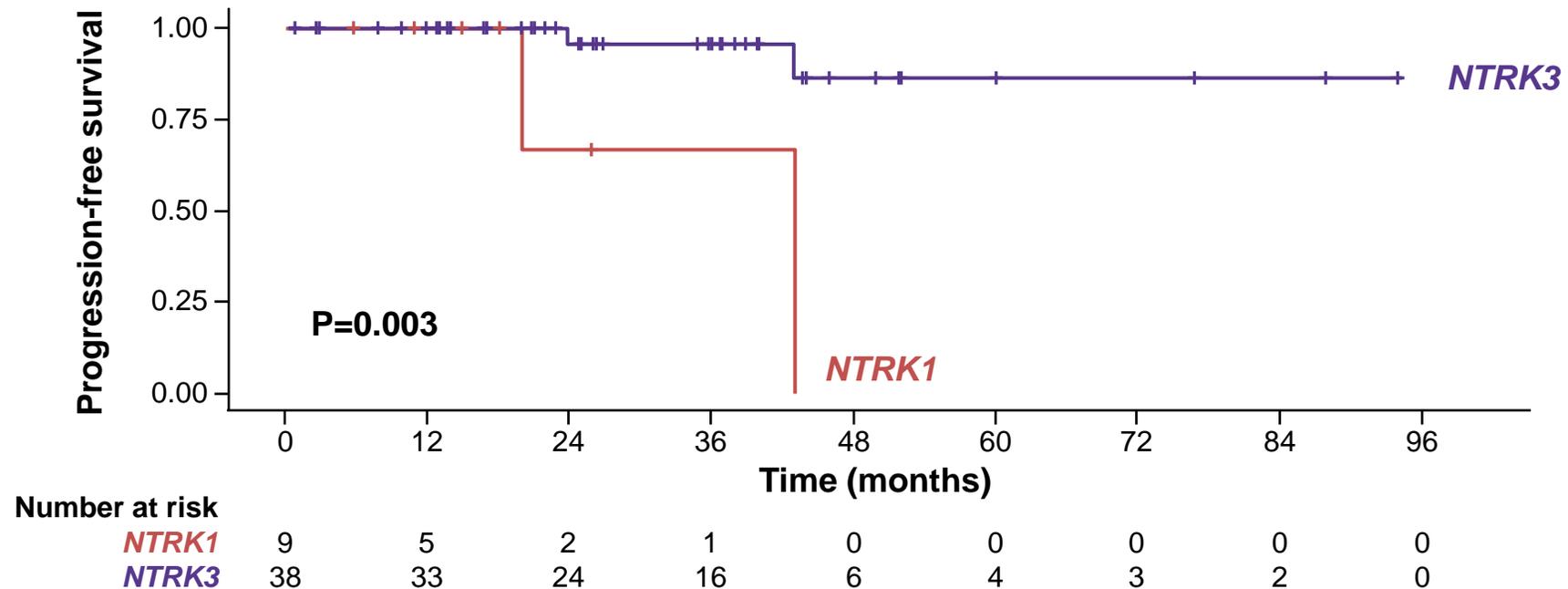
- 30 patients with TRK fusion-positive TC were enrolled, including 29 with an additional year of follow-up. There were 23 patients with differentiated TC (DTC) and seven patients with anaplastic TC (ATC).
- In this small sample, patients with TRK fusion-positive ATC had worse outcomes compared to TRK fusion-positive DTC



ATA, American Thyroid Association; ATC, anaplastic thyroid cancer; CI, confidence interval; DoR, duration of response; DTC, differentiated thyroid cancer; NE, not estimable; OS, overall survival; PFS, progression-free survival; TC, thyroid cancer; TRK, tropomyosin receptor kinase  
 Cabanillas ME, et al. Thyroid. 2022; 32, Supplement 1:P-1-A-135 (highlighted poster 108; presented at ATA 2022)

# PROGRESSION-FREE SURVIVAL OF PTCs WITH *NTRK1* VERSUS *NTRK3* FUSIONS

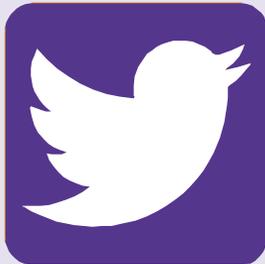
- NTRK1*-rearranged PTCs demonstrated increased aggressiveness and shorter PFS compared to *NTRK3*-positive cases



# CONCLUSION

- PTCs with different fusion types have:
  - unique demographic, histological, and clinicopathological features
  - *NTRK3* and *NTRK1* most frequent fusions, no *NTRK2* fusions
- DNA and RNA based NGS: best approach method for testing for *NTRK* gene fusions
- Larotrectinib and entrectinib:
  - TRK inhibitors have demonstrated strong and durable responses, with manageable safety profile
  - Both included as treatment options in EU, US and UK guidelines for thyroid tumours treatment
- Recent updated clinical data show:
  - A difference in progression-free survival between *NTRK1* and *NTRK3* fusion-positive thyroid tumours
  - A difference in the treatment outcome between DTC and ATC

REACH NTRK CONNECT VIA  
TWITTER, LINKEDIN, VIMEO & EMAIL  
OR VISIT THE GROUP'S WEBSITE  
<https://ntrkconnect.cor2ed.com/>



Follow us on Twitter  
[@ntrkconnectinfo](https://twitter.com/ntrkconnectinfo)



Follow the  
[NTRK CONNECT](#)  
group on LinkedIn



Watch us on the  
Vimeo Channel  
[NTRK CONNECT](#)



Email  
[lain.murdoch@cor2ed.com](mailto:lain.murdoch@cor2ed.com)



NTRK CONNECT  
Bodenackerstrasse 17  
4103 Bottmingen  
SWITZERLAND

**Dr. Froukje Sosef MD**

+31 6 2324 3636

froukje.sosef@cor2ed.com

**Dr. Antoine Lacombe Pharm D, MBA**

+41 79 529 42 79

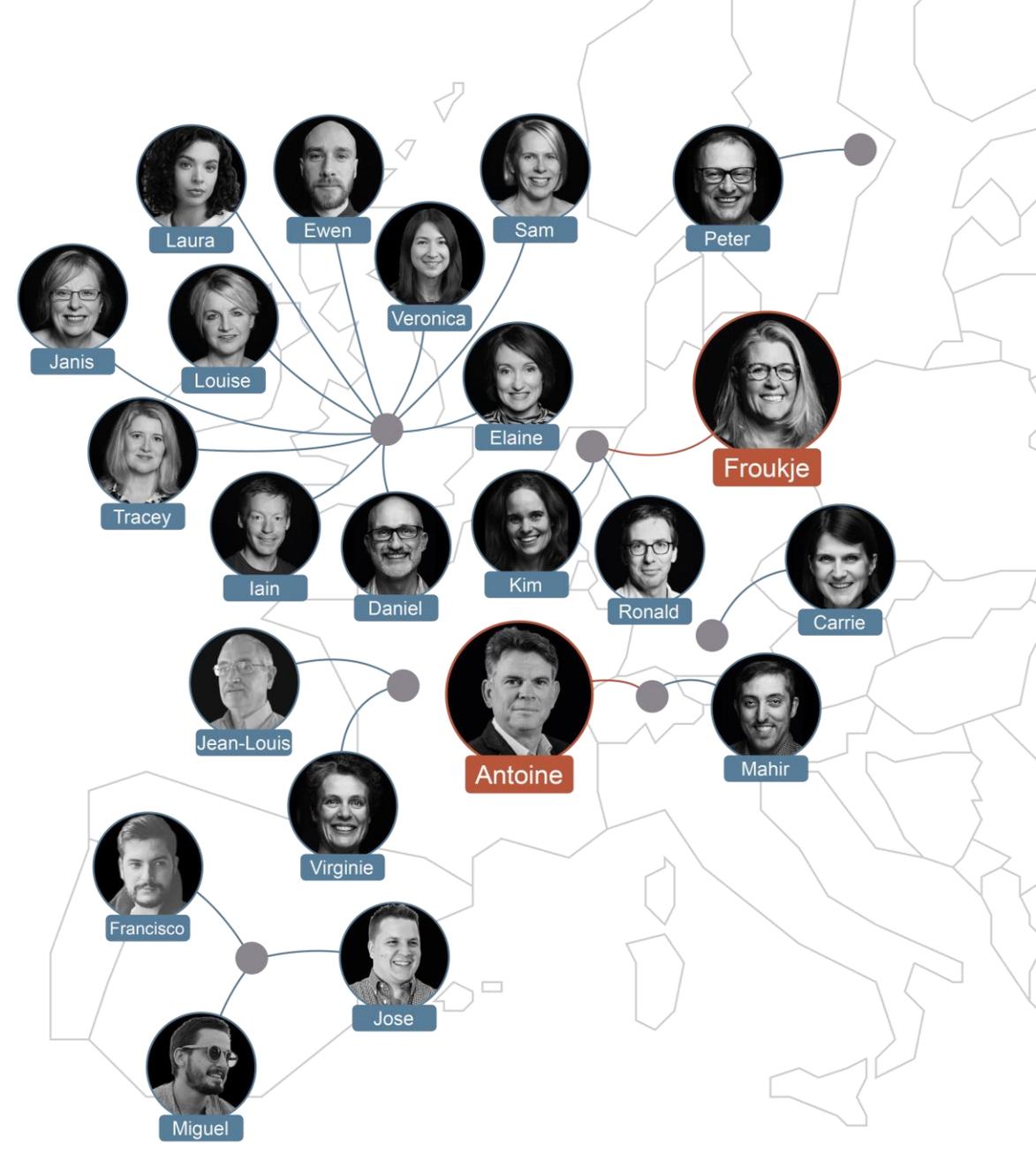
antoine.lacombe@cor2ed.com

Connect on  
LinkedIn @NTRK CONNECT

Visit us at  
<https://ntrkconnect.cor2ed.com/>

Watch on  
Vimeo @NTRK CONNECT

Follow us on  
Twitter @ntrkconnectinfo



**Heading to the heart of Independent Medical Education Since 2012**