



# Métrique et cartographie du visage

1ER CONGRÈS IMAGERIE CUTANÉE ET CHIRURGIE DERMATOLOGIQUE  
Marseille 14 et 15 juin 2024

JL Perrot Service de dermatologie CHU de St Etienne

J Chauvel Picard service CMF CHU de St Etienne

UMR CNR 5313 Laboratoire de Tribologie et Dynamique des Systèmes

UMR CNR 5316 Lab H Curien

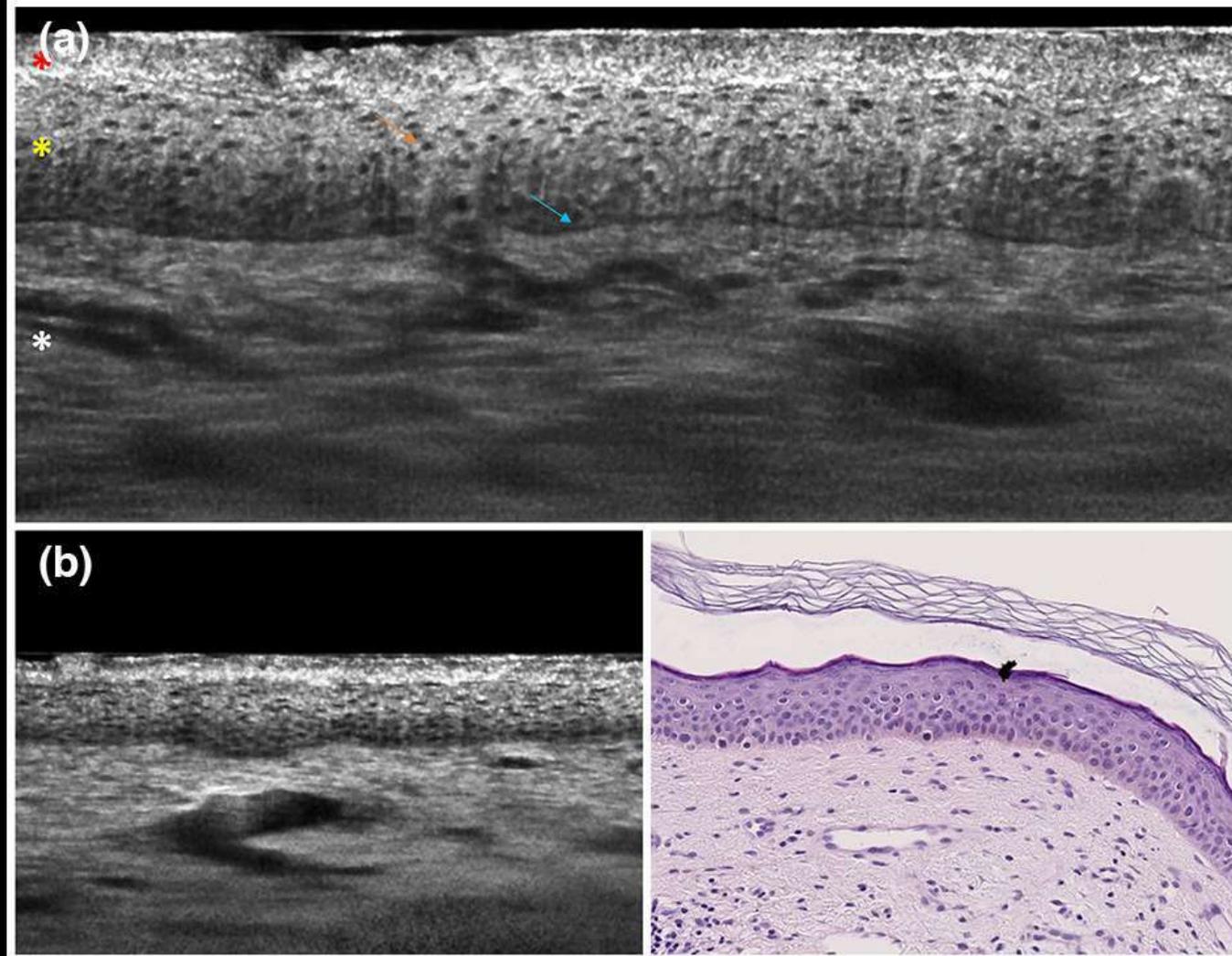


# Introduction (1)

- Mesurer est un élément majeur de la démarche scientifique
- La mesure de l'épiderme est rendue compliquée par son ondularité et par les artéfacts potentiels liés aux outils de mesures
- Les mesures initiales ont porté sur des analyses histologiques
  - 1978: une étude portant sur l'analyse de 6 biopsies de volontaires sain retrouvait une densité de kératinocyte similaire selon l'âge des sujets (P. R. Bergstresser, R. J. Pariser, J. R. Taylor, *J. Invest. Dermatol.* 1978, **70**, 280)
  - 2000: une étude montrait une augmentation de l'ondularité de la JDE de 20% chez les sujets jeune versus sujets âgés (F. Timar, G. Soos, B. Szende, A. Horvath, *Skin Res. Technol.* 2000, **6**, 17)
- Mesure in vivo 2D de la JDE avec stack 2D en MCIV (S. G. Lagarrigue, J. George, E. Questel, C. Lauze, N. Meyer, J.-M. Lagarde, M. Simon, A.-M. Schmitt, G. Serre, C. Paul, *Exp. Dermatol.* 2012, **21**, 281.) d'autres études suivront
- Mesure avec Multi photons , mais champ de vue très réduit et tj D2 (E. Decencière, E. Tancrede-Bohin, P. Dokládál, S. Koudoro, A.-M. Pena, T. Baldeweck, *Skin Res. Technol.* 2013, **19**, 115.)

# Introduction (2)

- La LC OCT  
-1<sup>er</sup> travail imagerie 2 D de la  
peau saine (J. Monnier, L. Tognetti, M.  
Miyamoto, M. Suppa, E. Cinotti, M. Fontaine, J. Perez, C.  
Orte Cano, O. Yélamos, S. Puig, A. Dubois, P. Rubegni, V.  
Marmol, J. Malveyh, J.-L. Perrot, J. Eur. Acad. Dermatol.  
Venereol. 2020, 34, 2914.



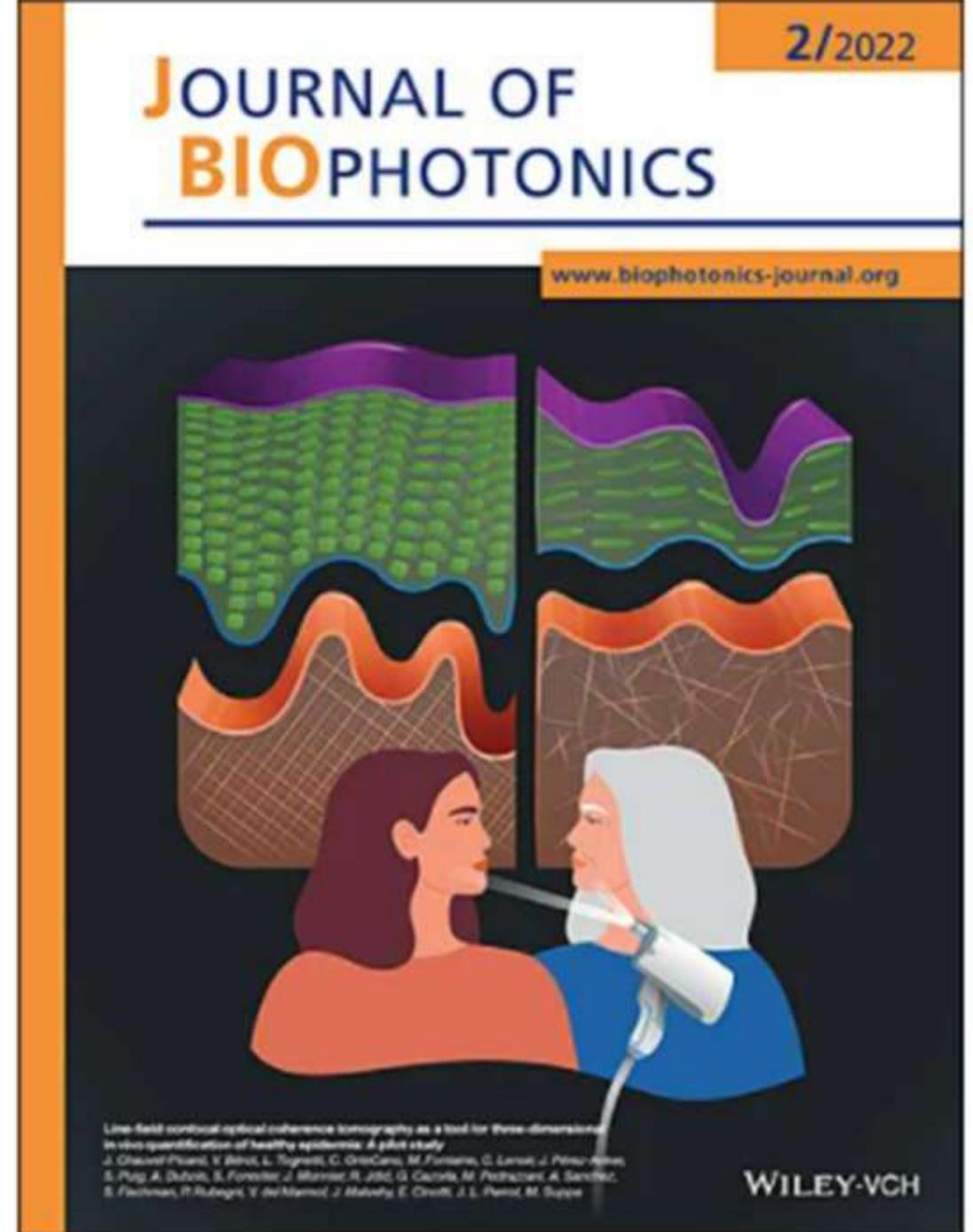
# Introduction (2)

- La LC OCT  
-1<sup>er</sup> travail imagerie 2 D de la  
peau saine (J. Monnier, L. Tognetti, M.  
Miyamoto, M. Suppa, E. Cinotti, M. Fontaine, J. Perez, C.  
Orte Cano, O. Yélamos, S. Puig, A. Dubois, P. Rubegni, V.  
Marmol, J. Malvehy, J.-L. Perrot, J. Eur. Acad. Dermatol.  
Venereol. 2020, 34, 2914.

Body site	Stratum corneum thickness (%)	Epidermal thickness (%)	Height of dermal papillae (%)
Forehead	11.6 ± 1.7 (15)	81.1 ± 12.9 (16)	18.3 ± 21.5 (117)
Nose	10.4 ± 1.4 (14)	84.4 ± 15 (18)	—
Cheek	9 ± 1.1 (13)	58.7 ± 9.7 (16)	—
Chest	9.1 ± 1.2 (14)	54.3 ± 5.9 (11)	22.6 ± 12.9 (57)
Back	9.5 ± 1.3 (14)	59.9 ± 4.5 (8)	27.5 ± 7.2 (26)
Forearm (posterior)	12.7 ± 3.2 (25)	70.7 ± 12.8 (18)	7 ± 10.1 (144)
Hand (back)	29.5 ± 5.7 (19)	98.9 ± 15.6 (16)	18.7 ± 22.8 (122)
<b>Inter-observer agreement (ICC; 95% CI)</b>	<b>0.95 (0.91–0.97)</b>	<b>0.87 (0.82–0.91)</b>	<b>0.72 (0.56–0.83)</b>

# Introduction (2)

- La LC OCT
  - 1<sup>er</sup> travail imagerie 2 D de la peau saine (J. Monnier, L. Tognetti, M. Miyamoto, M. Suppa, E. Cinotti, M. Fontaine, J. Perez, C. Orte Cano, O. Yélamos, S. Puig, A. Dubois, P. Rubegni, V. Marmol, J. Malvehy, J.-L. Perrot, J. Eur. Acad. Dermatol. Venereol. 2020, 34, 2914.
  - 2<sup>ème</sup> travail imagerie 3D in vivo et outil d'IA (Julie Chauvel-Picard, Vincent Bérot, Linda Tognetti, Carmen Orte Cano, Margot Fontaine, Clément Lenoir, Javiera Pérez-Anker, Susana Puig, Arnaud Dubois, Sandra Forestier, Jilliana Monnier, Randa Jdid, Gabriel Cazorla, Mélanie Pedrazzani, Antoine Sanchez, Sébastien Fischman, Pietro Rubegni, Véronique del Marmol, Joseph Malvehy, Elisa Cinotti, Jean L. Perrot, Mariano Suppa Line-field confocal optical coherence tomography as a tool for three-dimensional in vivo quantification of healthy epidermis: A pilot study J Biophotonics. 2022 Feb;15(2) )



# Introduction (3)

> Clin Exp Dermatol. 2023 Apr 27;48(5):468-475. doi: 10.1093/ced/llad001.

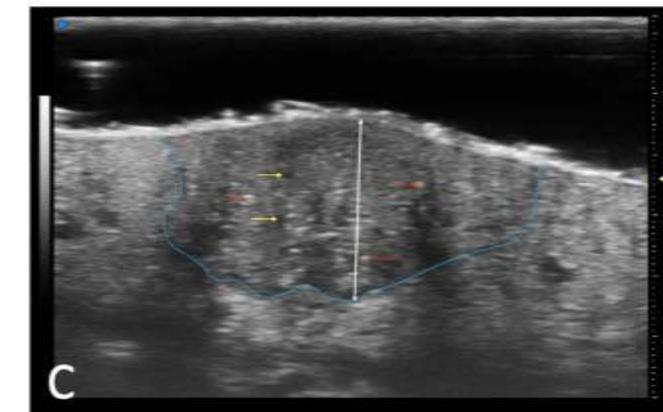
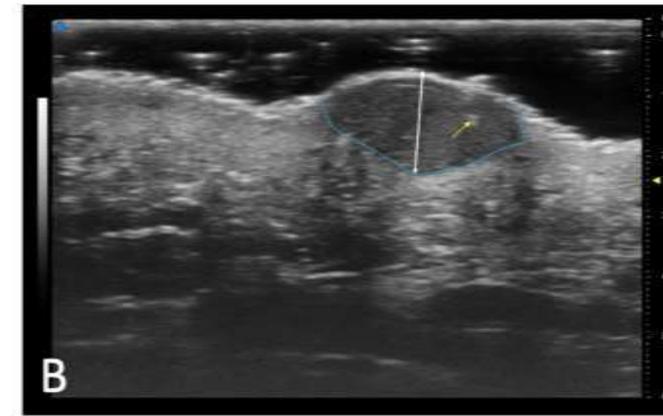
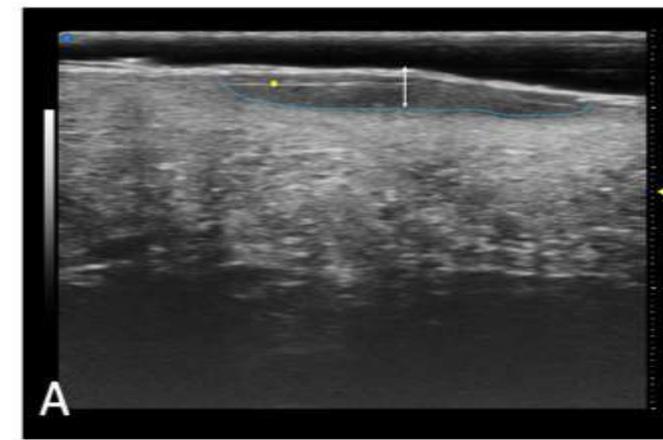
## Role of ultra-high-frequency ultrasound in the diagnosis and management of basal cell carcinoma: pilot study based on 117 cases

Julie Chauvel-Picard<sup>1</sup>, Linda Tognetti<sup>2</sup>, Elisa Ciniotti<sup>2</sup>, Cyril Habougit<sup>3</sup>, Mariano Suppa<sup>4</sup>, Clement Lenoir<sup>5</sup>, Pietro Rubegni<sup>2</sup>, Veronique Del Marmol<sup>4</sup>, Vincent Berot<sup>6</sup>, Arnaud Gleizal<sup>1</sup>, Paul Vercherin<sup>6</sup>, Guillaume Dejonckheere<sup>4</sup>, Charles Raffaelli<sup>7</sup>, Nathalie Cardot-Leccia<sup>8</sup>, Nicholas Azulay<sup>9</sup>, Anne Sudaka-Bahadoran<sup>1</sup>, Jean L Perrot<sup>9</sup>, Philippe Bahadoran<sup>9</sup>

Affiliations + expand

PMID: 36763772 DOI: 10.1093/ced/llad001

- Étudier la profondeur de la peau est un 2<sup>ème</sup> challenge
- On est confronté au dilemme définition versus profondeur
- L'échographie Haute définition est un compromis acceptable
- Nous avons dans une étude pu montrer par comparaison de l'épaisseur échographique in vivo des carcinomes basocellulaires et de leur mesure par le pathologiste sur coupe histologique
  - une reproductibilité est quasiment parfaite
  - la répétabilité inter observateur

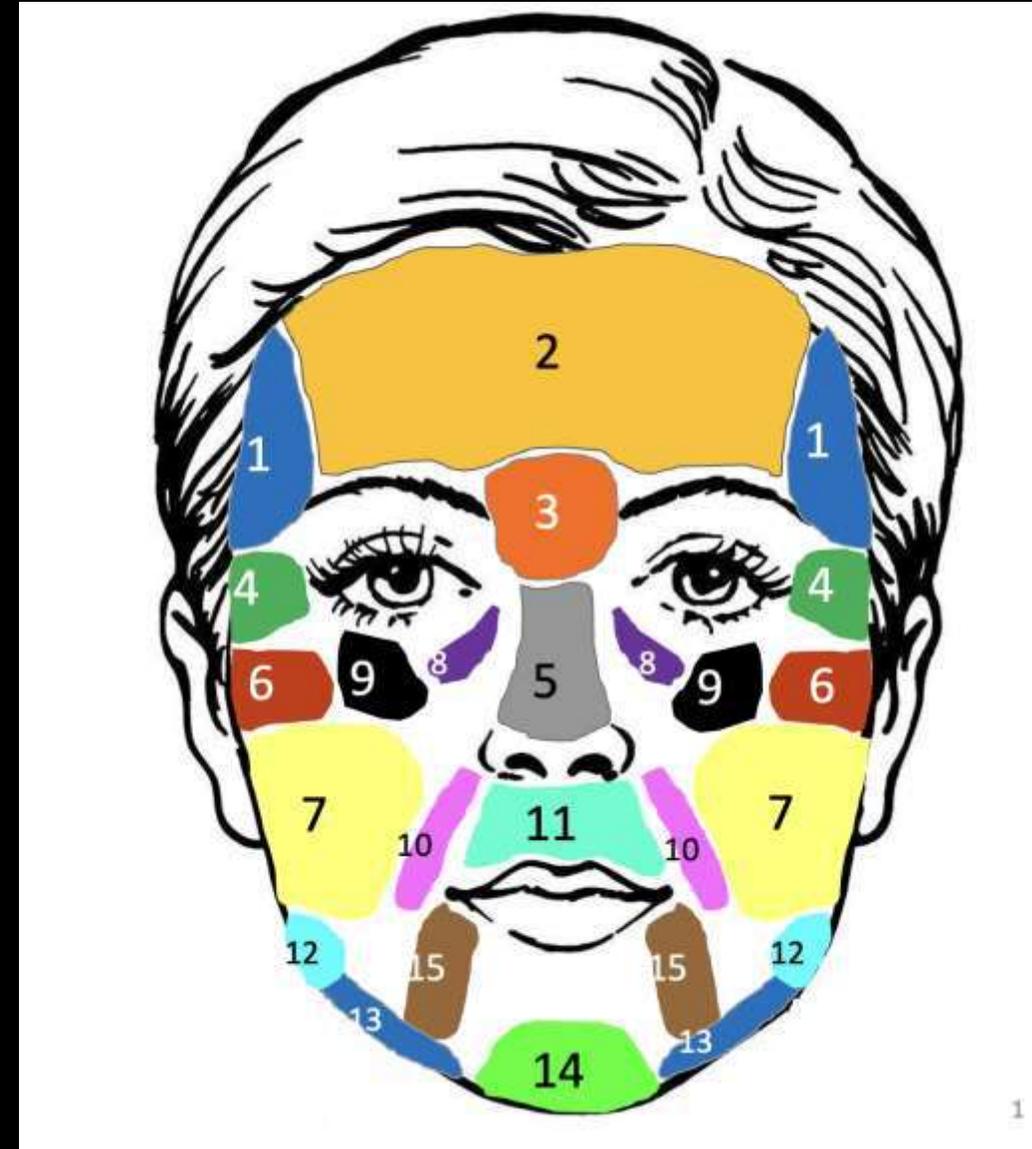


# Etude Tissue

- Un outil de mesure microscopique in vivo : artefacts réduits au maximum
- Un outil d'imagerie 3 D pour visualiser un objet tridimensionnel
- Etude mono-centrique observationnelle (Sponsor lab Fillmed /Investigateur principal JL Perrot, réalisée locaux DERMATECH Lyon)
  - Population : 50 femmes en bonne santé
  - 5 groupes
  - [ 20 – 30 years]; [ 31 – 40 years]; [ 41 – 50 years]; [ 51 – 64 years]; [  $\geq$  65 years]
  - de phototype I à IV
  - 15 zones du visage étudiées
  - 2 mesures par zones ( moyenne)

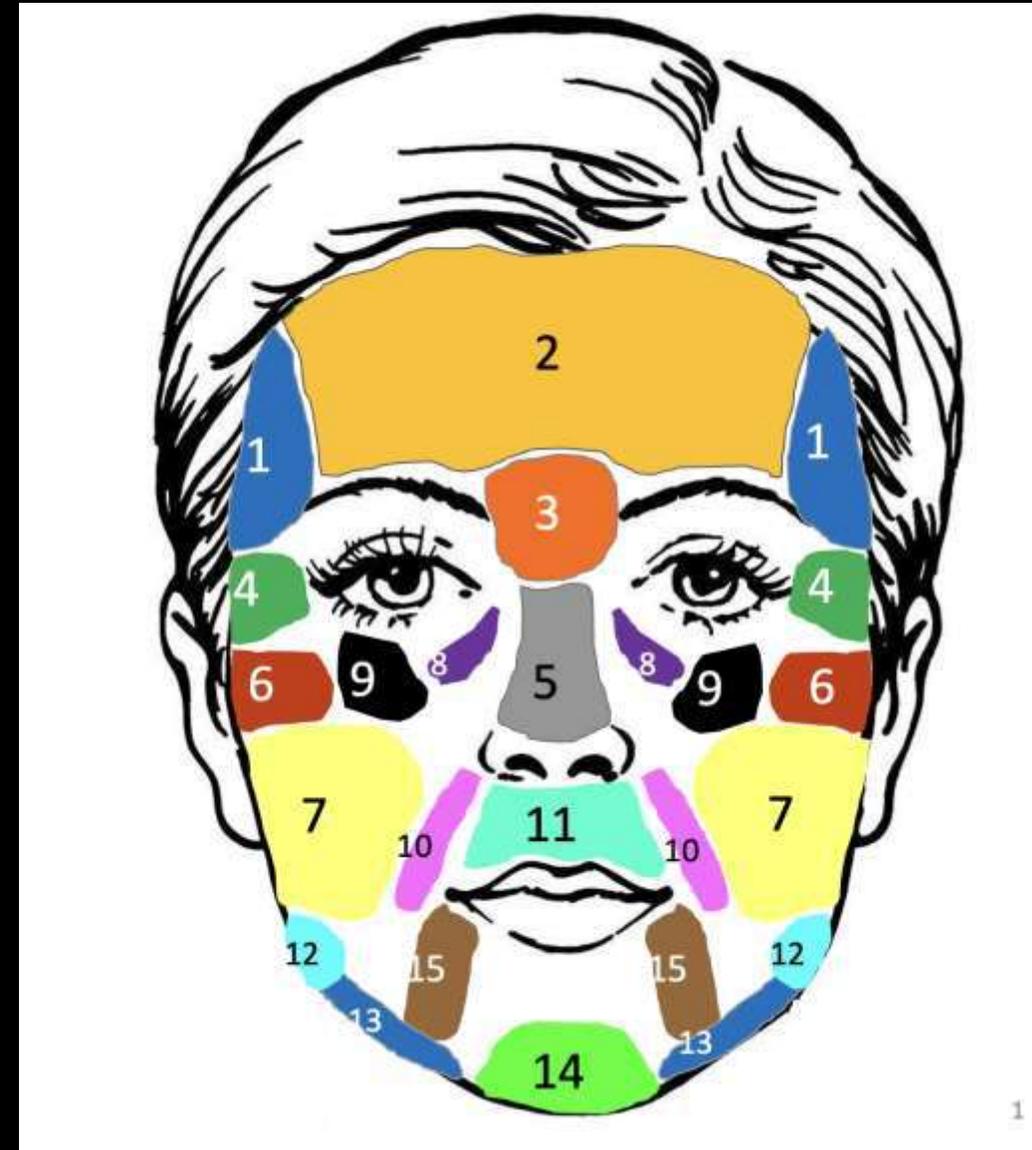
# Evaluation des variables

- Variable clinique:
  - Score of Lemperle cheek fold clinical scoring,
  - Score of Bazin crow's feet wrinkle clinical scoring,
  - Score of Bazin forehead wrinkle clinical scoring,
  - Score of Bazin under eye wrinkle clinical scoring,
  - Score of Bazin nasolabial fold clinical scoring,
- Critères morphologiques:
  - Thickness of Total skin (Vevo MD)
  - Thickness of hypodermis (Vevo MD)
  - Thickness of fascia (Vevo MD)
  - Dermal echogenicity (Vevo MD)
  - Thickness of epidermis (DeepLive)
  - Waving index of the dermis-epidermis junction (DeepLive)
- Critères structurels:
  - 3-D imaging of the topology of tension lines of the skin (tension index)
  - Skin biomechanics measurement using the Cutometer (suction technique)
  - Skin Elasticity measurement using the Underskin system (a contact free impact test measurement)
  - Echogenicity (tissues density) by Ultra High frequency ultrasound imaging (Vevo MD)
  - Collagen density in the superficial dermis (DeepLive)
  - Waving of dermal fibres (Deeplive)



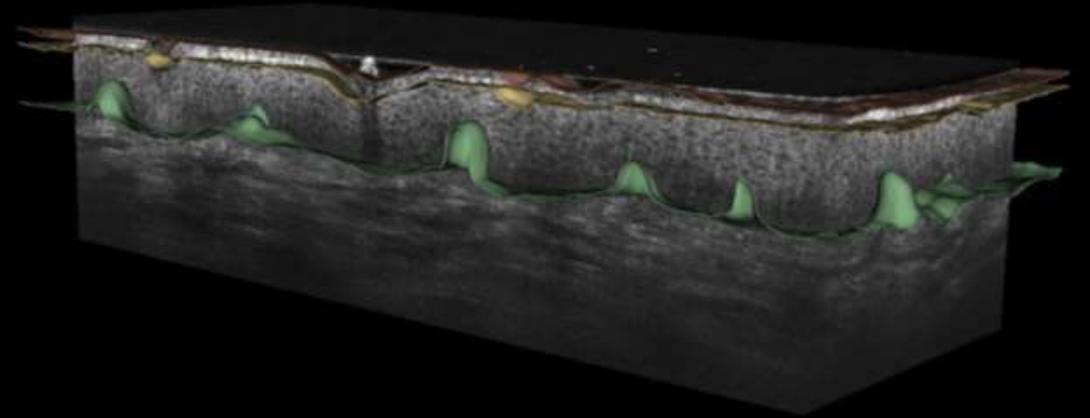
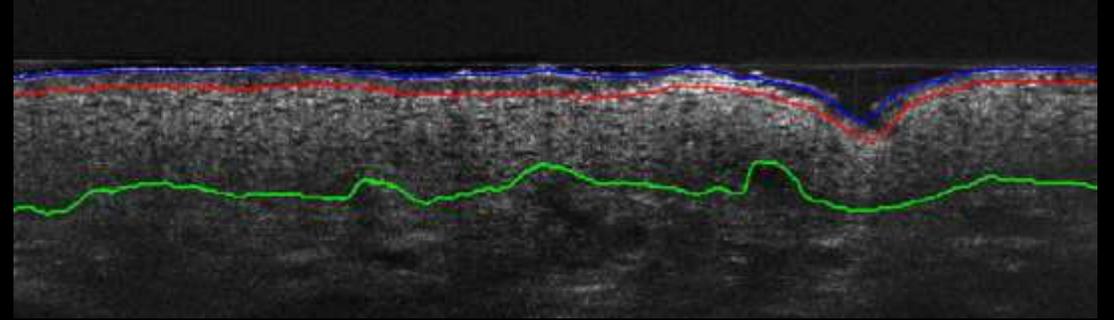
# Evaluation des variables

- Variable clinique:
  - Score of Lempereur cheek fold clinical scoring,
  - Score of Bazin crow's feet wrinkle clinical scoring,
  - Score of Bazin forehead wrinkle clinical scoring,
  - Score of Bazin under eye wrinkle clinical scoring,
  - Score of Bazin nasolabial fold clinical scoring,
- Critères morphologiques:
  - **Thickness of Total skin (Vevo MD)**
  - **Thickness of hypodermis (Vevo MD)**
  - **Thickness of fascia (Vevo MD)**
  - **Dermal echogenicity (Vevo MD)**
  - **Thickness of epidermis (DeepLive)**
  - **Waving index of the dermis-epidermis junction (DeepLive)**
- Critères structurels:
  - 3-D imaging of the topology of tension lines of the skin (tension index)
  - Skin biomechanics measurement using the Cutometer (suction technique)
  - Skin Elasticity measurement using the Underskin system (a contact free impact test measurement)
  - **Skin Tension**
  - **Echogenicity (tissues density) by Ultra High frequency ultrasound imaging (Vevo MD)**
  - **Collagen density in the superficial dermis (DeepLive)**
  - **Waving of dermal fibres (DeepLive)**



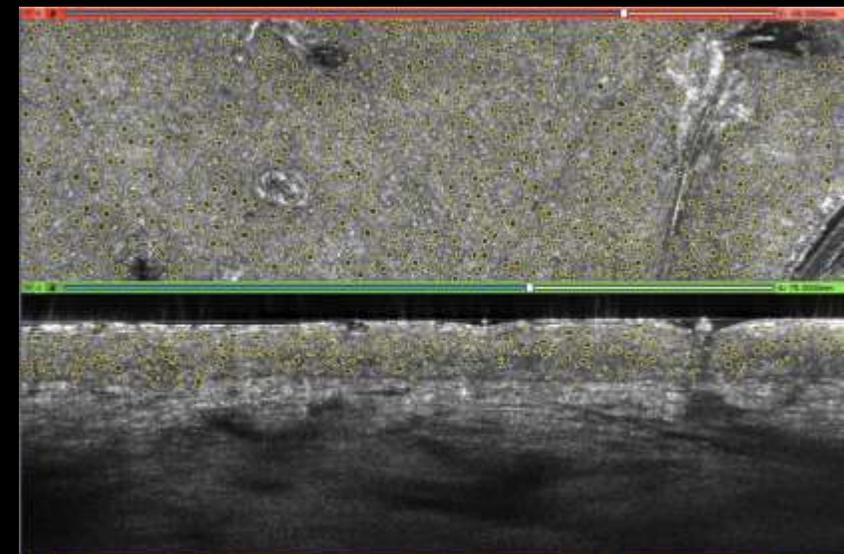
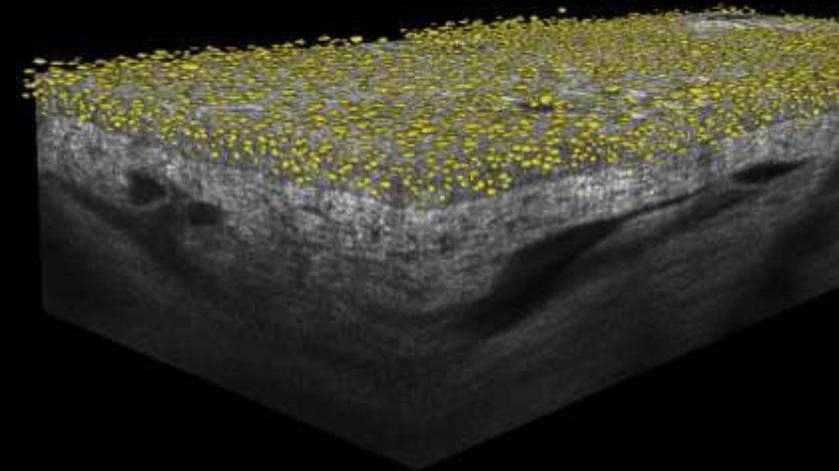
# Segmentation automatique par IA

- Stratum corneum, Epiderme, JDE
- Elimination follicules pileux

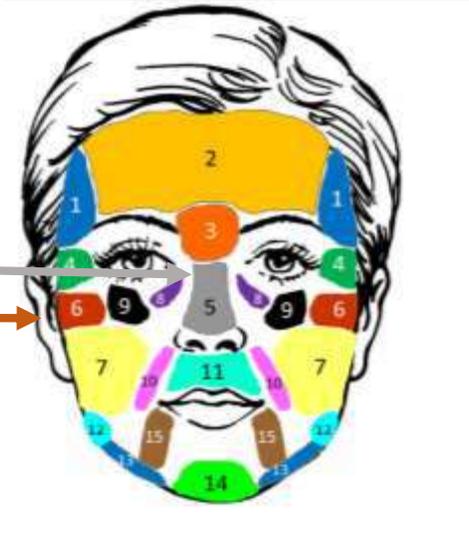
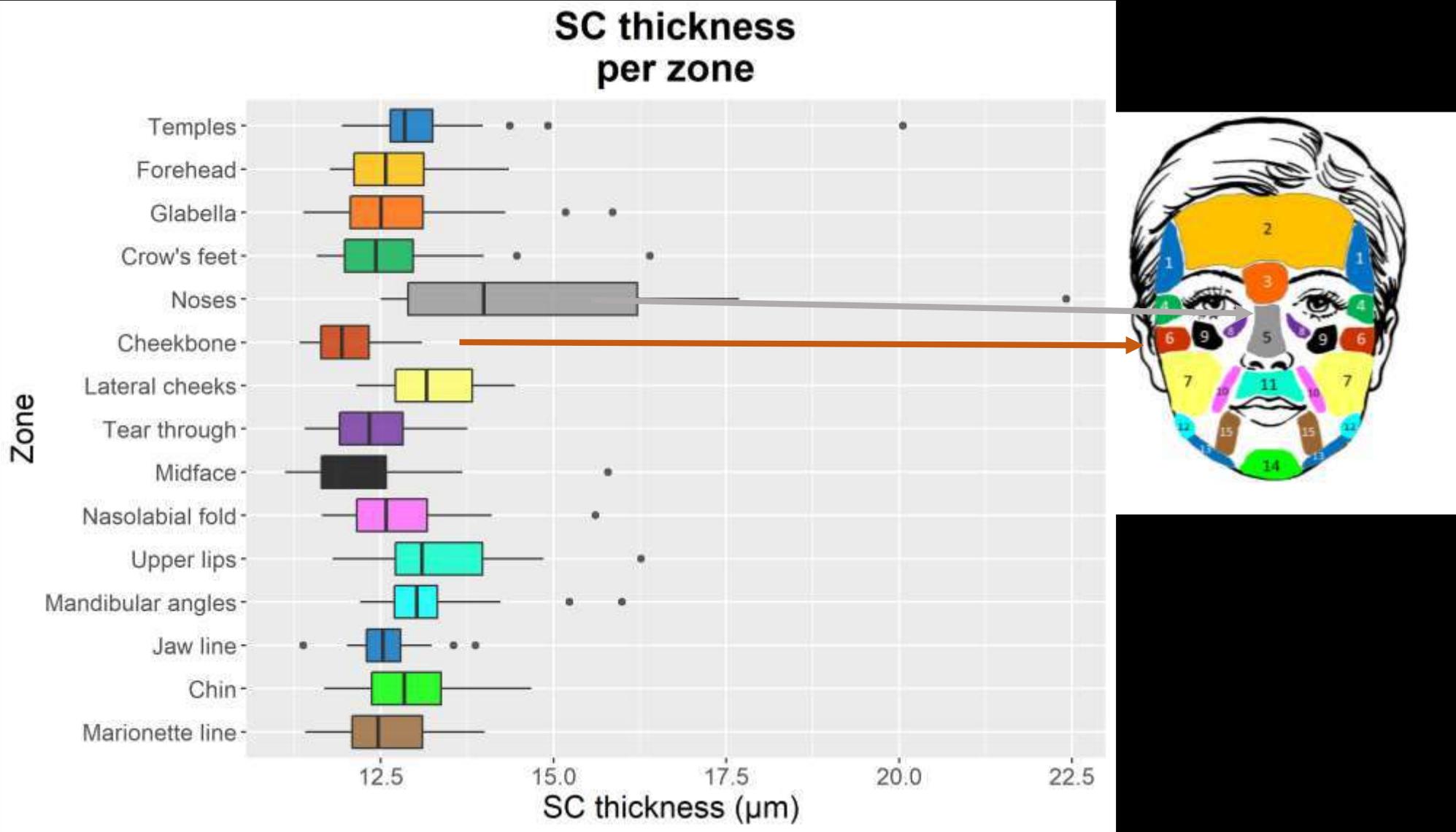


# Segmentation automatique par IA

- Stratum corneum, Epiderme, JDE
- Elimination follicules pileux
- Mesure densité de kératinocytes par unité de surface
- Mesure nombre de couches de kératinocytes
- Mesure volume des noyaux
- Mesure compacité des noyaux



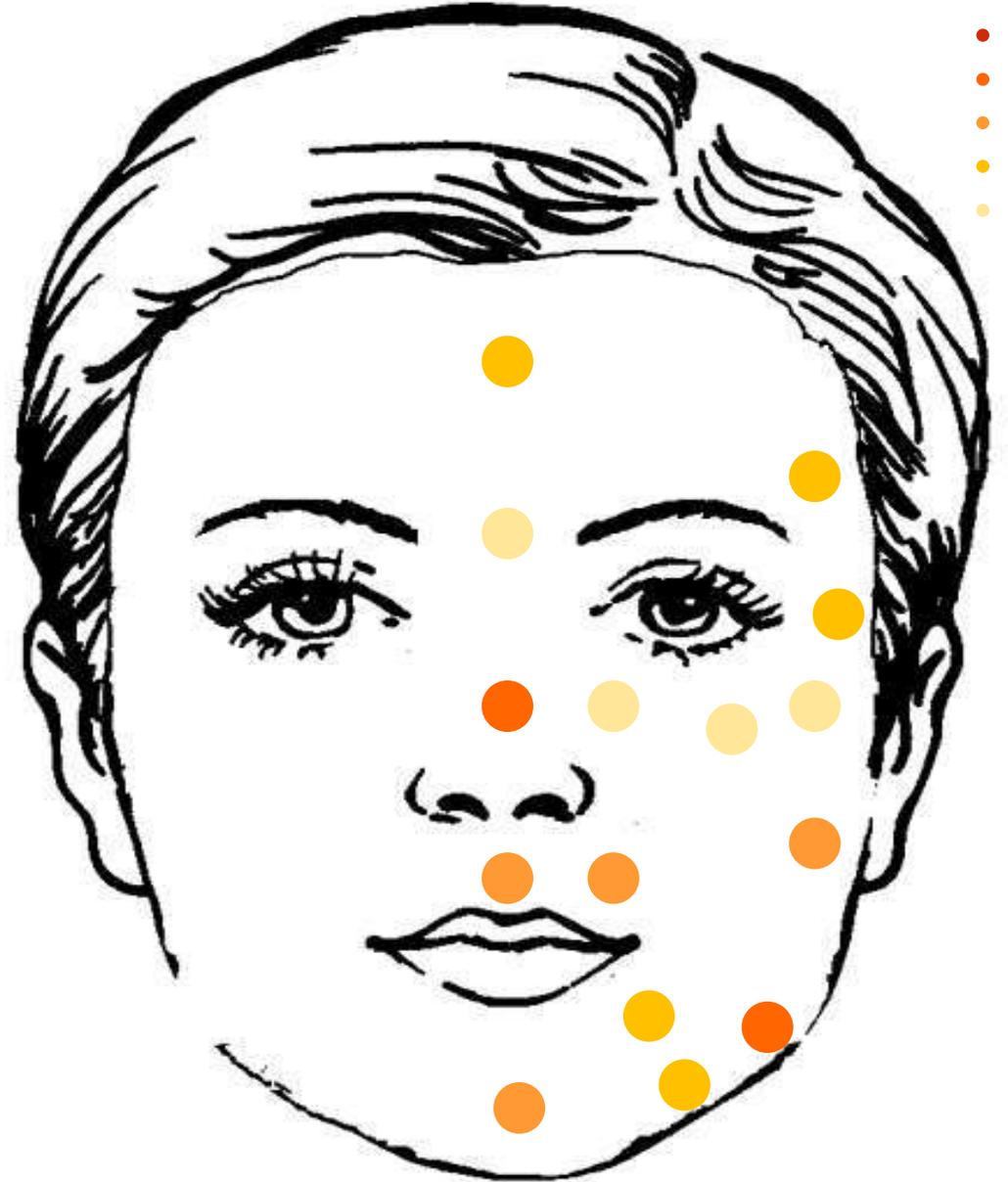
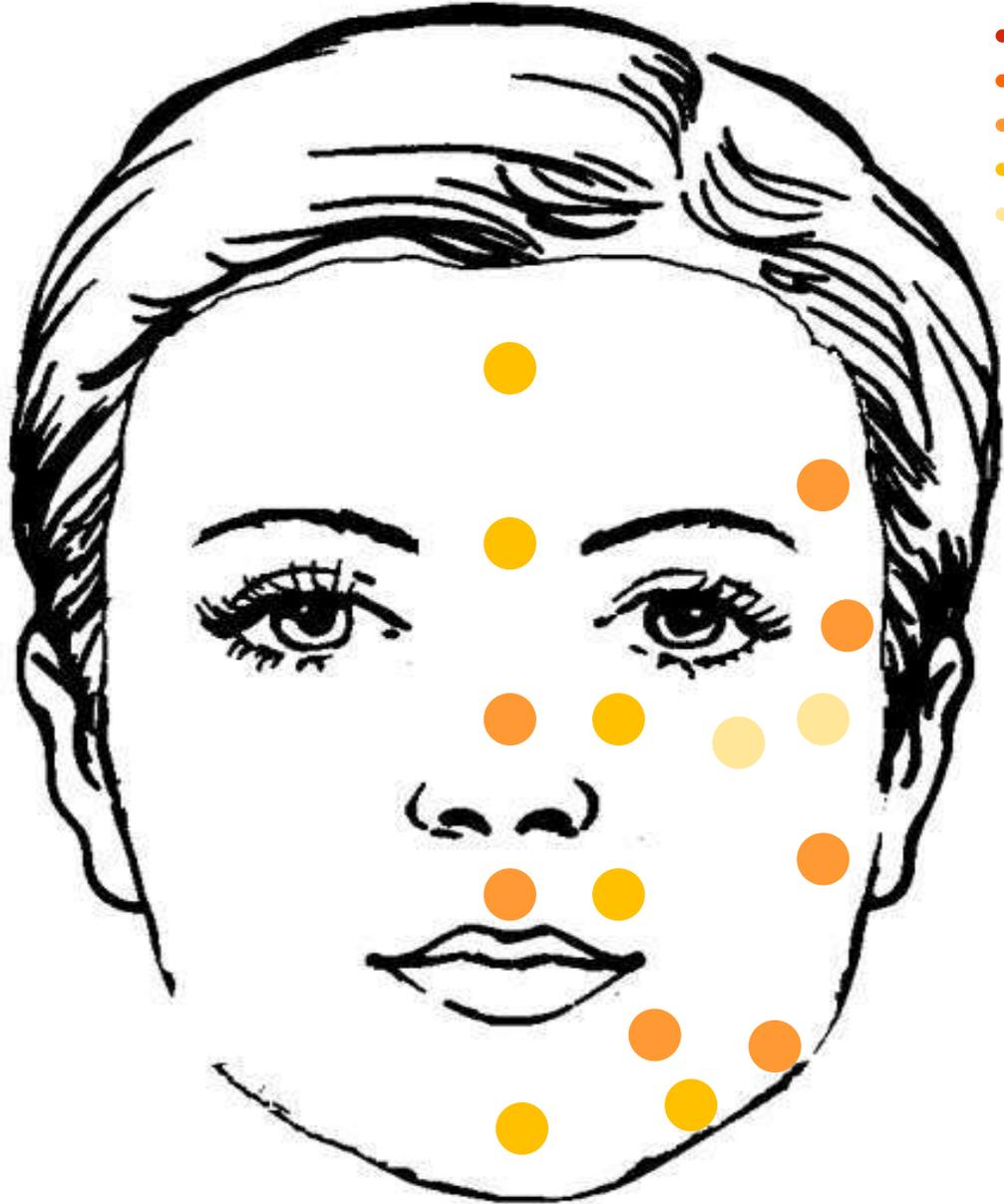
# Epaisseur du stratum corneum



# SC thickness

20-30 y. old

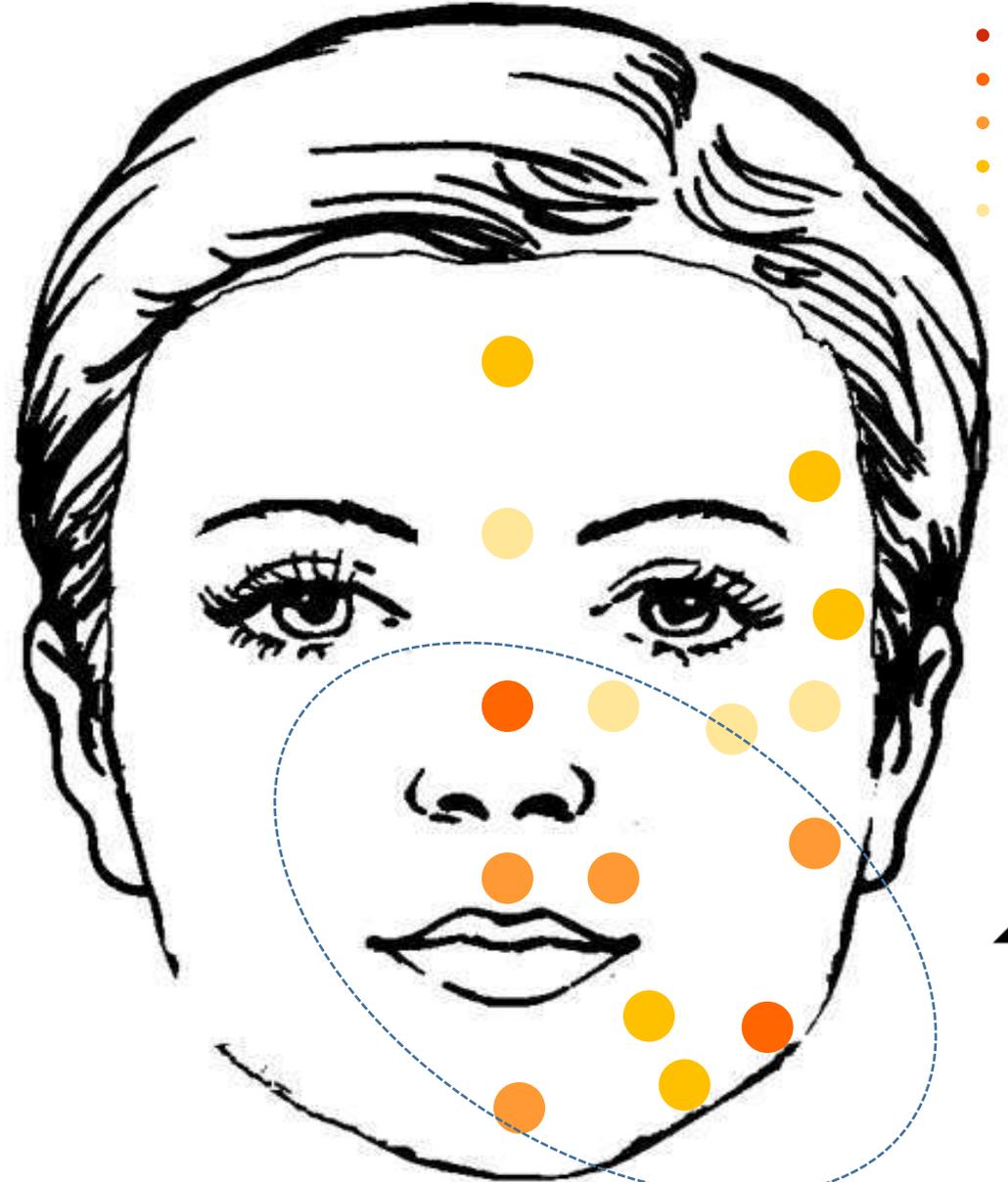
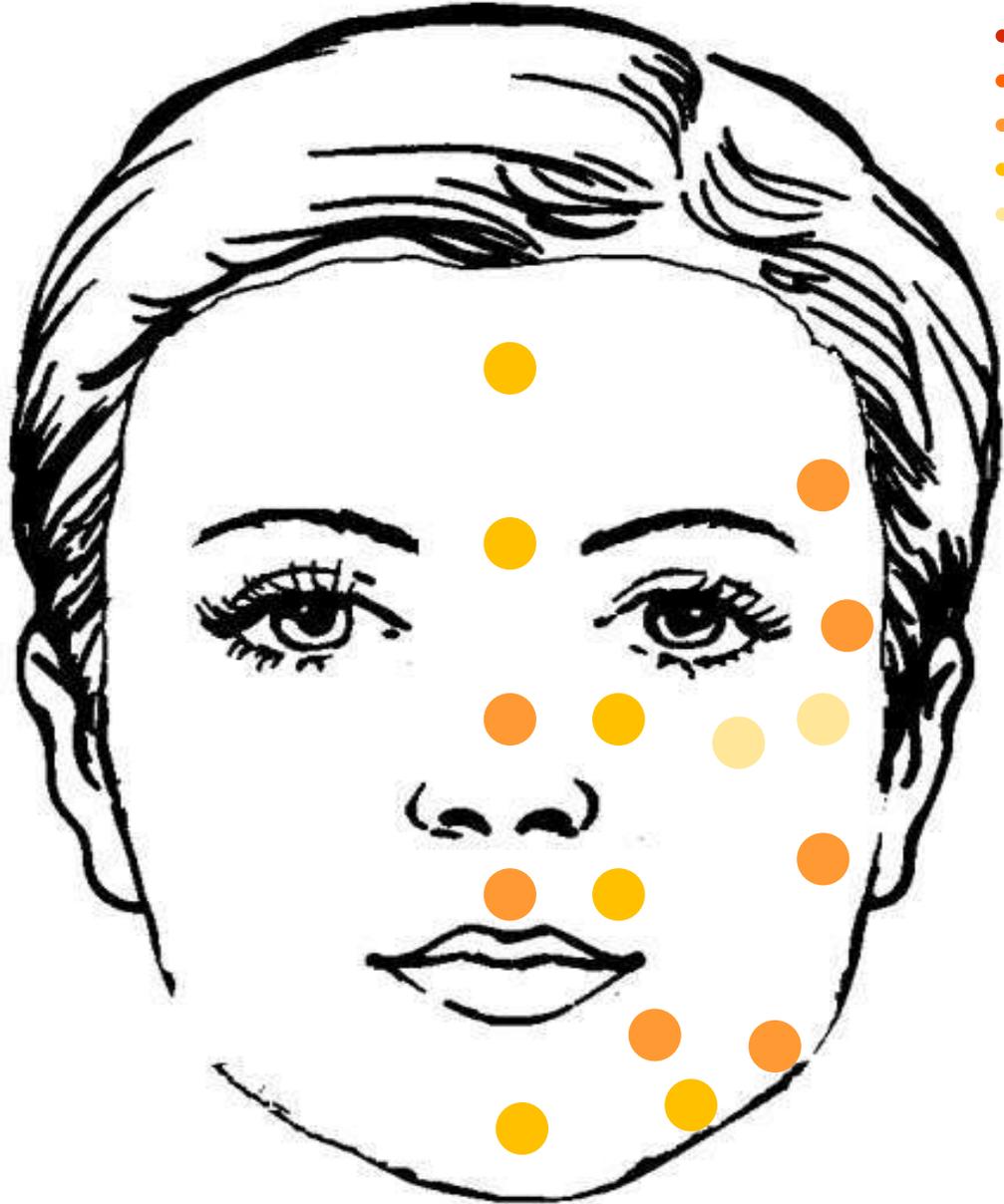
> 65 y. old



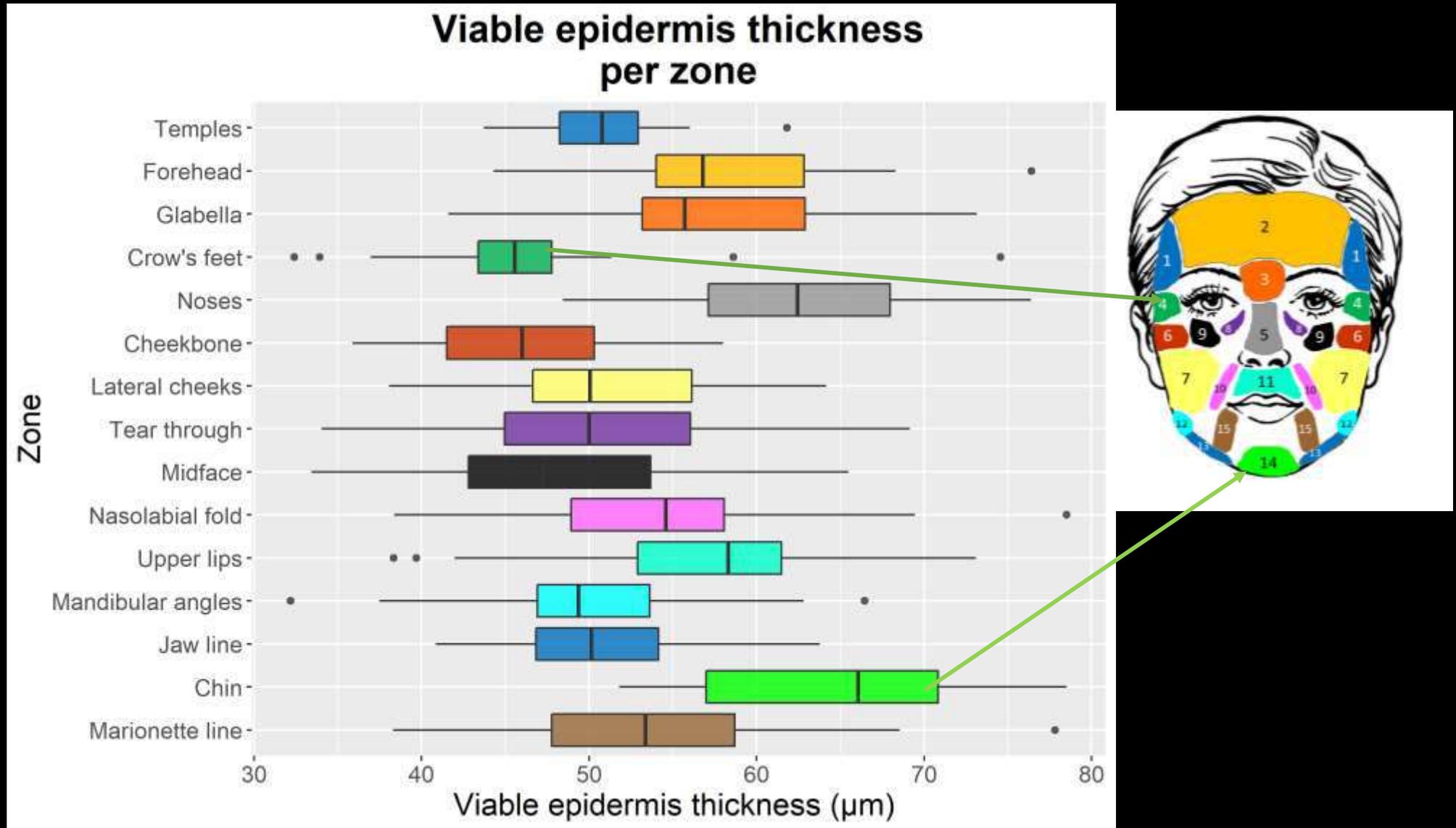
# SC thickness

20-30 y. old

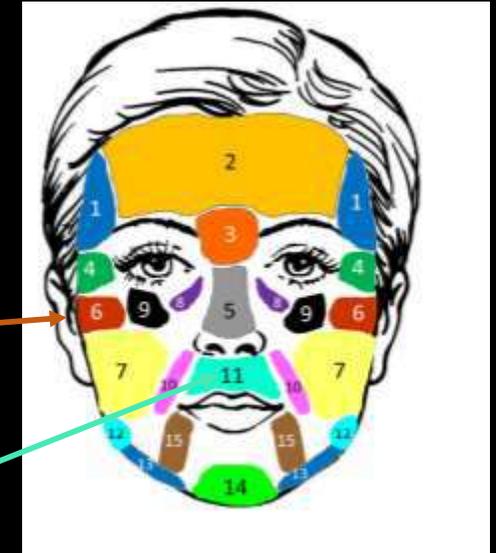
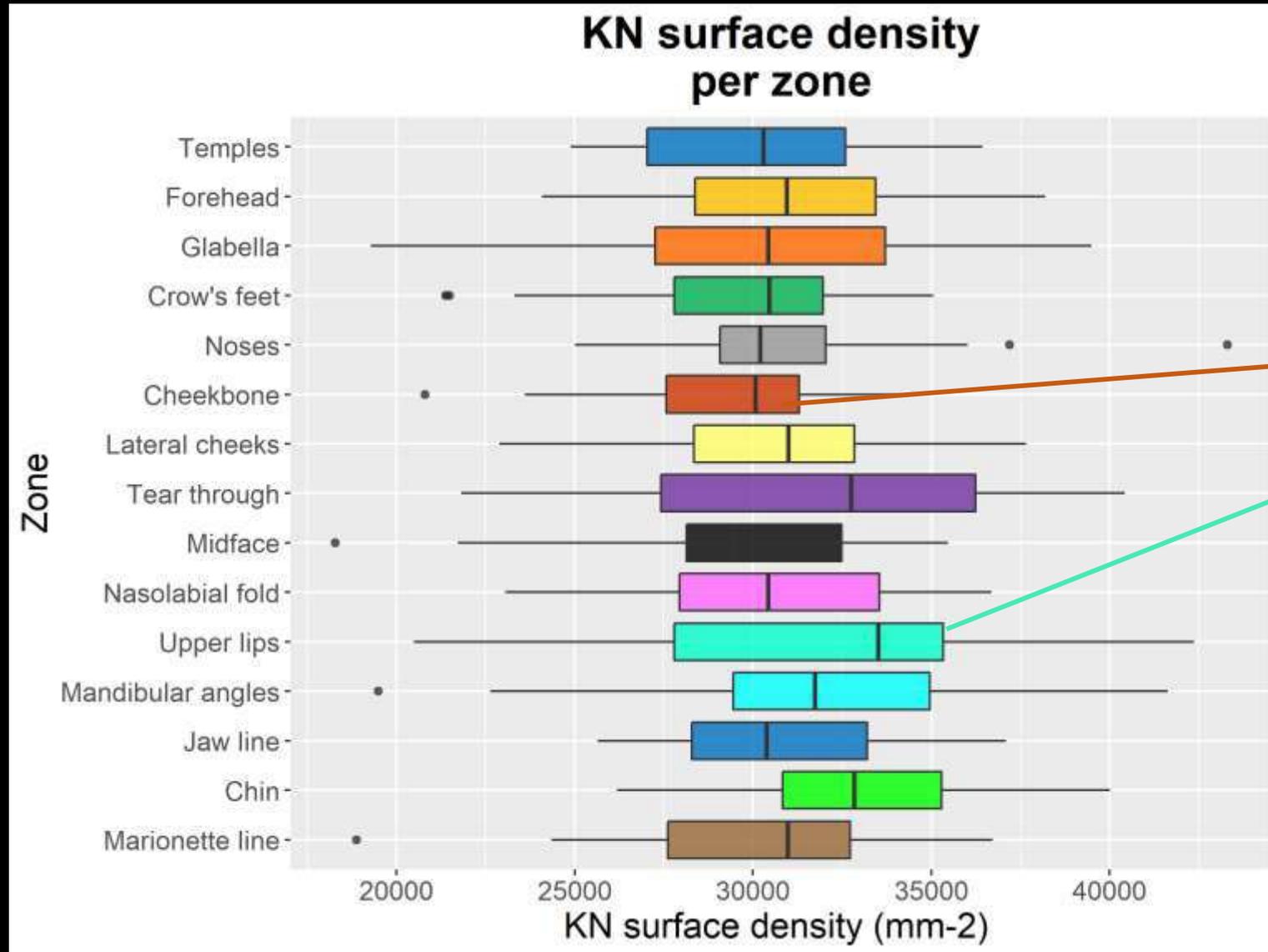
> 65 y. old



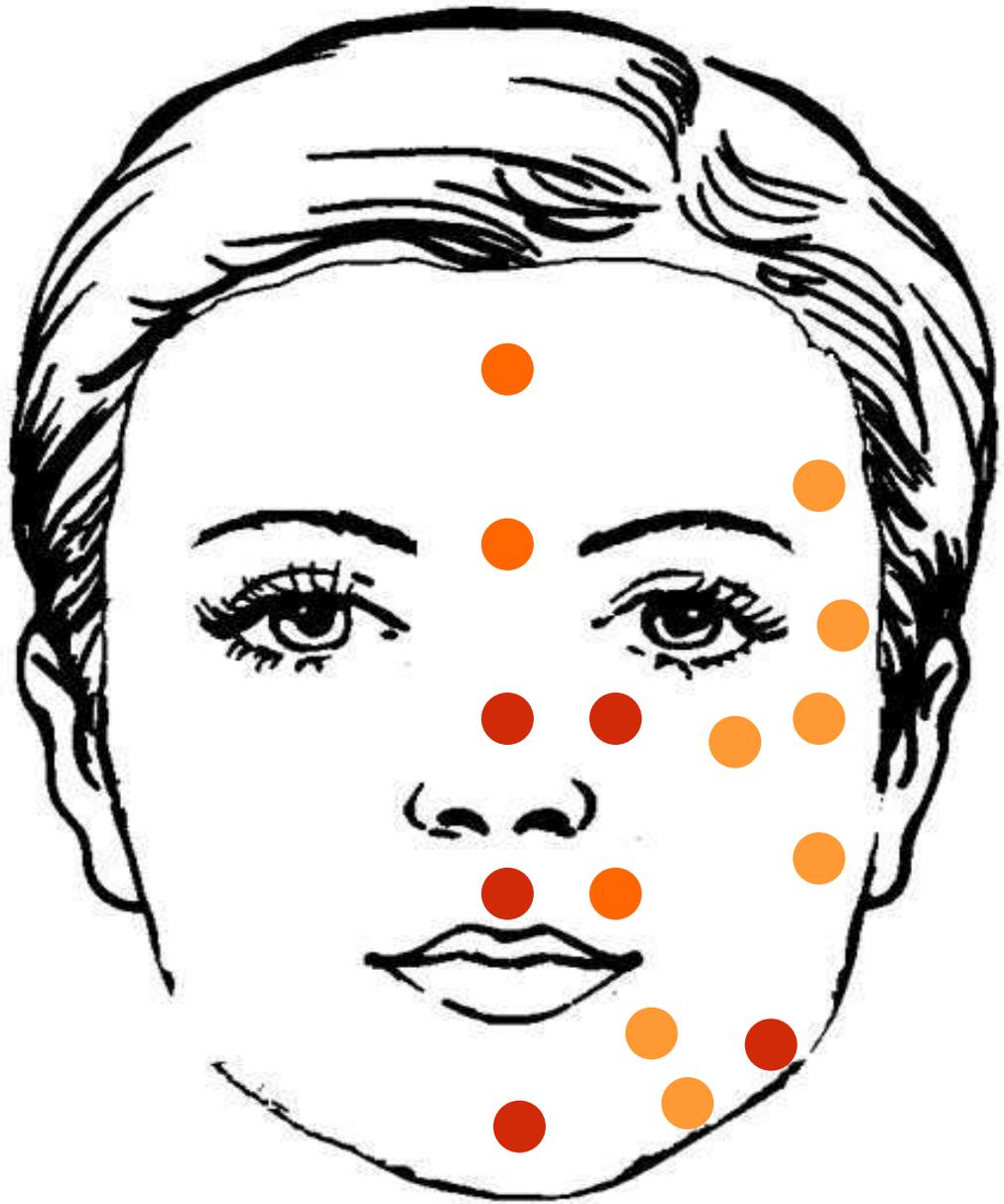
# Epaisseur épiderme vivant thickness



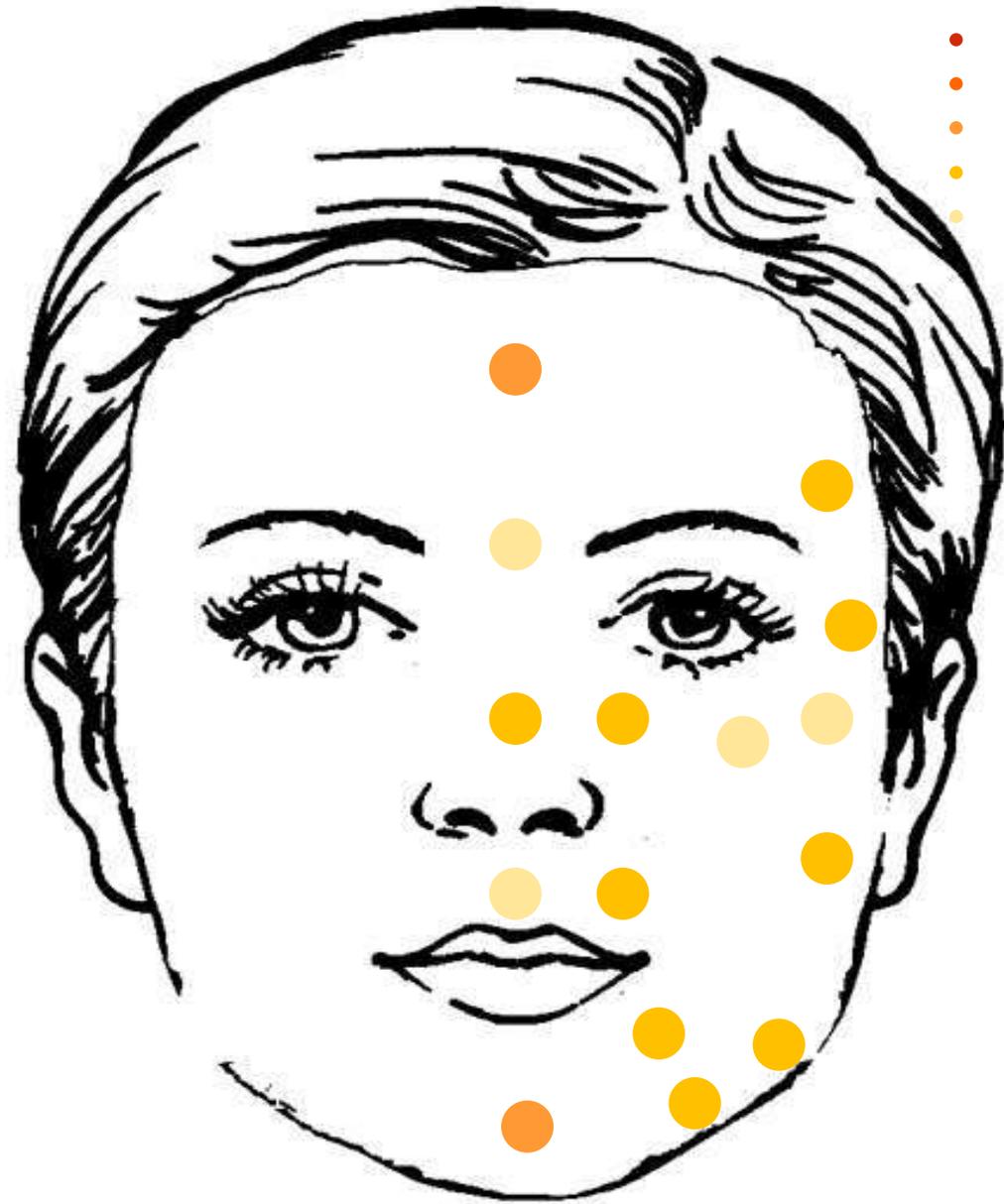
# Densité des kératinocytes par unité de surface surface density



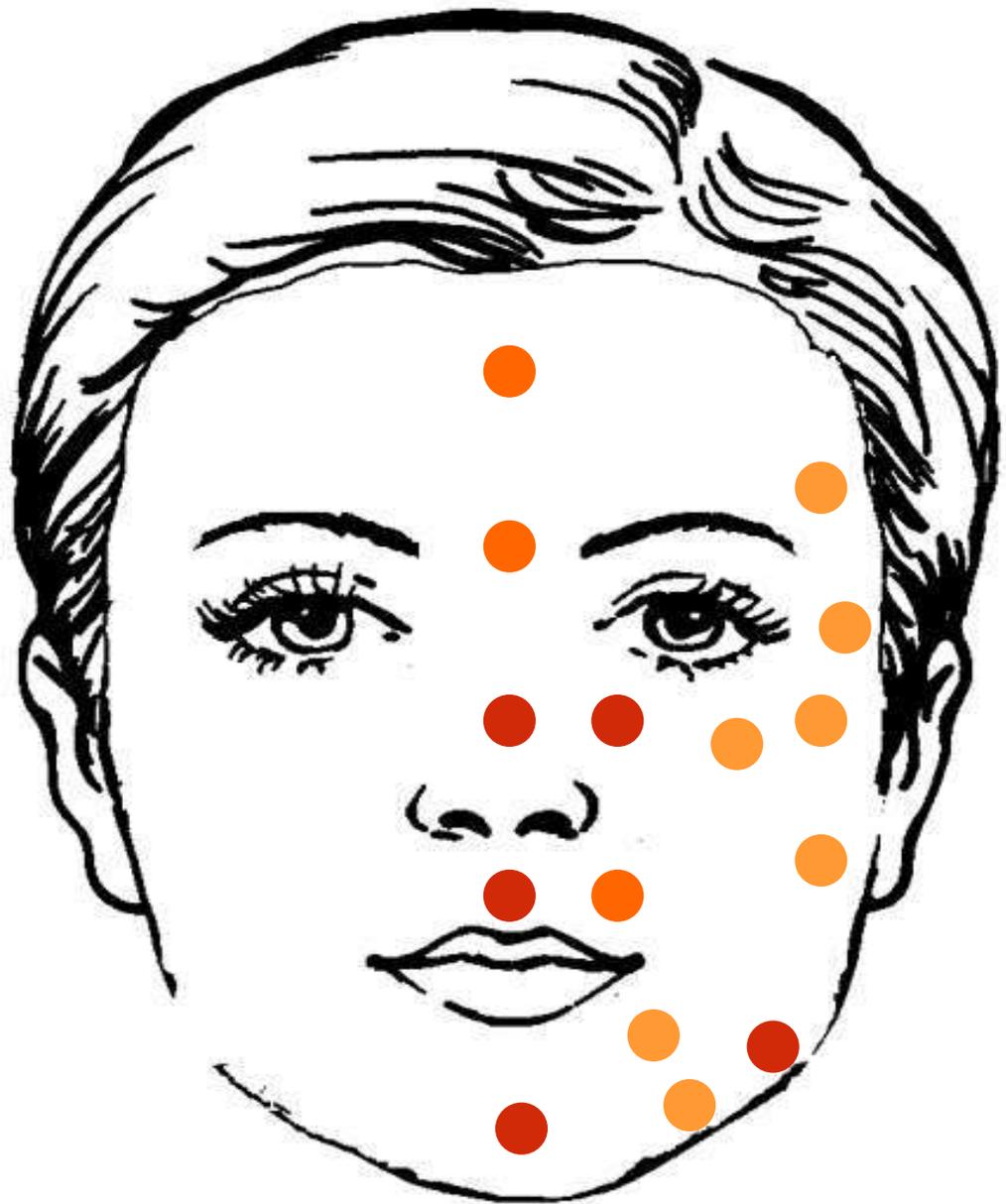
20-30 y. old



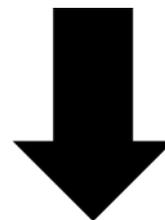
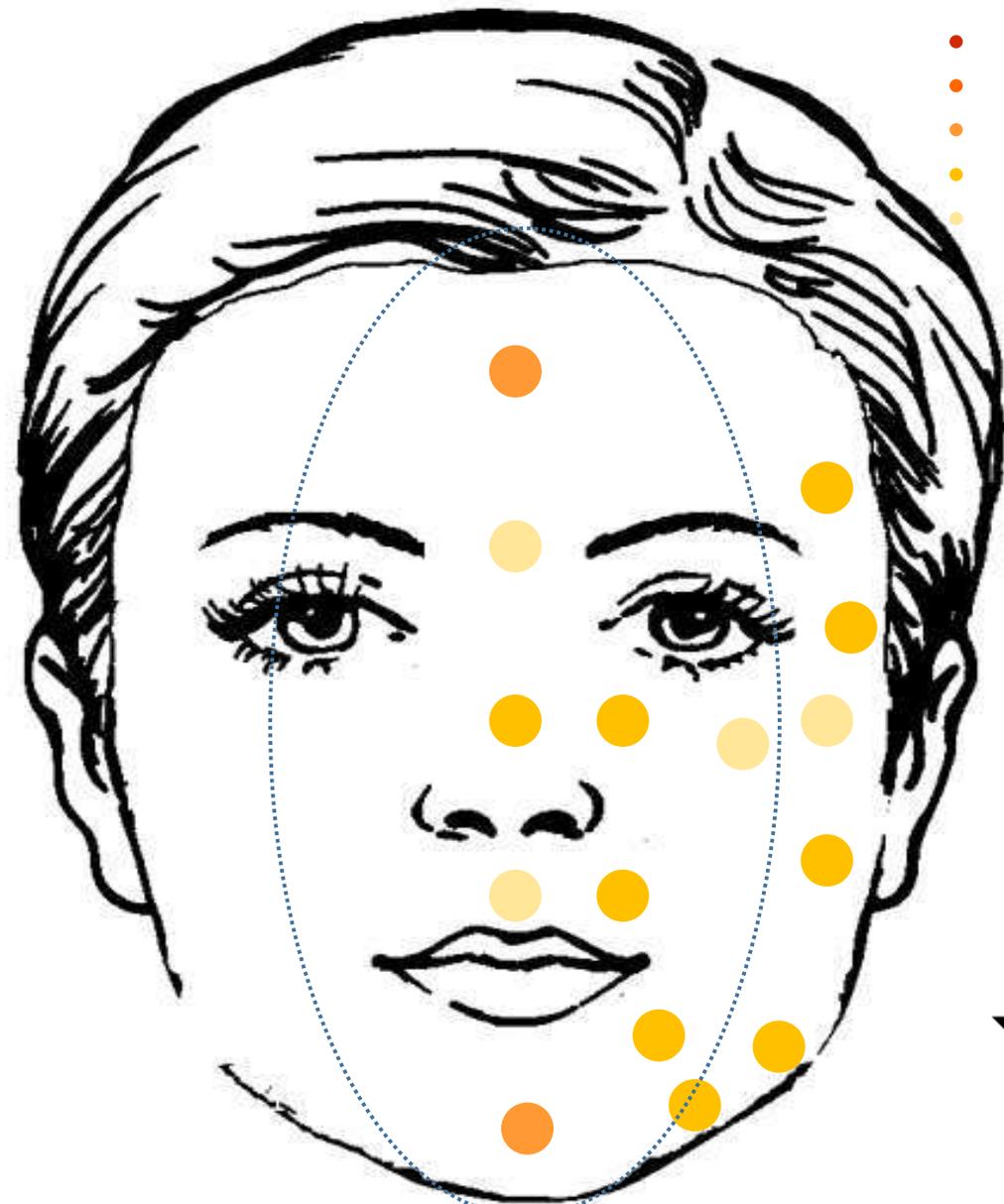
> 65 y. old



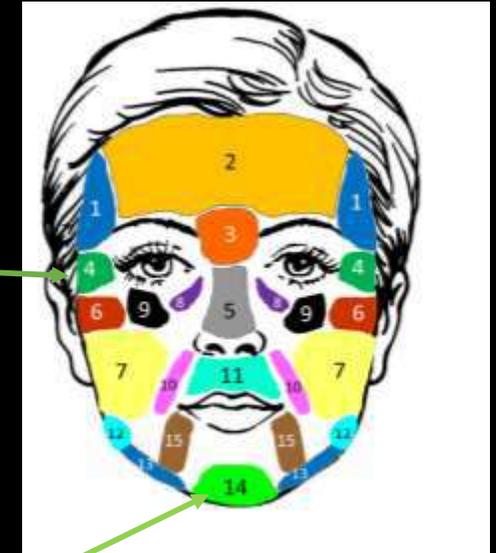
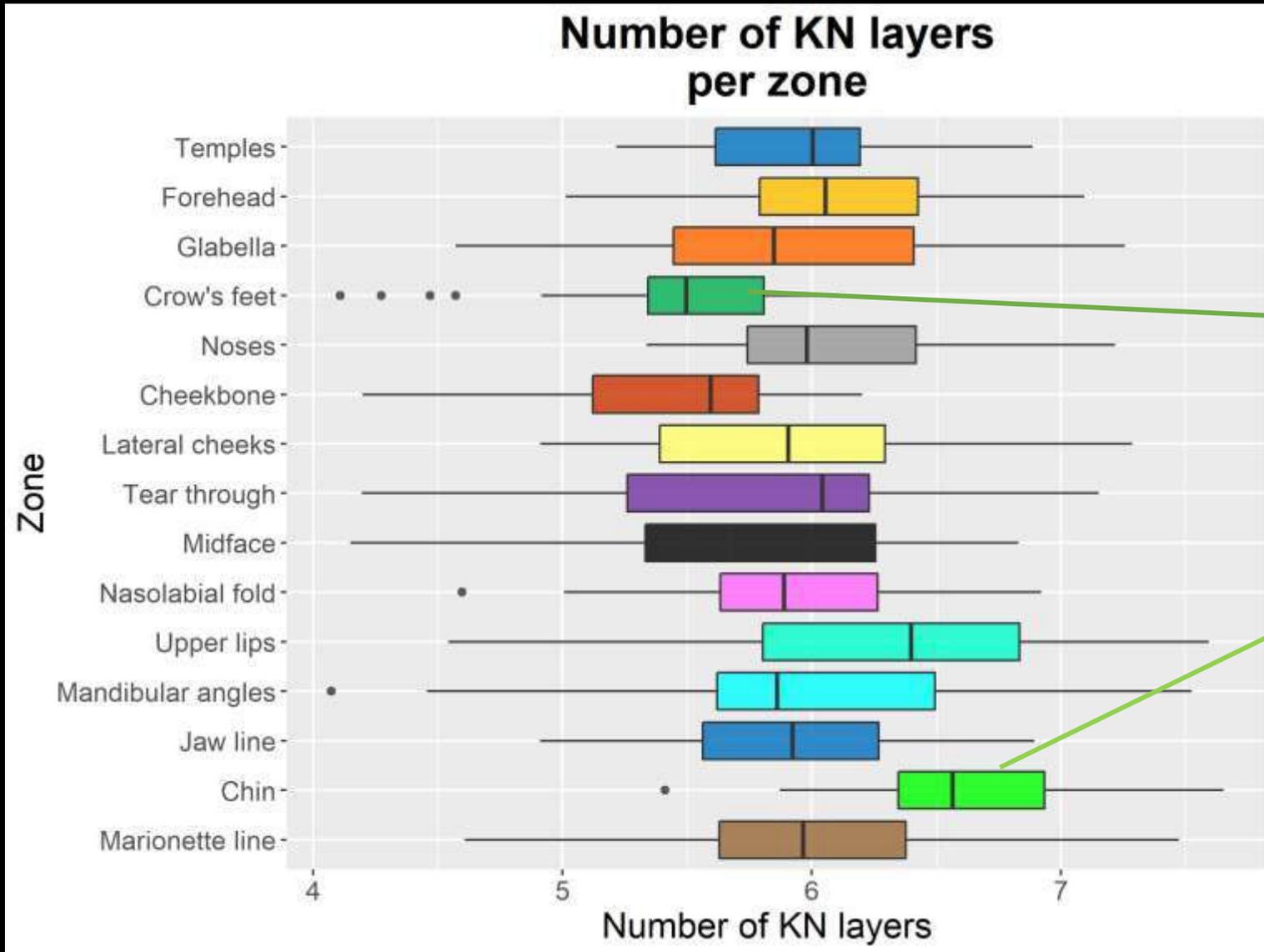
20-30 y. old



> 65 y. old



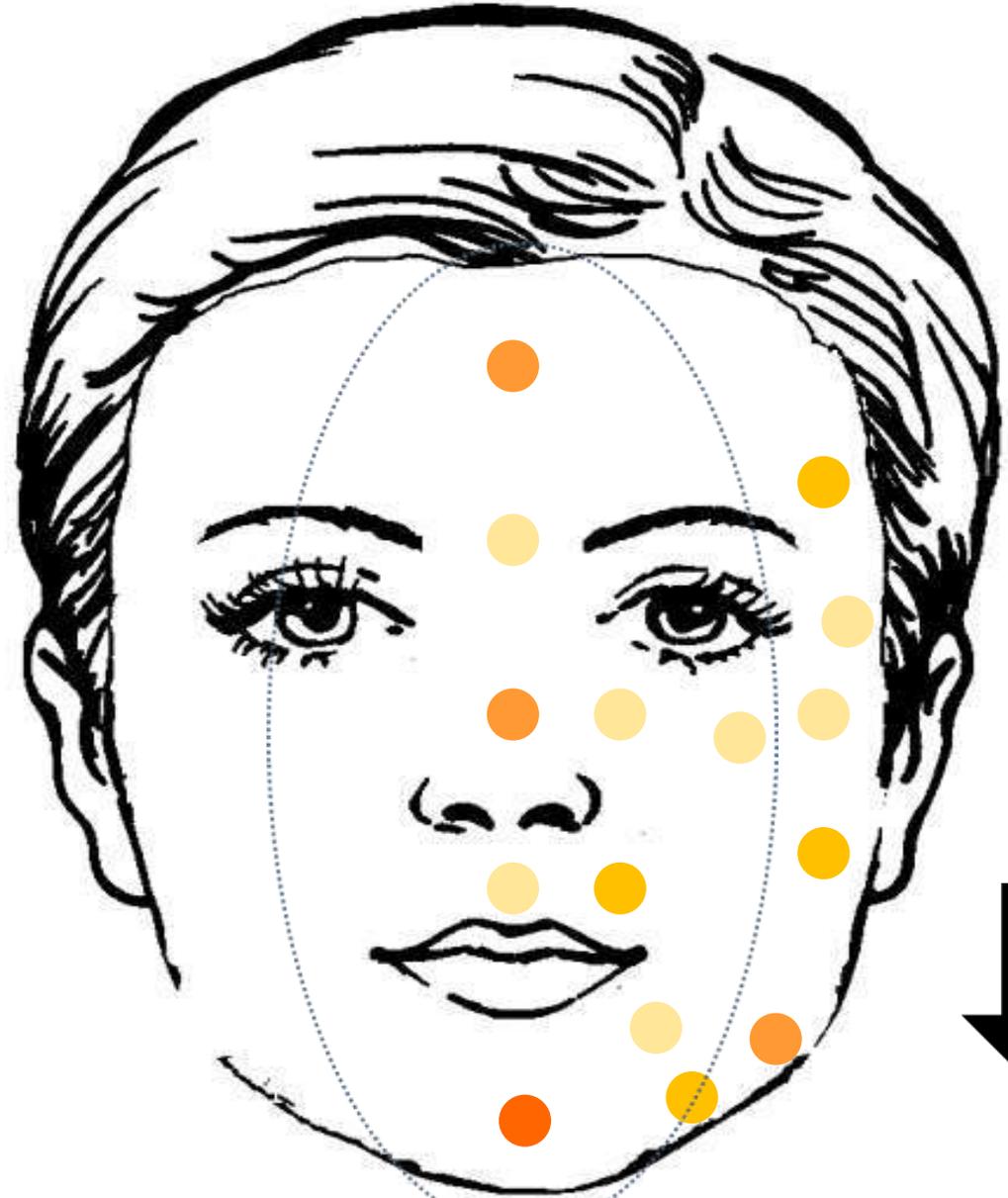
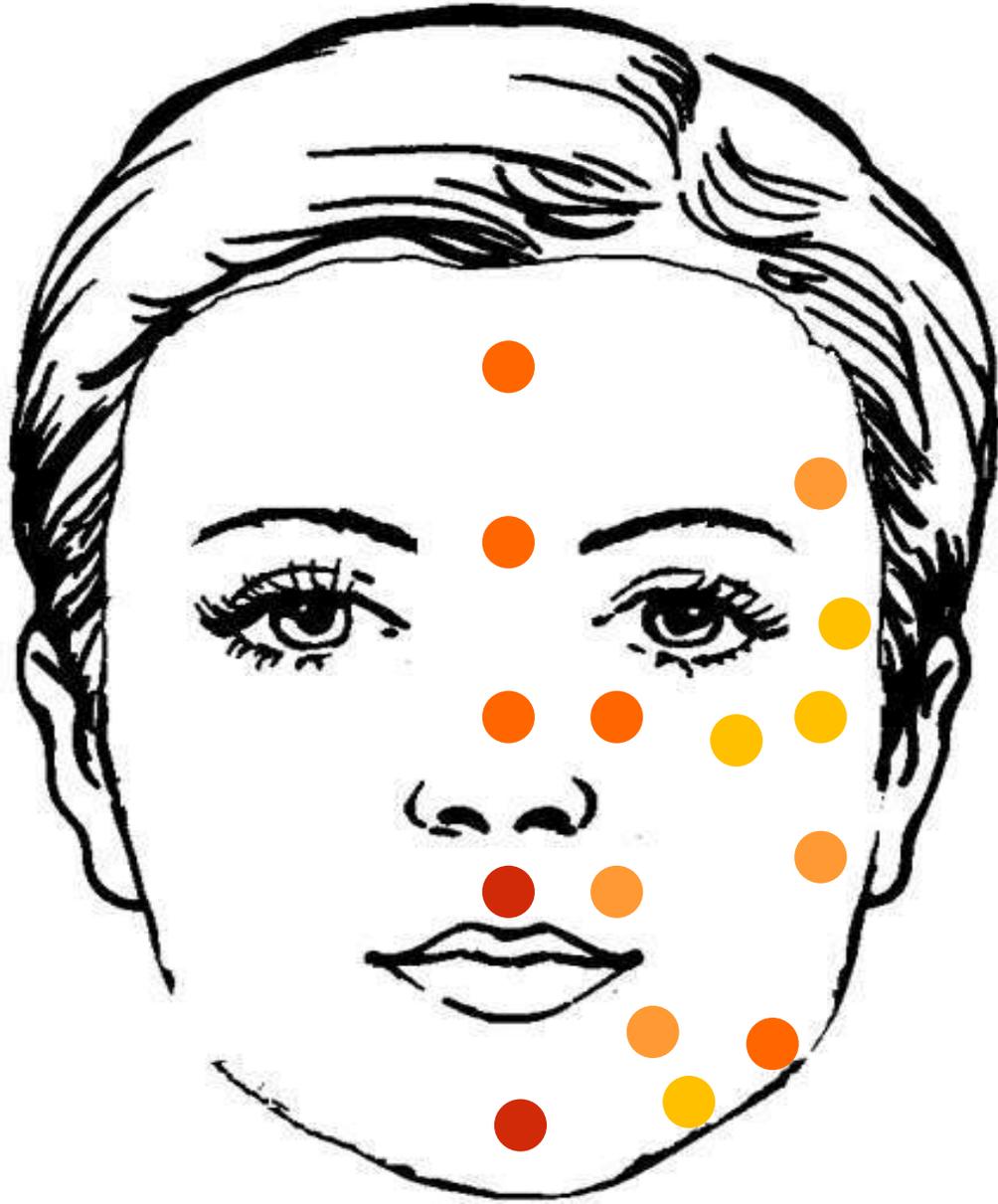
# Nombre de couche de kératinocytes



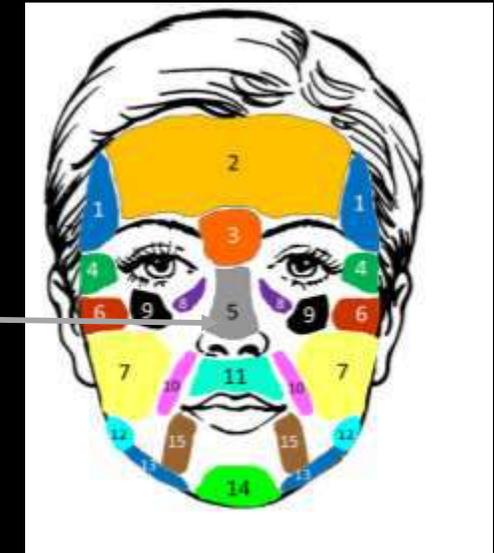
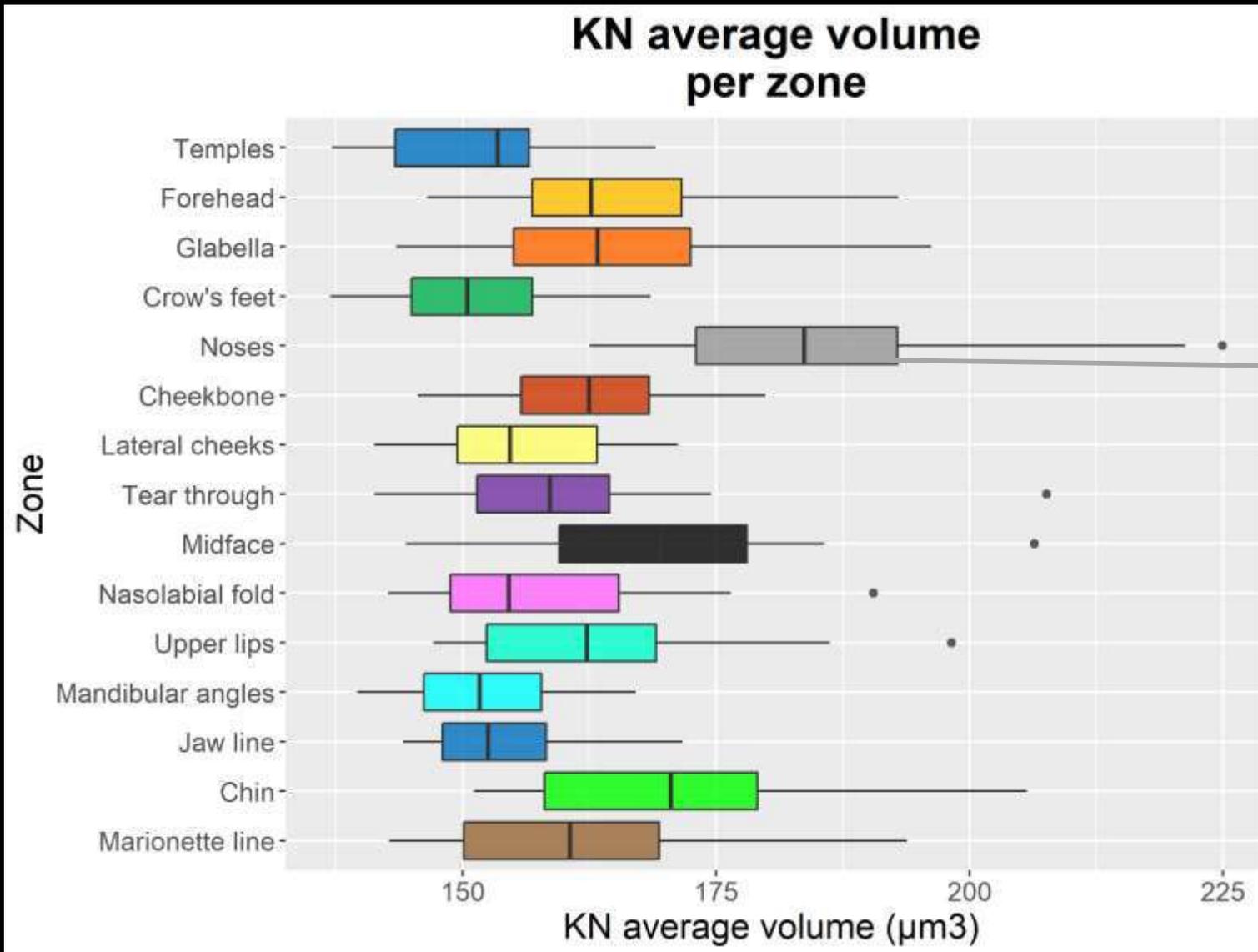
# KN layers number

20-30 y. old

> 65 y. old



# Volume moyen de noyaux ds kératinocytes

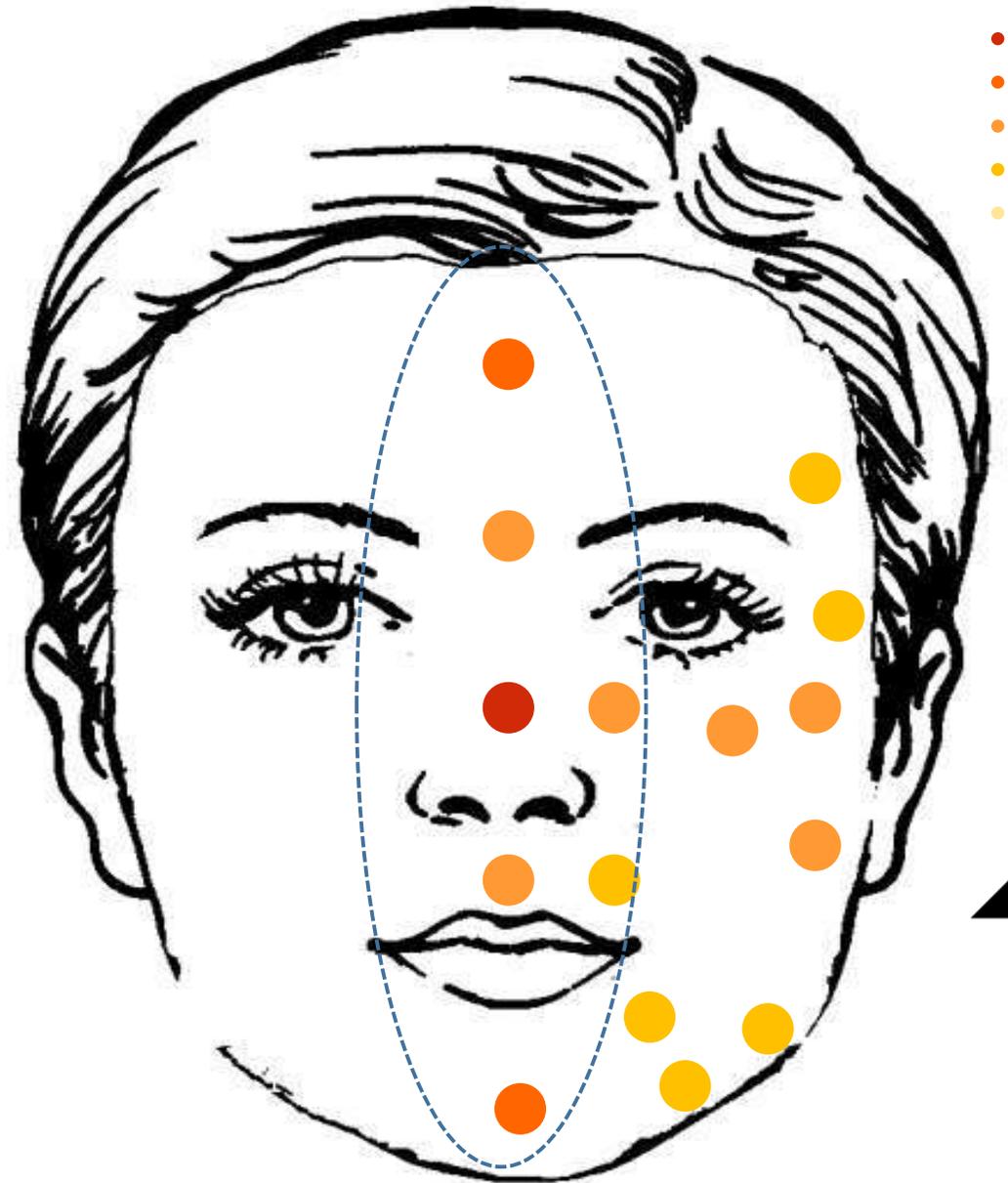
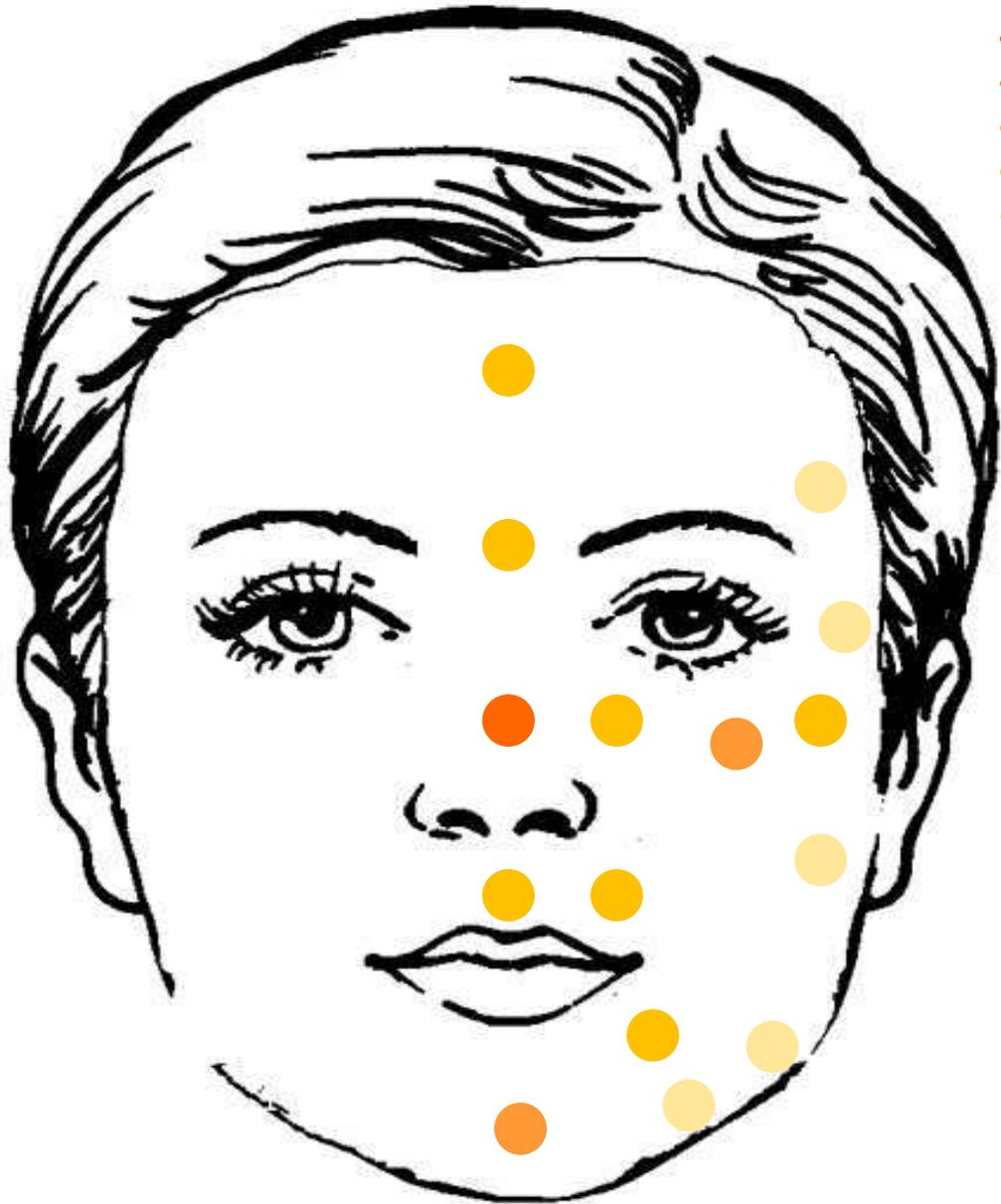


Les zones 1,4,11 et 13 ont les noyaux les moins altérés à la différence de la région médiofaciale

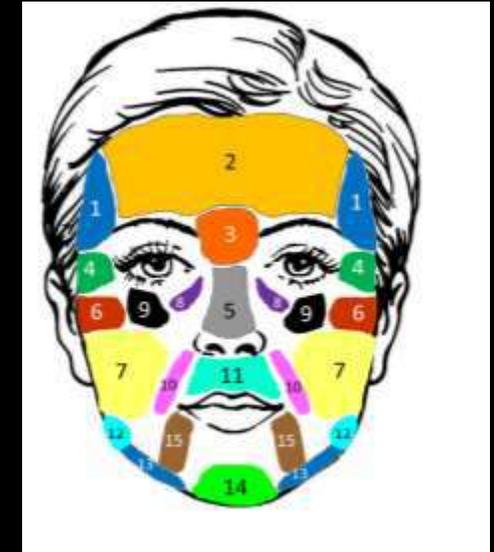
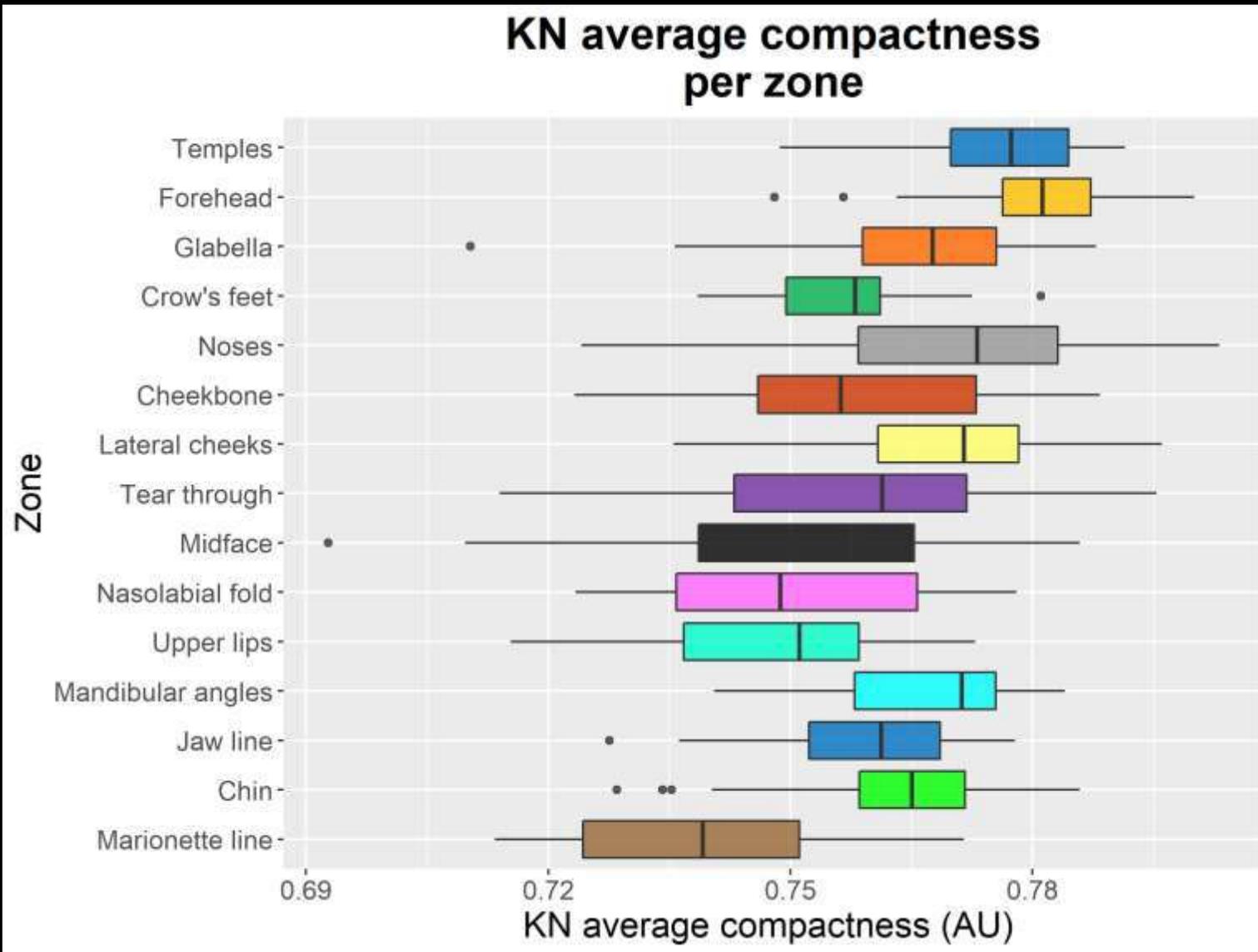
# KN mean volume

20-30 y. old

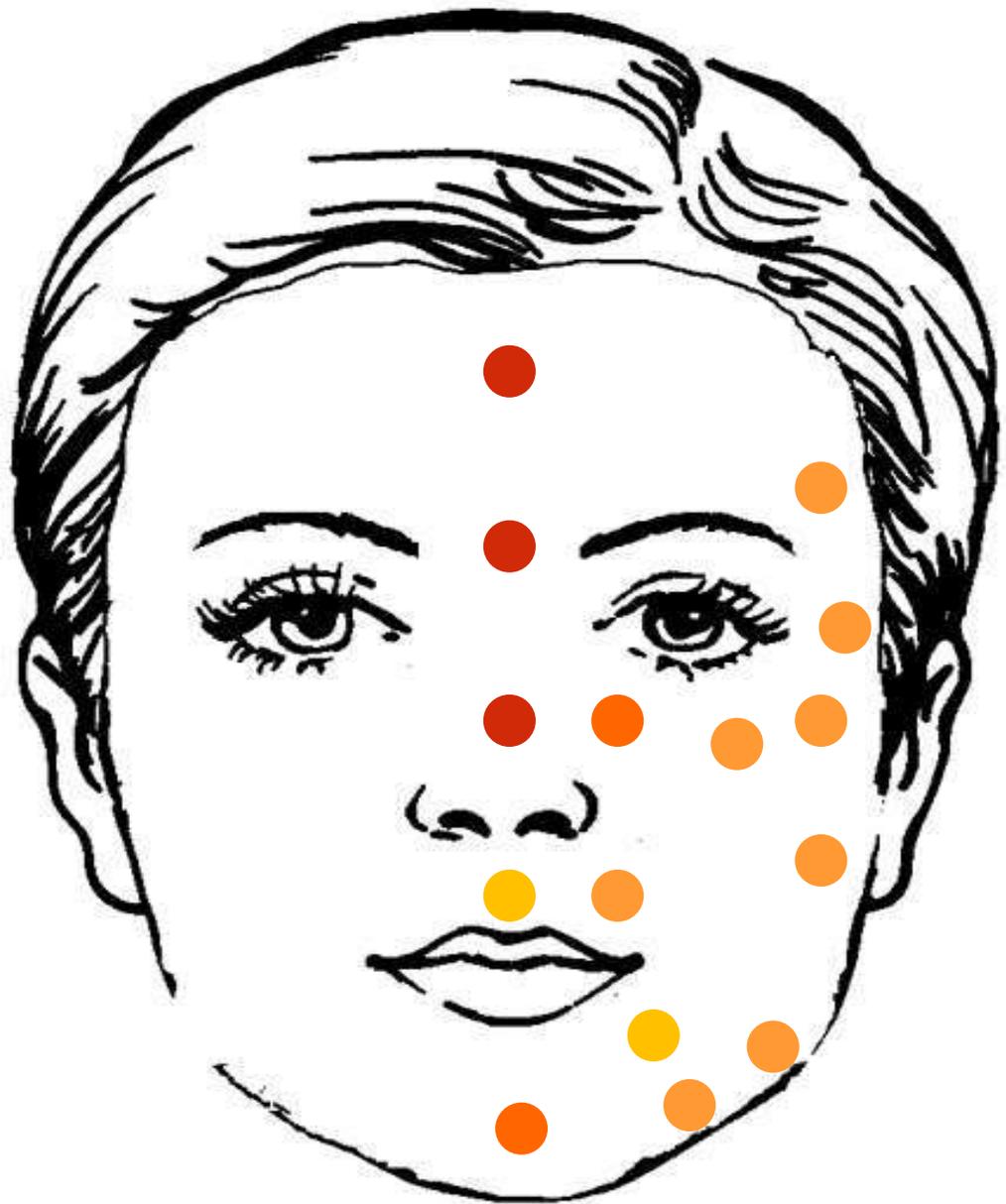
> 65 y. old



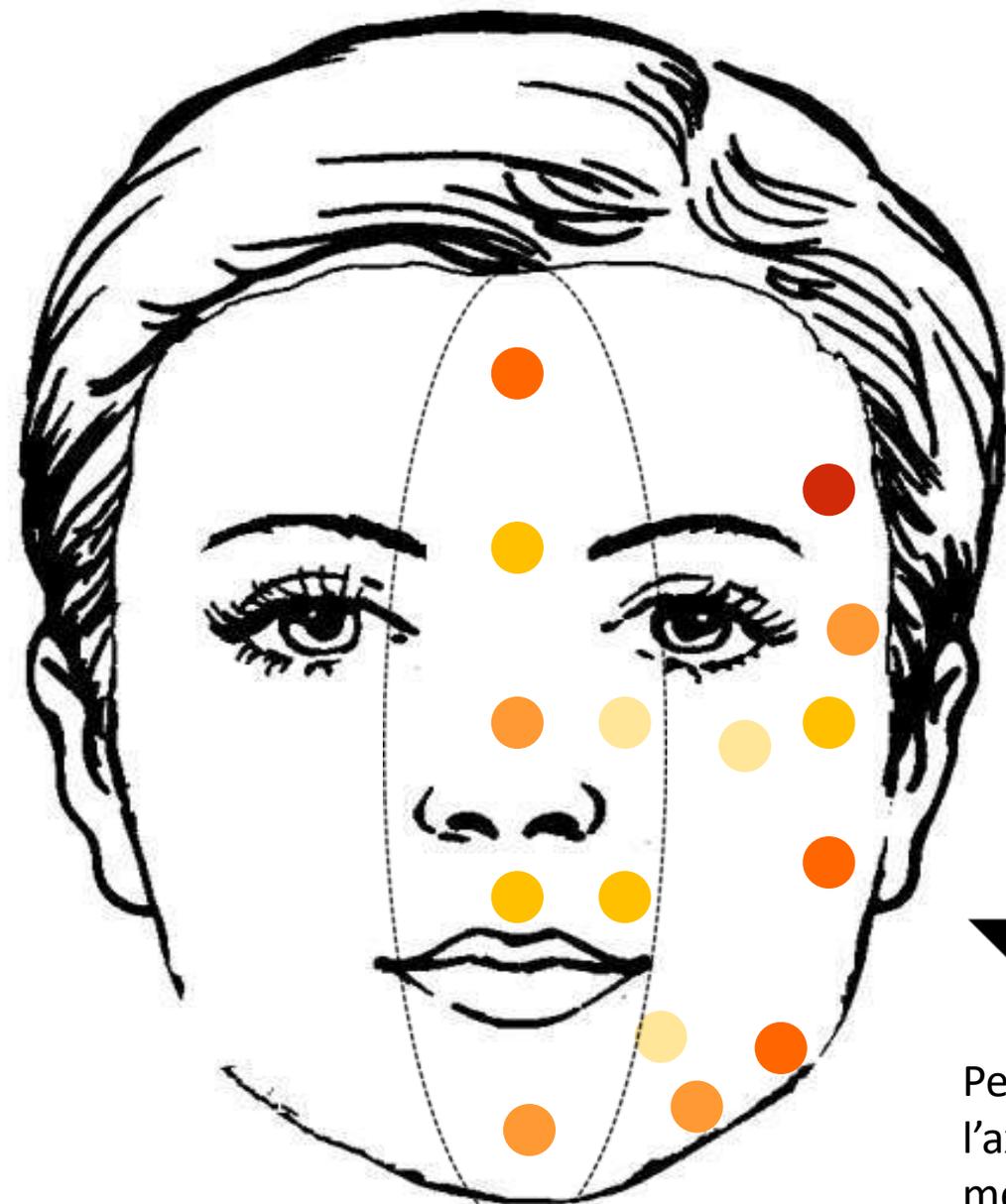
# Compacité moyenne des noyaux des kératinocytes



20-30 y. old



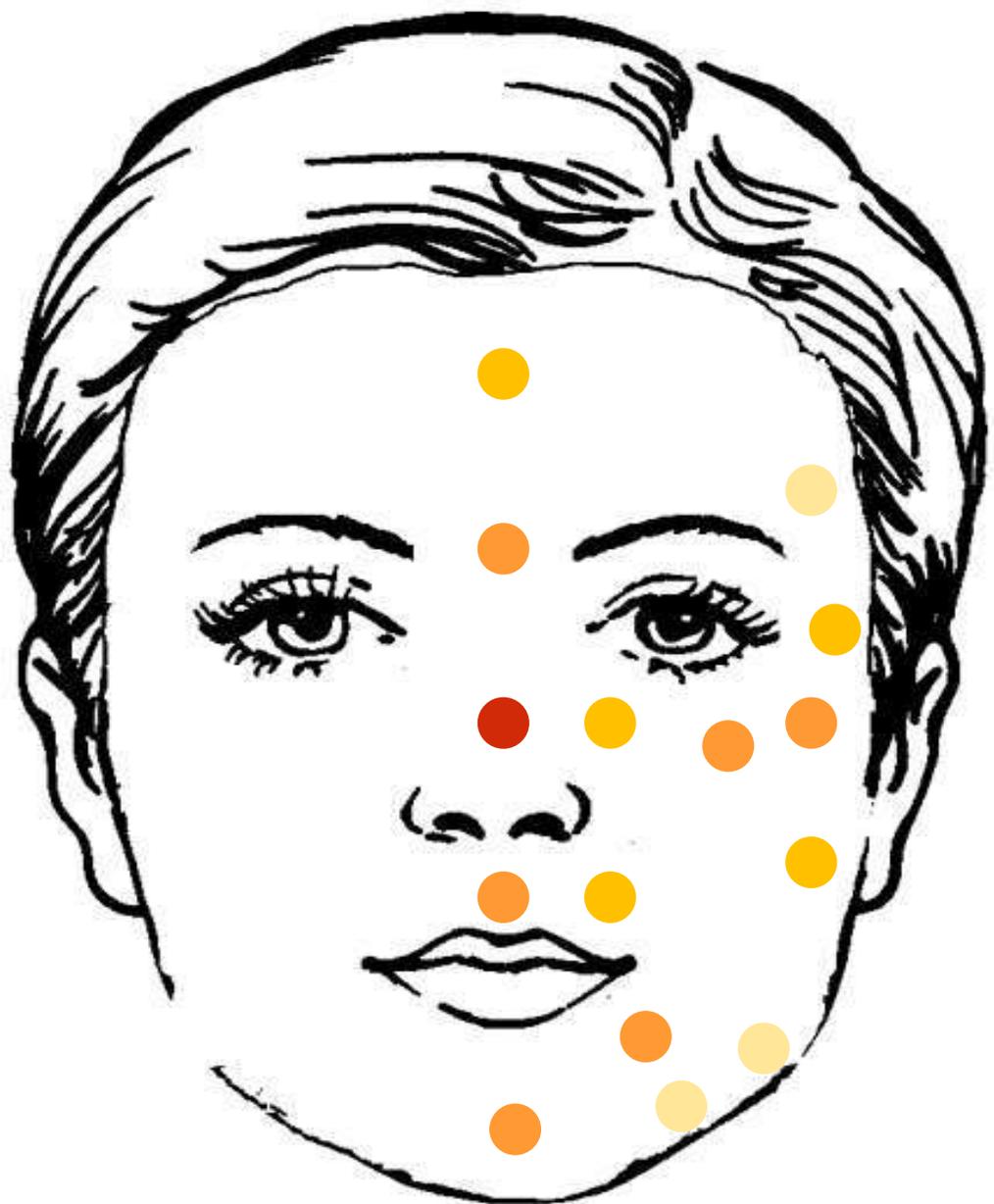
> 65 y. old



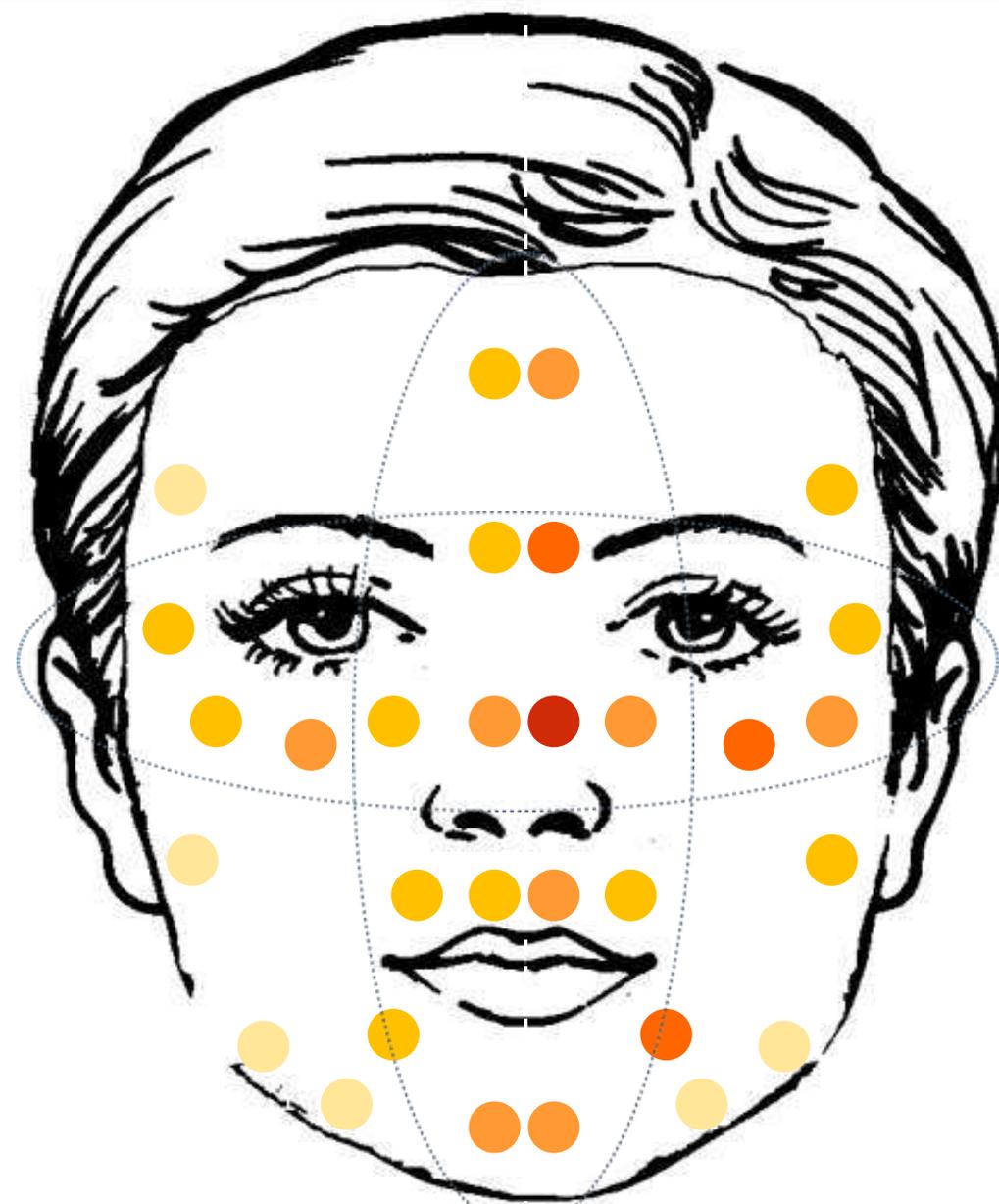
Perte de  
l'axe  
médian

# Atypies cellulaires kératinocytaires Algorithme IA XGB

All volunteers



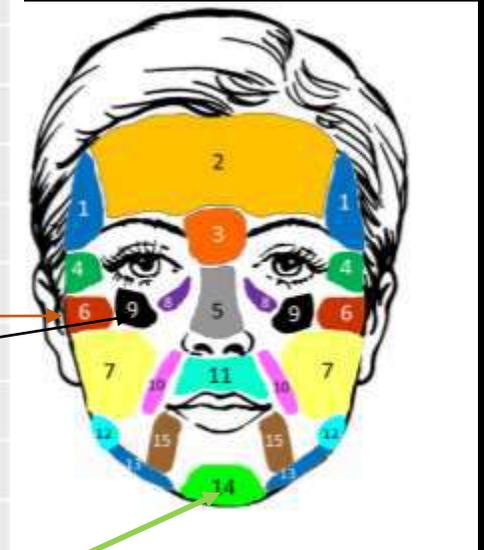
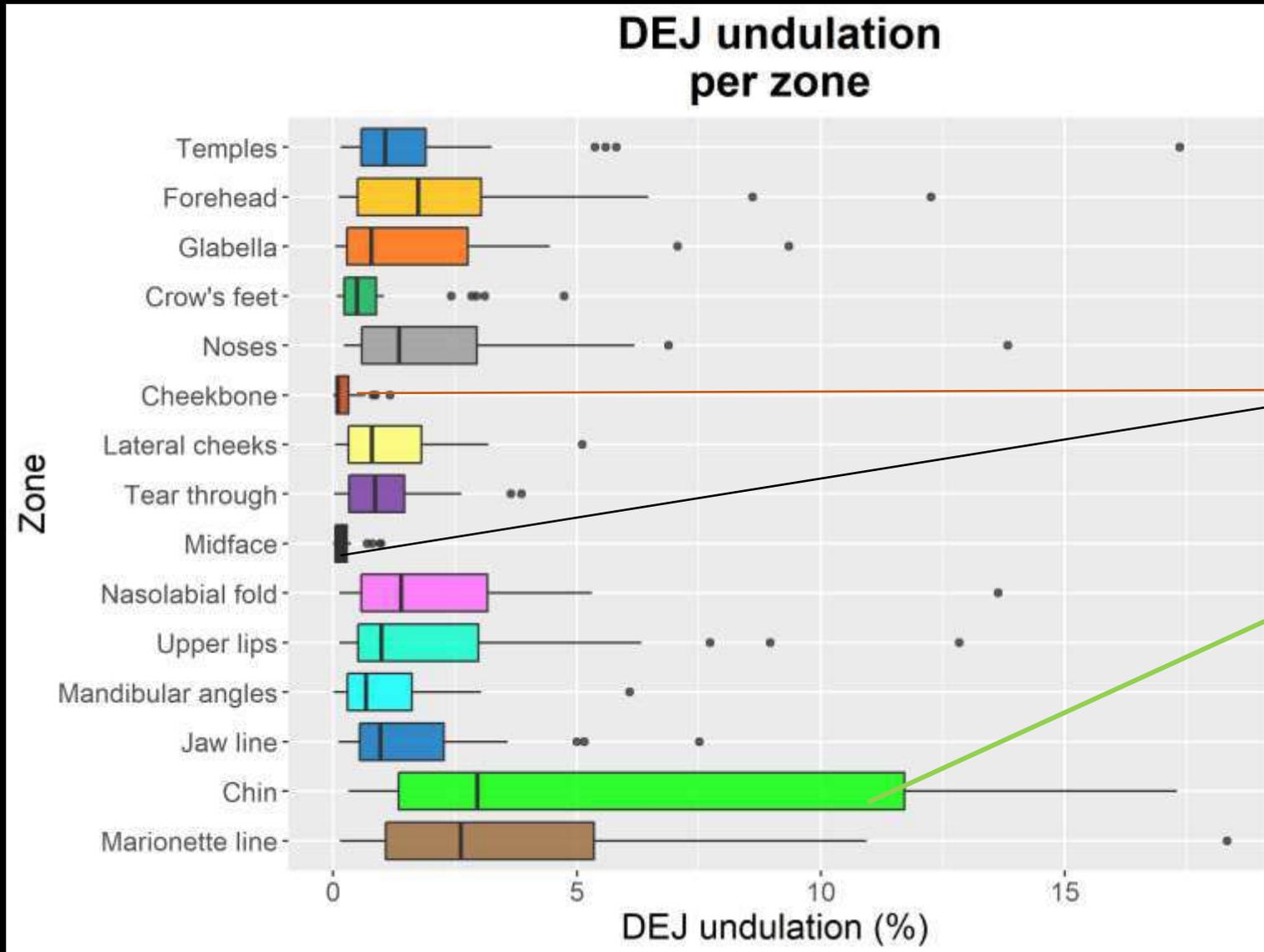
20-30 y. old



> 65 y. old

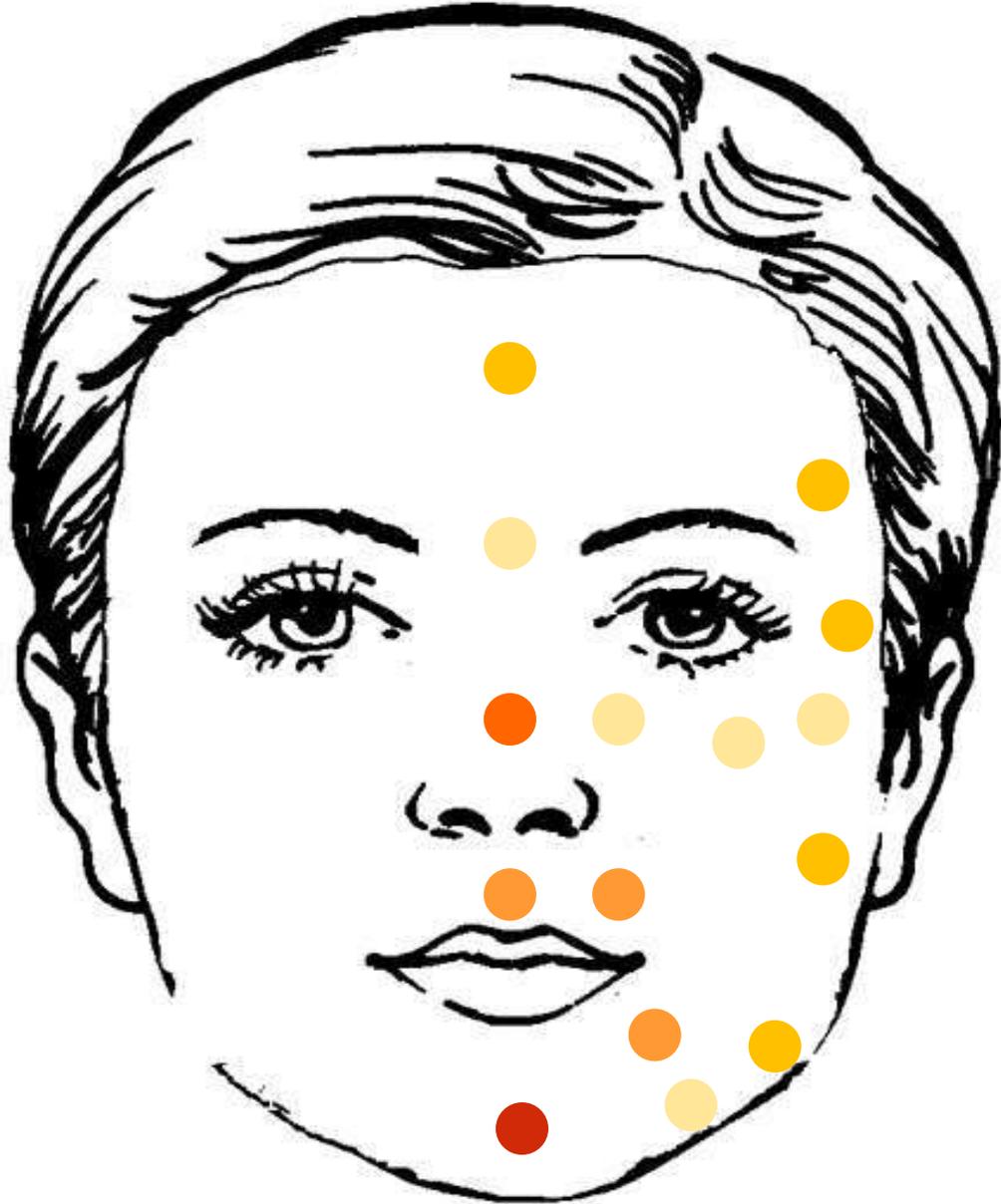


# Ondularité de la JDE



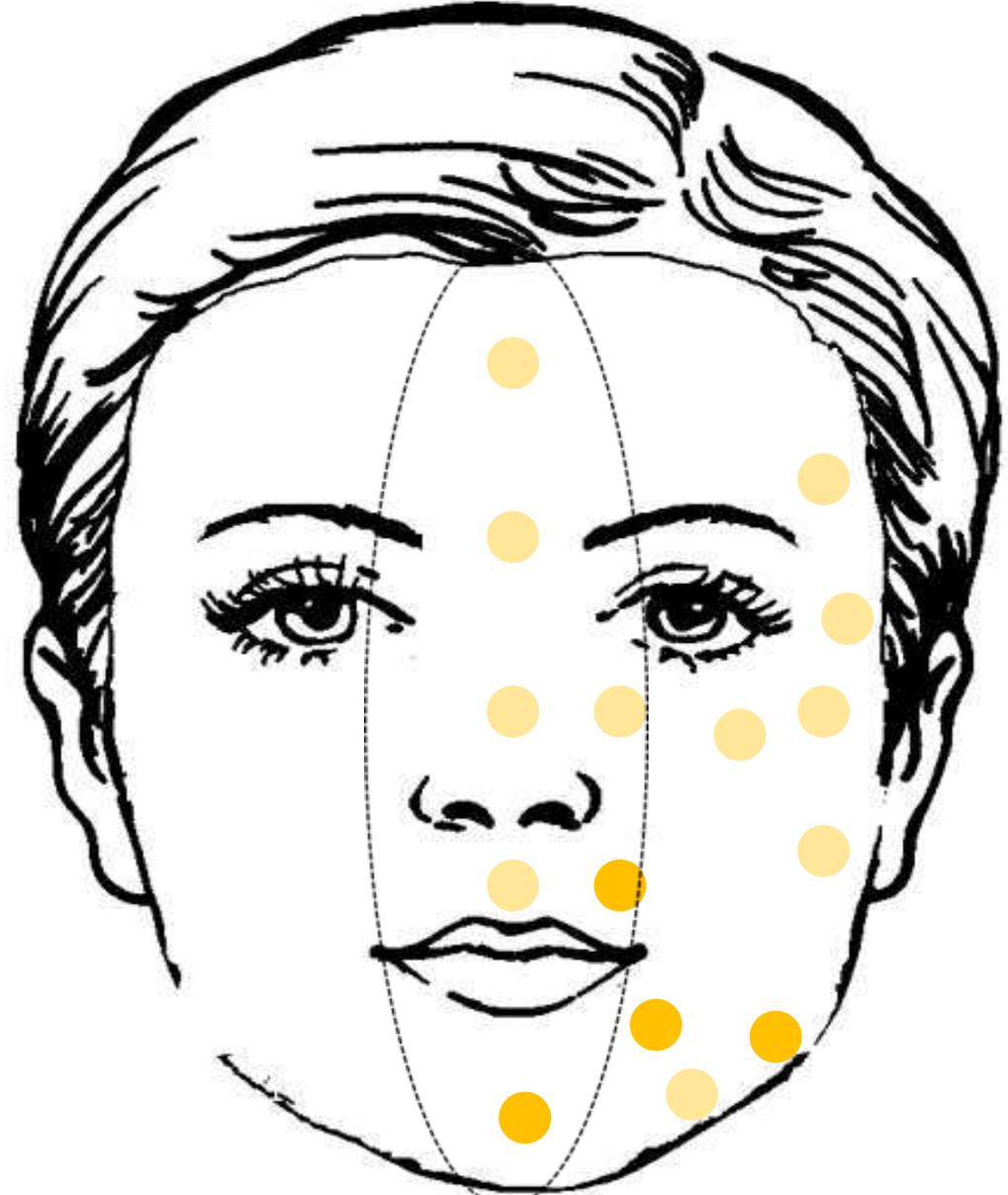
# DEJ undulation

20-30 y. old



- 6-11.2
- 4.5-6
- 3-4.5
- 1.5-3
- 0-1.5

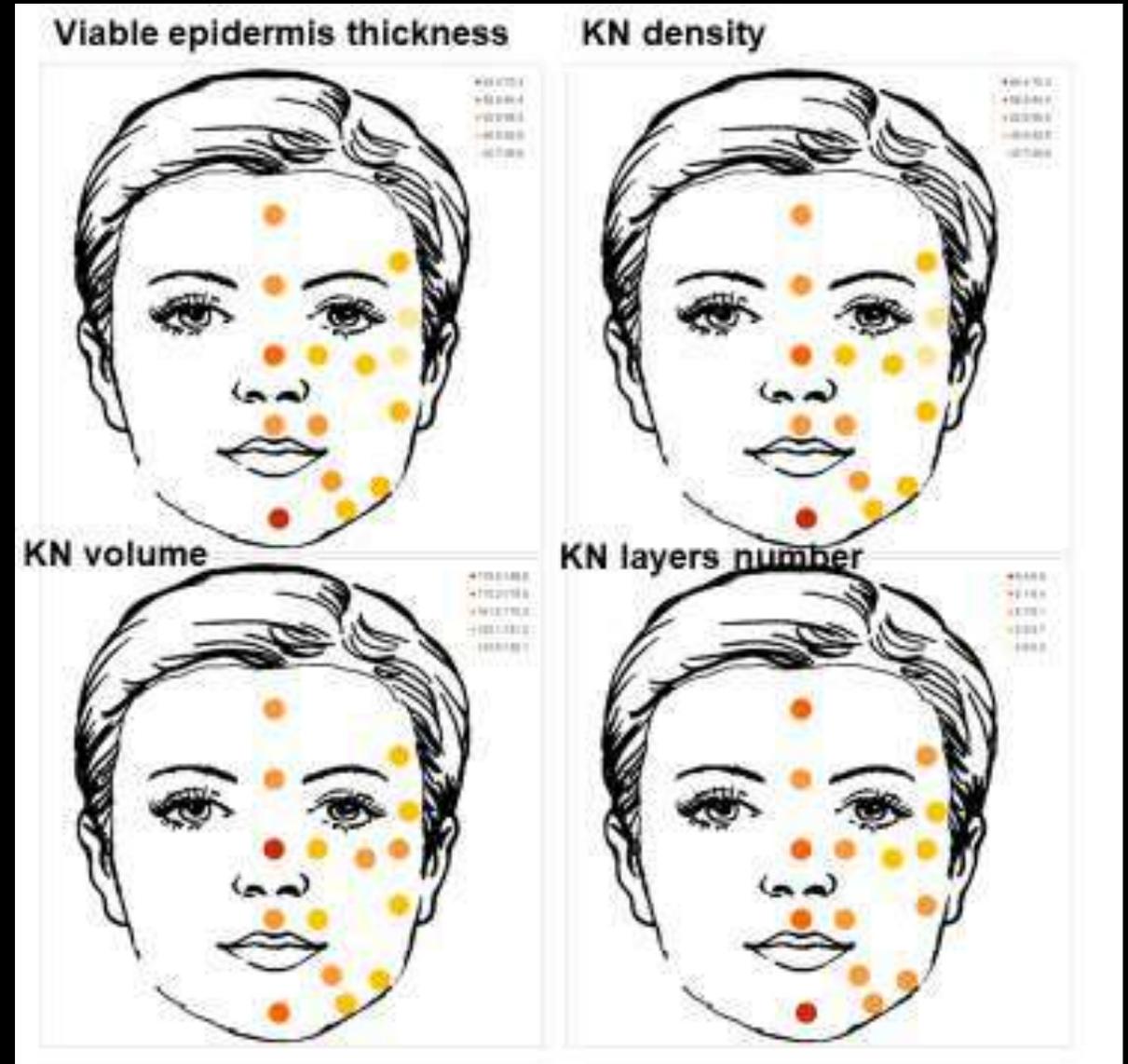
> 65 y. old



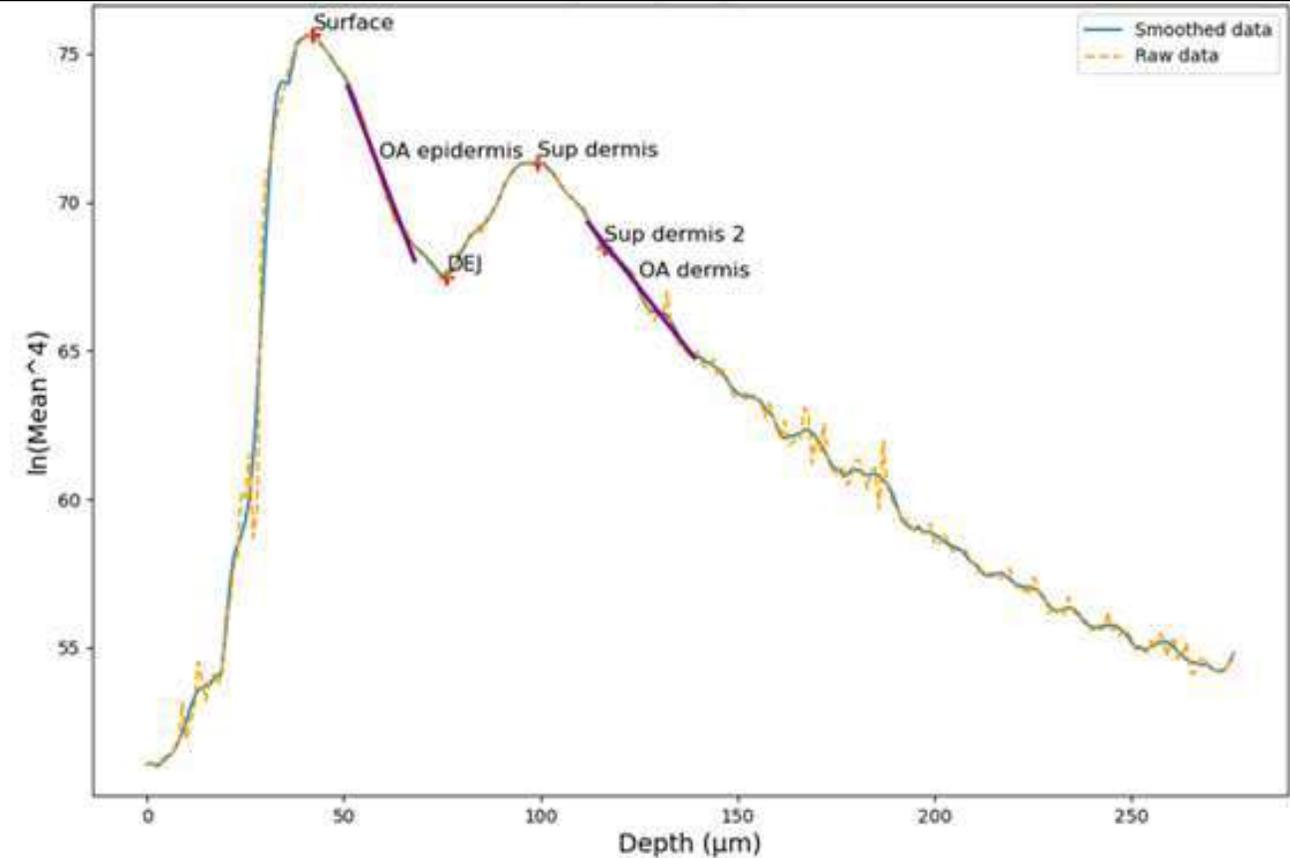
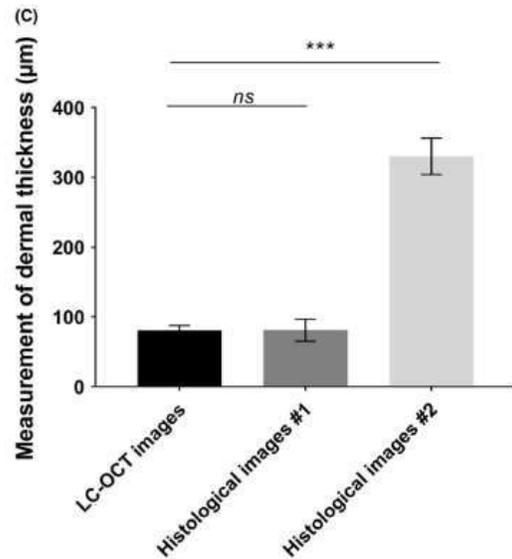
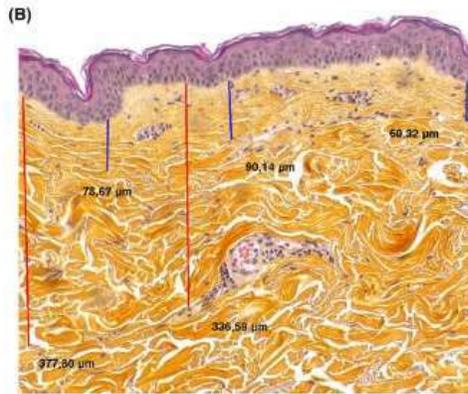
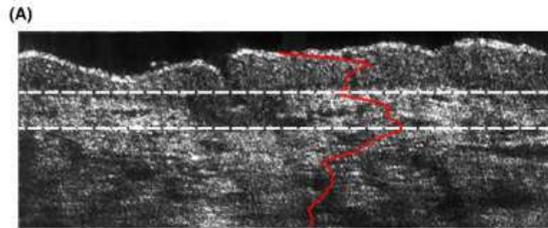
- 6-11.2
- 4.5-6
- 3-4.5
- 1.5-3
- 0-1.5

# Tendances

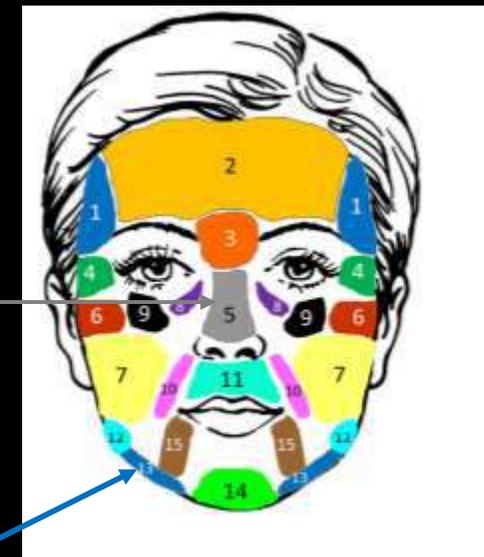
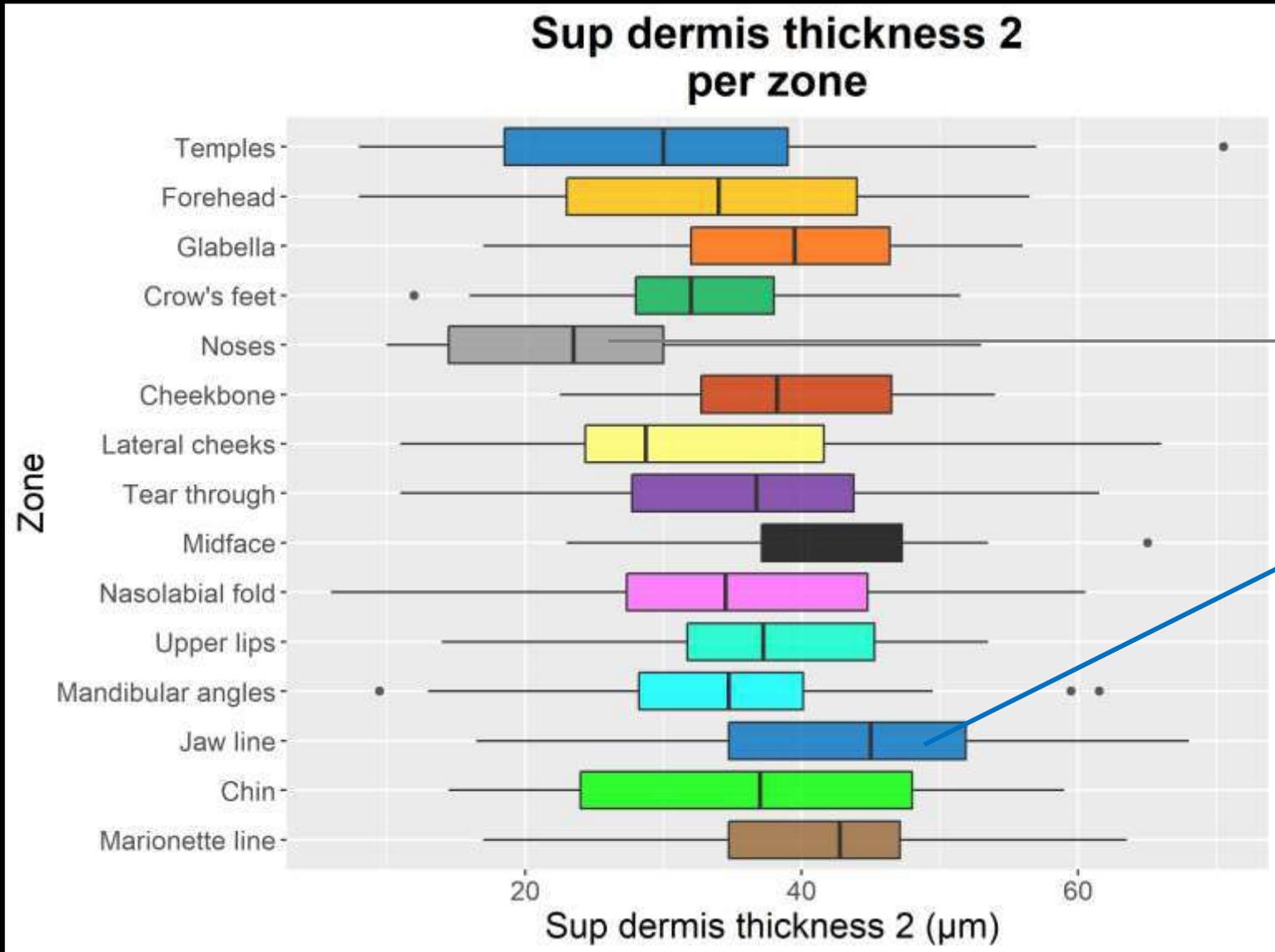
- Stratum corneum
  - > plus épais sur le nez
  - > plus important centre et bas du visage avec l'âge
- Viable epidermis:
  - > plus épais au centre du visage
  - > affinement avec l'âge
- DEJ:
  - > plus ondulée au centre et bas du visage
  - > aplatissement avec l'âge
- KN layers number
  - > plus important centre et bas du visage
  - > décroît avec l'âge
- KN mean volume
  - > plus important centre visage
  - > augmente avec l'âge
- KN compacité
  - > plus important centre visage
  - > diminue avec l'âge
- KN atypie
  - > plus important centre visage et région malaire
  - > augmente avec l'âge



# Métrique de derme en LC OCT

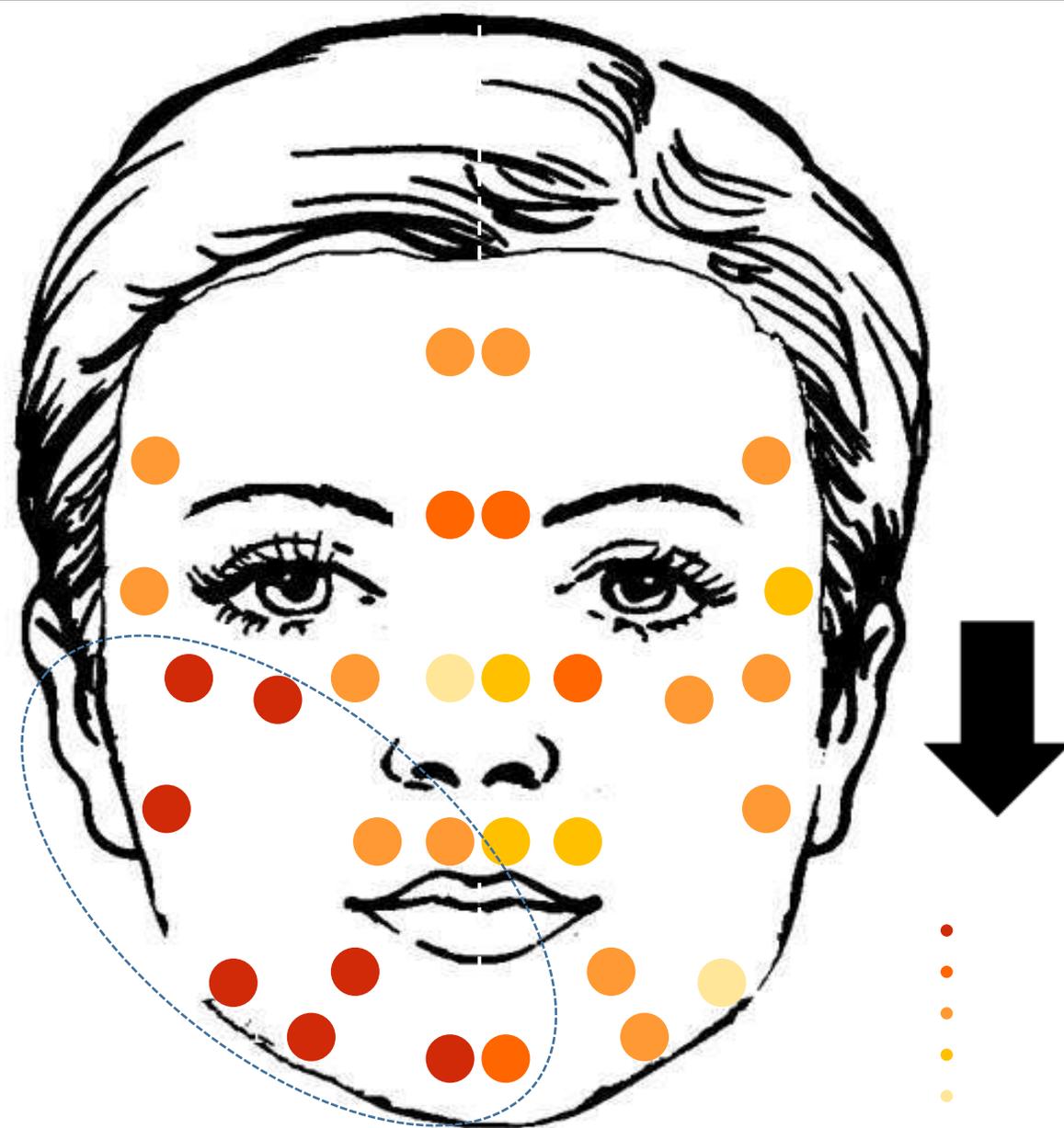
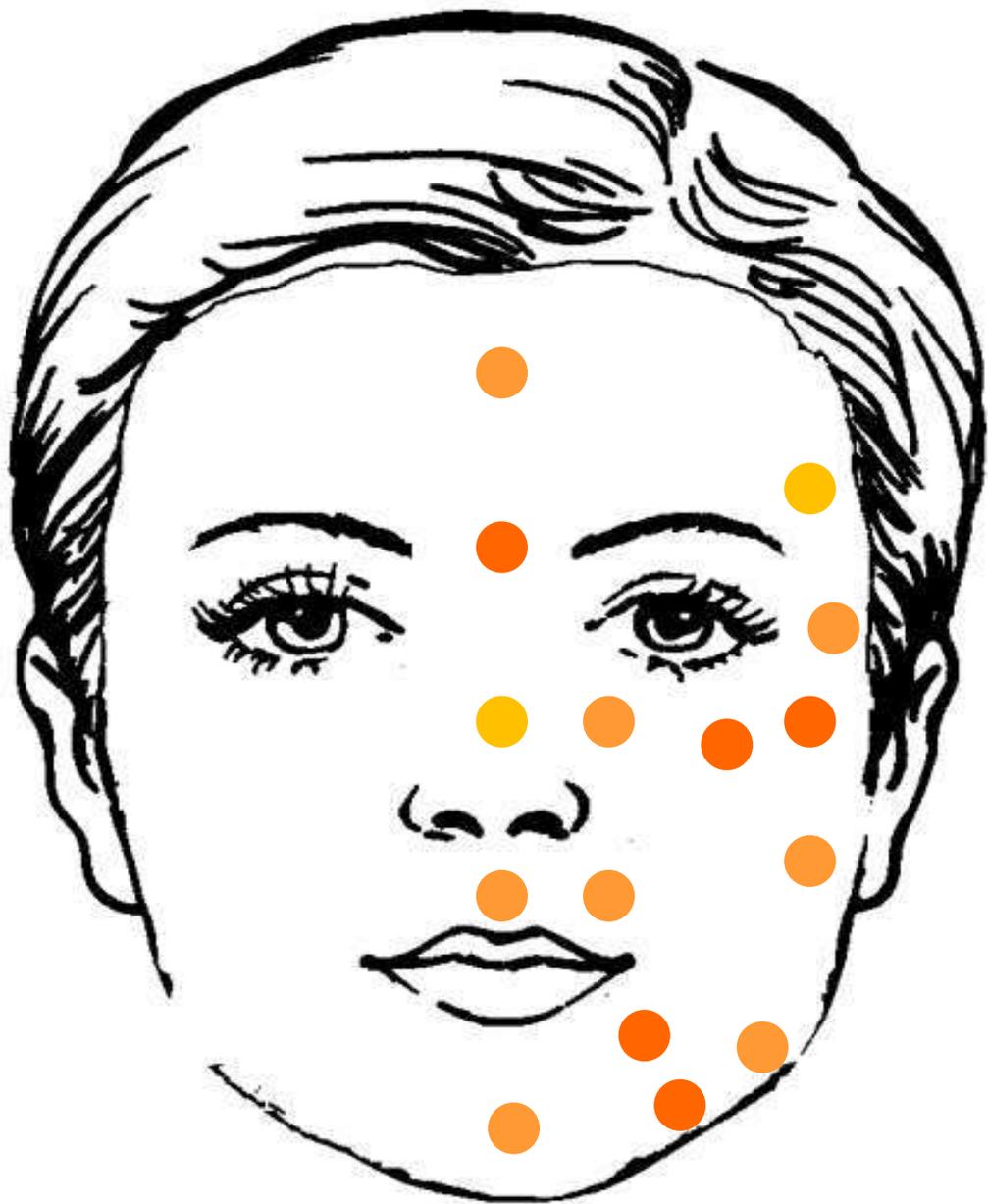


# Epaisseur du derme superficiel dermis thickness



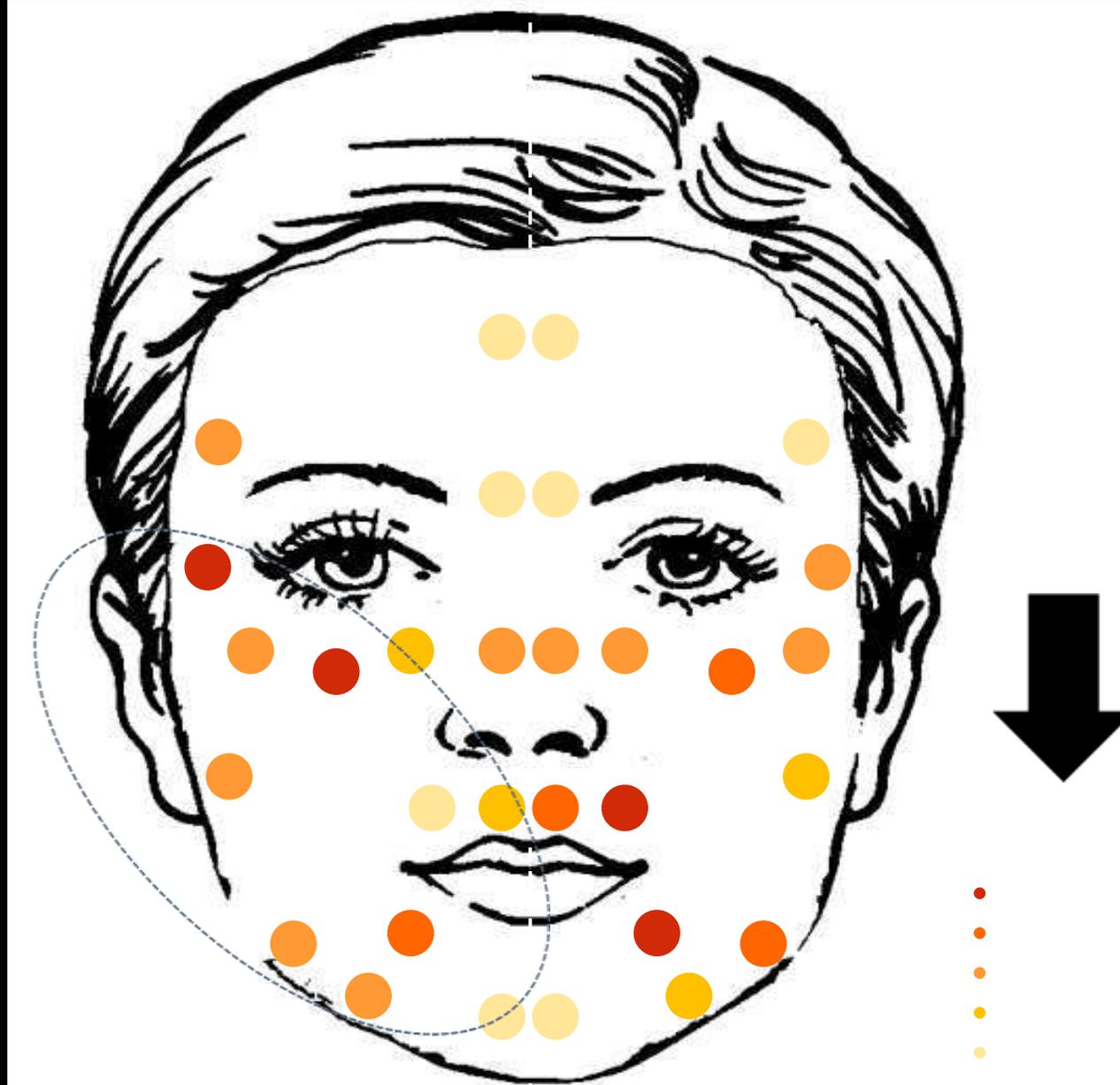
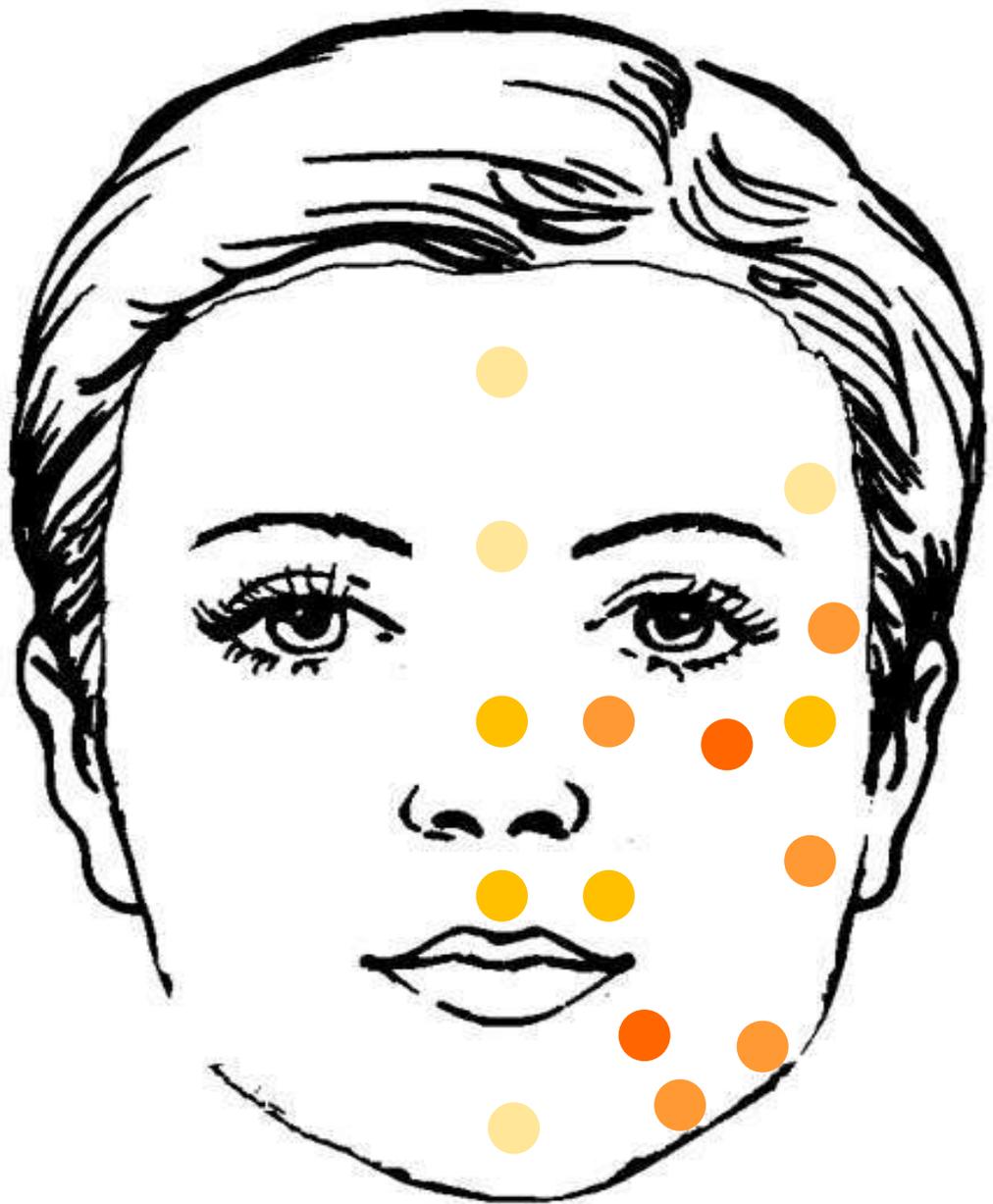
# Epaisseur du derme superficiel

All volunteers



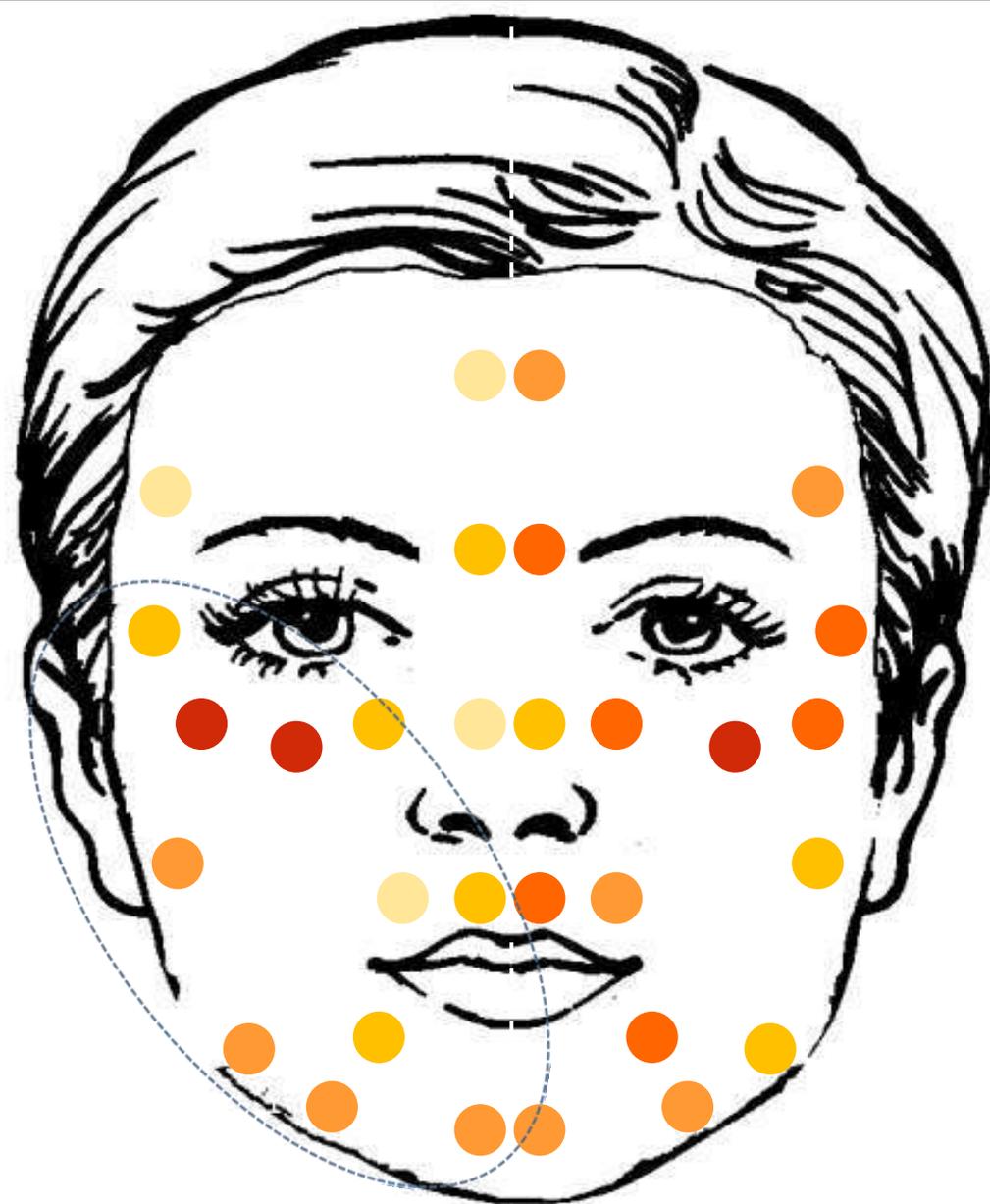
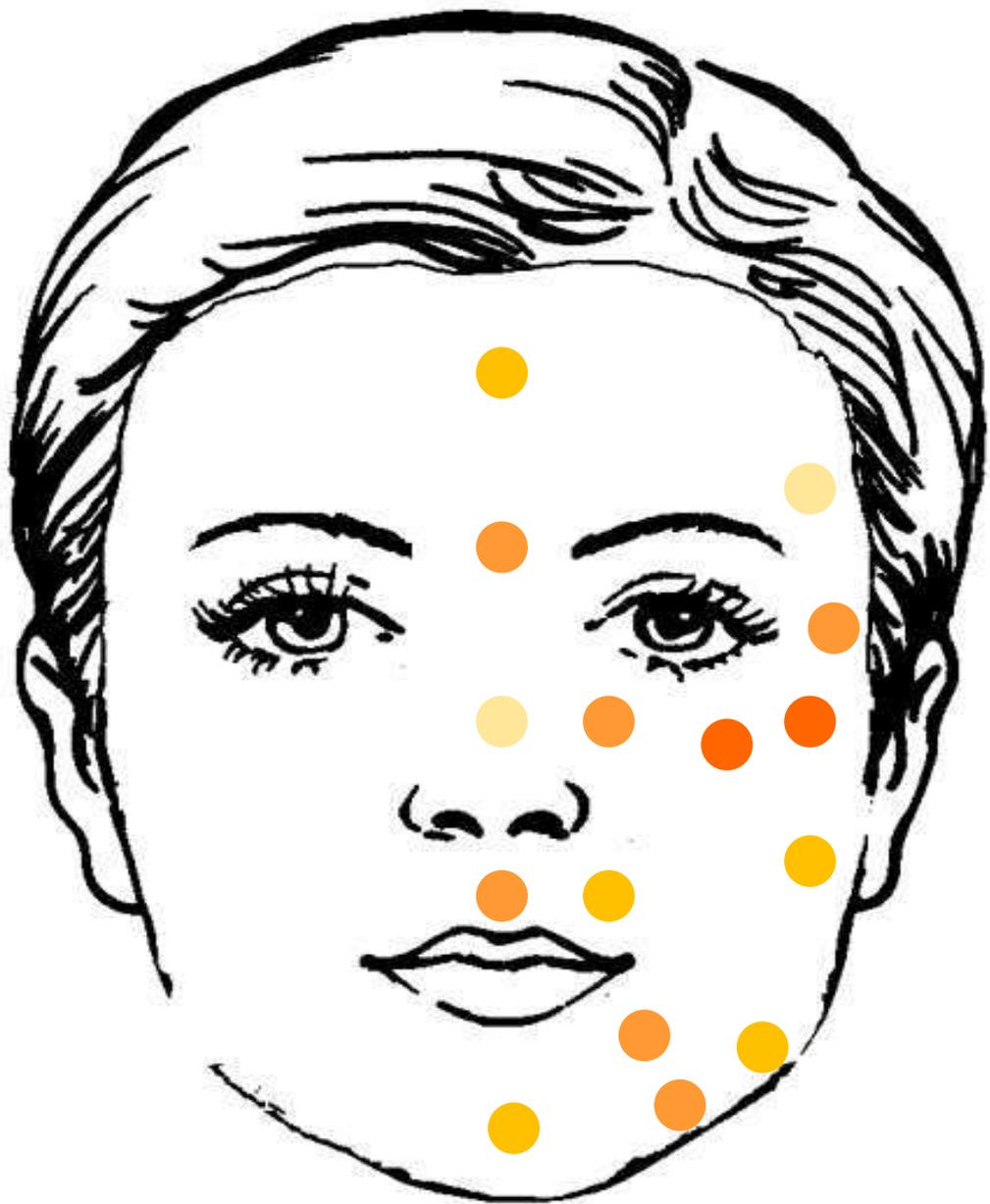
# Densité optique du derme

All volunteers



# Atténuation optique du derme

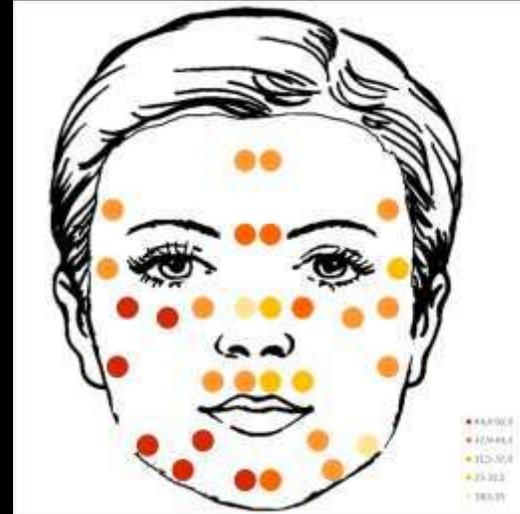
All volunteers



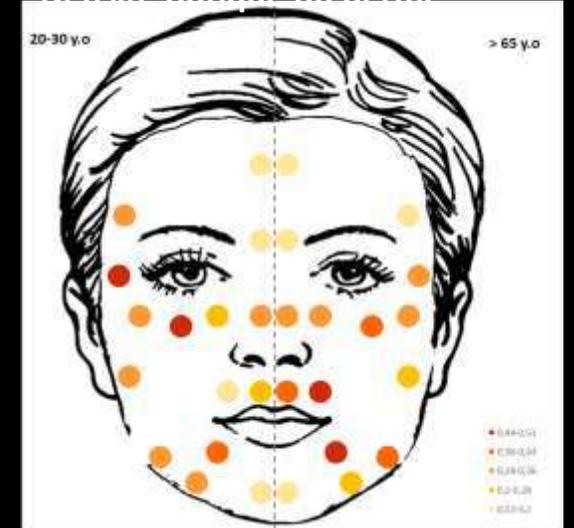
# Tendances suite

- Epaisseur derme:
  - > plus épais ½ inf du visage
  - > décroît avec l'âge
- Densité optique derme:
  - > plus dense ½ inf du visage
  - > décroît avec l'âge
- Atténuation optique derme
  - > plus importante ½ inf du visage
  - > décroît avec l'âge

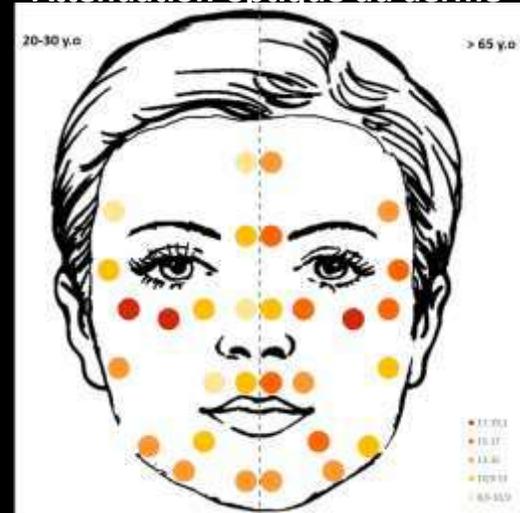
Epaisseur du derme superficiel



Densité optique du derme

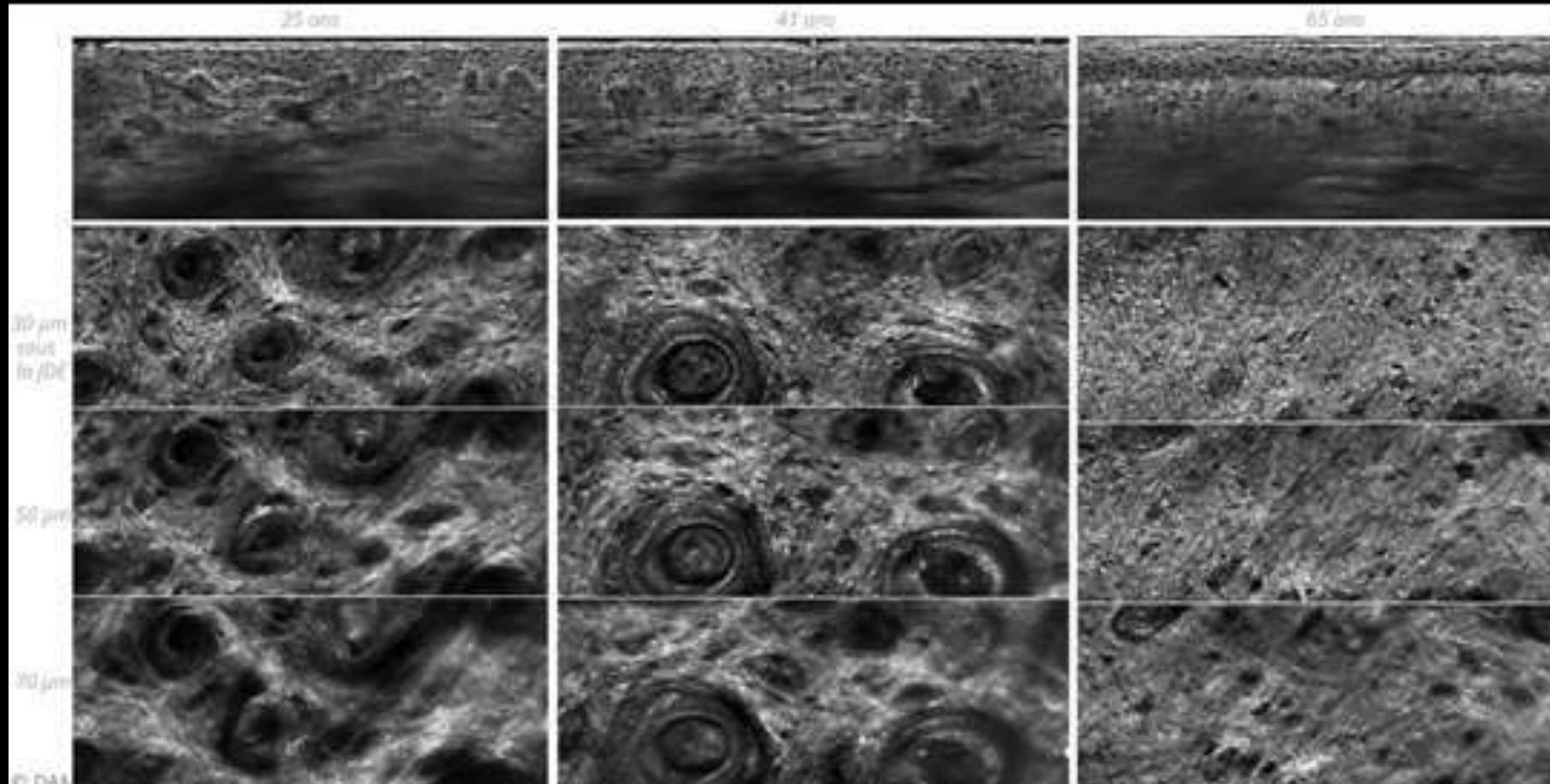


Atténuation optique du derme

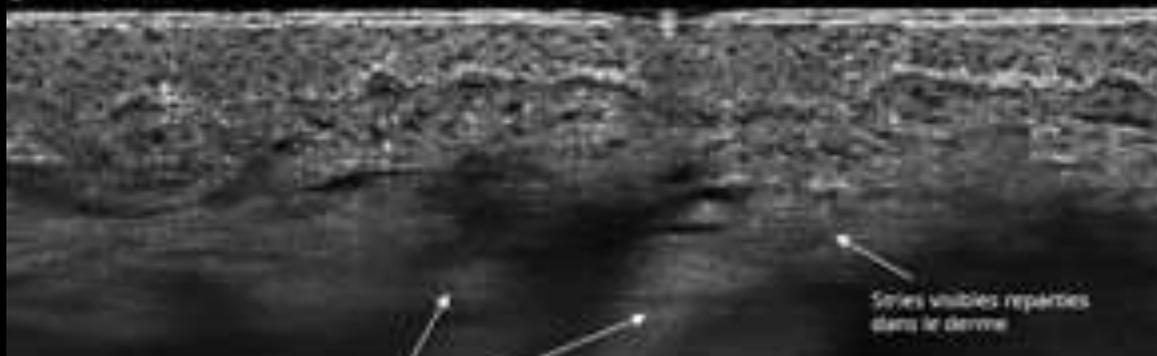


# Autres métriques

## Aspect en LC OCT du derme du front selon l'âge



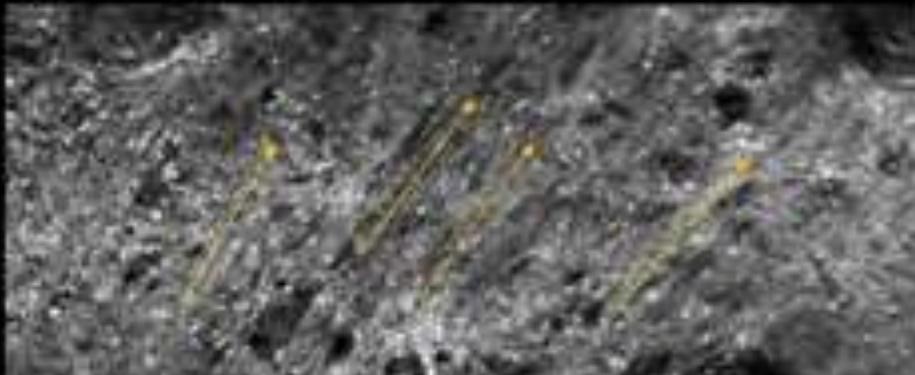
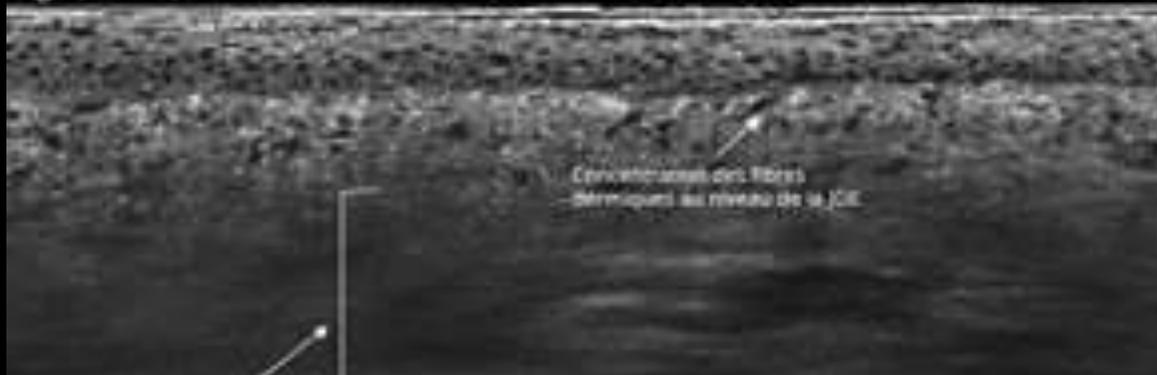
Jeune (25 ans)



50  $\mu$ m en dessous de la JDE

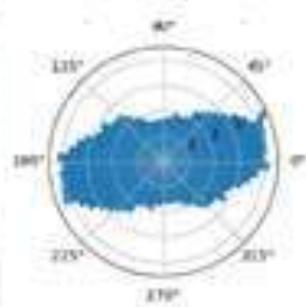
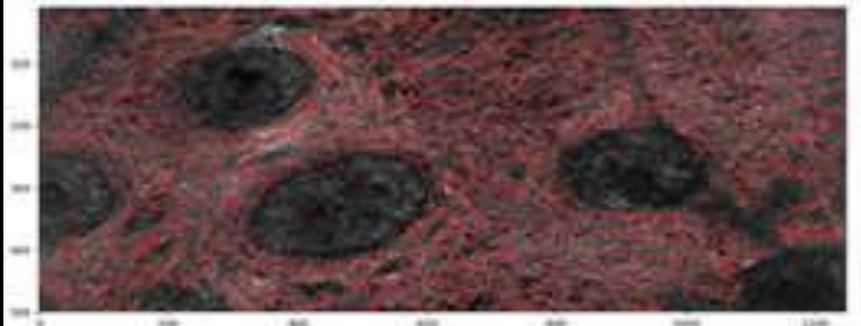
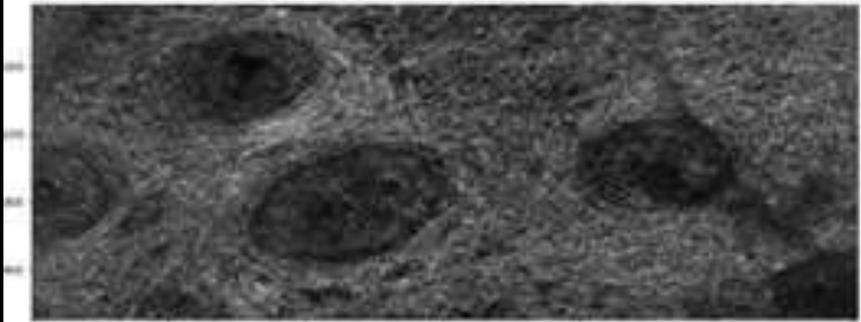


Agé (65 ans)



# Segmentation des fibres pour mesures

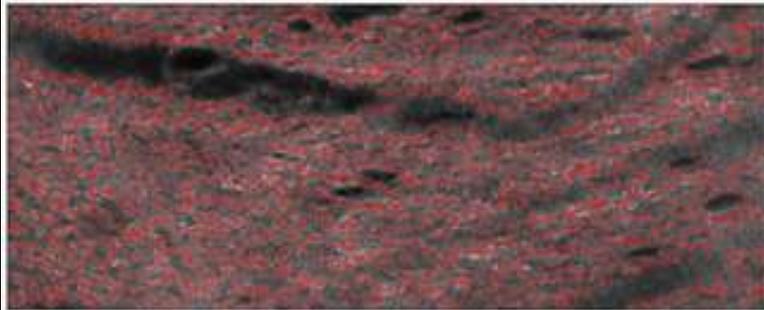
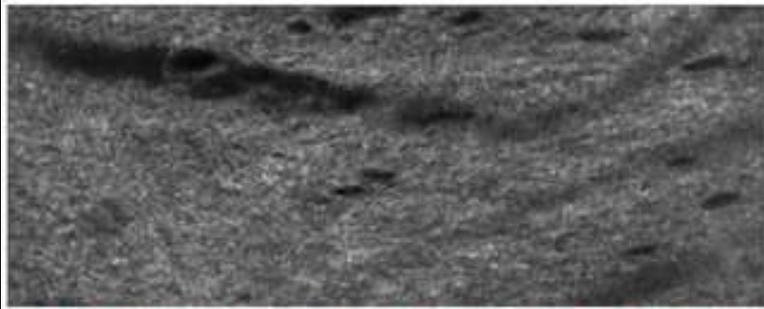
Left cheek of a 46 y. old person



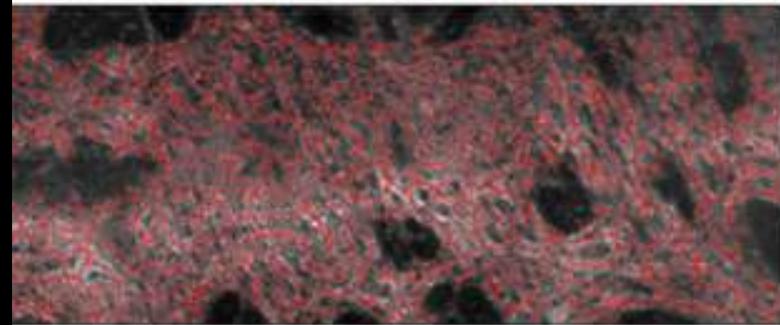
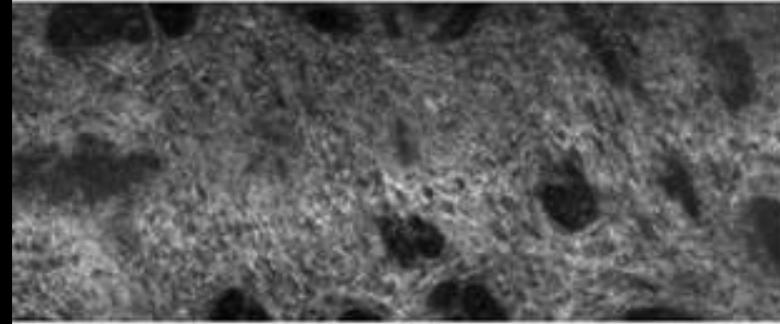
Metrics obtained from the segmentation:

- Fiber **density** (%)
- Fiber **anisotropy** score

# L'orientation des fibre quand l'optique rejoint la mécanique



Anisotropy= 4.01  
Density= 29.11



Anisotropy= 1.55  
Density=28.75

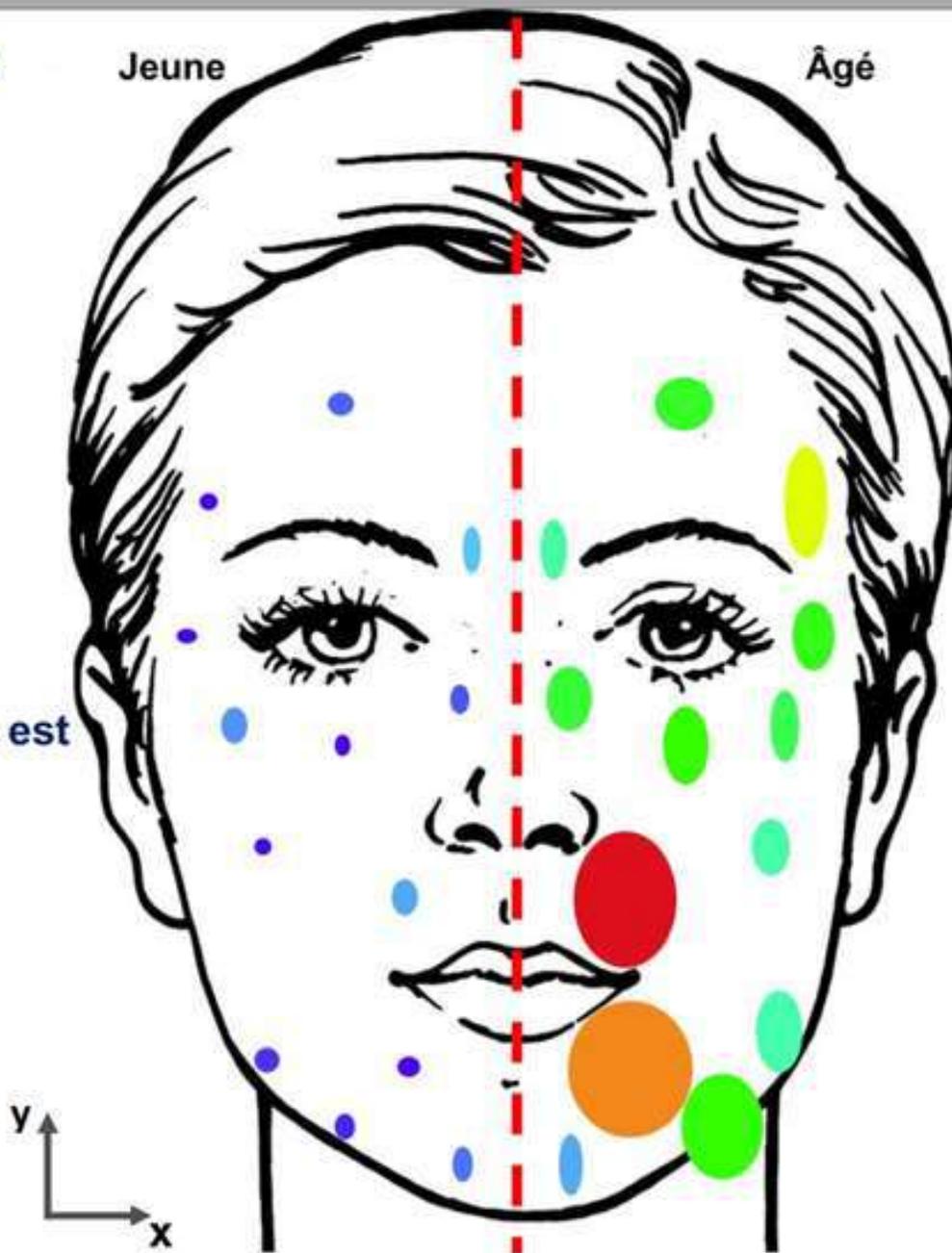
# Tension Mécanique du Visage

Jeune

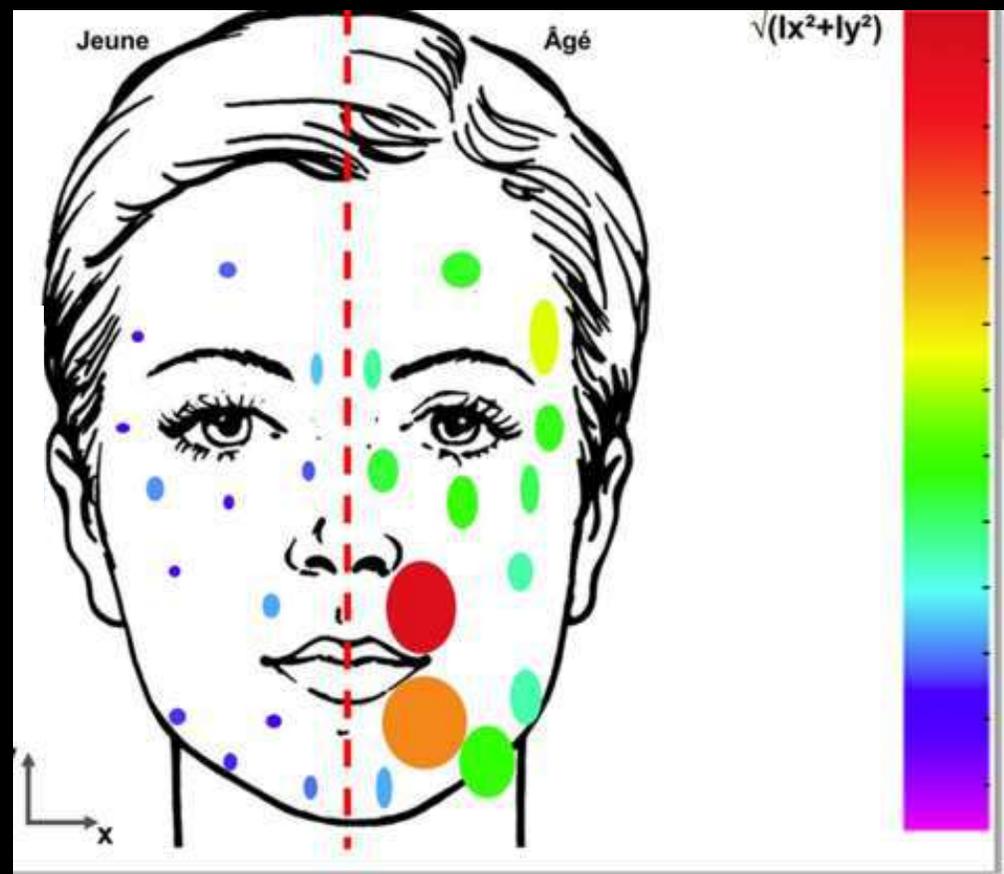
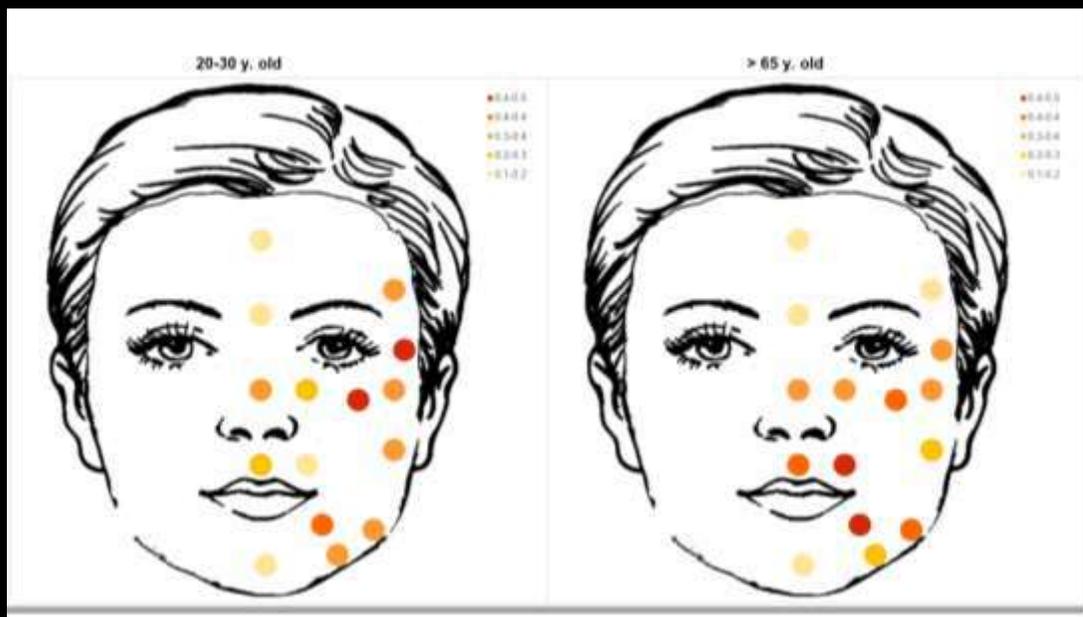
Âgé

$$\sqrt{(lx^2+ly^2)}$$

- L'anisotropie est indiquée par l'orientation de l'ellipse
- L'état de tension est indiqué par la couleur de l'ellipse
- Plus la tension est forte plus l'indice est Petit (couleur bleue foncée)

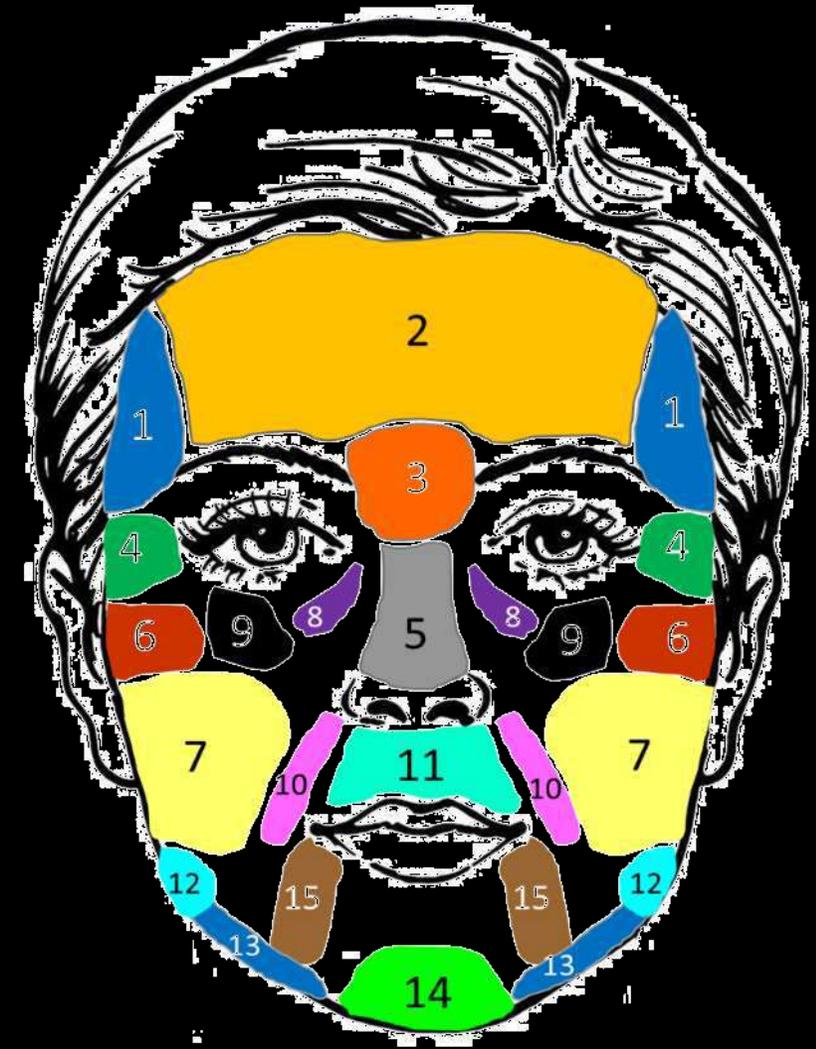


# Densité optique du derme



# Conclusion (1)

- Analyse des autres métriques en cours de réalisation
  - Mesure derme en LC OCT
  - cutométrie
  - échographie
  - mesures semi-quantitative
  - élastographie sans contact
  - moulages
  - intégration de ces différentes données



# Conclusion (1)

- Analyse des autres métriques en cours de réalisation
  - Mesure derme en LC OCT
  - cutométrie
  - échographie
  - mesures semi-quantitative
  - élastographie sans contact
  - moulages
  - intégration de ces différentes données
  - **couplage mécanique imagerie**

ROYAL SOCIETY  
OPEN SCIENCE

royalsocietypublishing.org/journal/rsos

Research

**Cite this article:** Ammam I, Guillermin I, Ouilou L, Vargiolu R, Perrot J-L, Zahouani H. 2024 Coupling tensile test with LC-OCT and ultrasound imaging: investigation of the skin sublayers mechanical behaviour. *R. Soc. Open Sci.* 11: 231712. <https://doi.org/10.1098/rsos.231712>

Received: 8 November 2023  
Accepted: 6 May 2024

**Subject Category:**  
Engineering

**Subject Areas:**  
bioengineering, biomechanics, biomaterials

**Keywords:**  
skin, viscoelastic properties, multi-layer behaviour, skin anisotropy, imaging tools

**Author for correspondence:**  
Ilan Ammam  
e-mail: [ilam@univ-lyon.fr](mailto:ilam@univ-lyon.fr)

Electronic supplementary material is available online at <https://doi.org/10.1098/rsos.231712>

THE ROYAL SOCIETY  
OPEN SCIENCE

Coupling tensile test with LC-OCT and ultrasound imaging: investigation of the skin sublayers mechanical behaviour

Ilan Ammam<sup>1</sup>, Amaury Guillermin<sup>1</sup>, Lucas Ouilou<sup>1</sup>, Roberto Vargiolu<sup>1</sup>, Jean-Luc Perrot<sup>2</sup> and Hassan Zahouani<sup>1</sup>

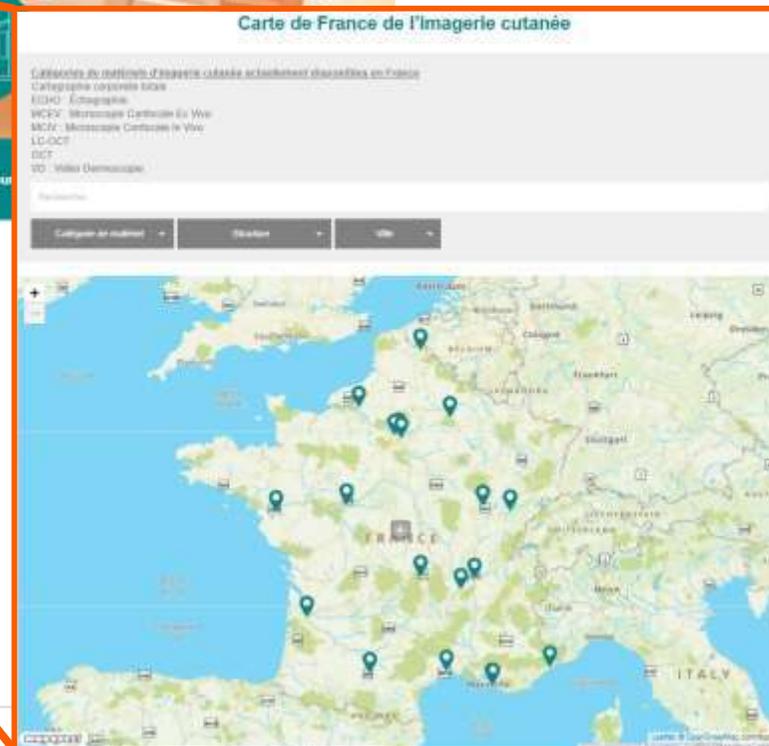
<sup>1</sup>Université de Lyon, IMEC, UFR, 69622-0001, St-Jean Pierre, Saint-Etienne Cedex 2, 42023, France  
<sup>2</sup>Dermatology Department, University Hospital of Saint-Etienne, Saint-Etienne, France  
DOI: 10.1098/rsos.231712

The skin is an envelope that covers the entire body. Nowadays, understanding and studying the mechanical, biological and sensory properties of the skin is essential, especially in dermatology and cosmetology. The in-depth study of the skin's mechanical behaviour is a highly intriguing challenge, enabling the differentiation of the behaviour of each layer. An extension device was developed to perform relaxation and extension tests to characterize the skin. The device has also been coupled with imaging tools (LC-OCT and ultrasound), allowing us to observe layer-by-layer deformations during the tests. Relaxation tests revealed significant skin anisotropy, as well as an influence of age and gender on skin viscoelastic parameters calculated from relaxation curves and a skin viscoelastic model. These tests also revealed their ability to distinguish certain characteristic pathologies that alter the mechanical properties of the skin, such as scleroderma or heliodermatitis. Furthermore, the optical-mechanical coupling and deformation calculation through image analysis demonstrated that the skin layers exhibit distinct mechanical behaviours owing to their different structures. Finally, Poisson's ratio of the skin was obtained by calculating the deformation in two directions for each layer.

© 2024 The Authors. Published by the Royal Society under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, provided the original author and source are credited.

# Conclusion 2

- Analyse par IA des données multimodales
- Construction d'un jumeau numérique du visage



Découvrez notre nouveau site internet :

[gicni-sfd.fr](http://gicni-sfd.fr)