



Fascial system and
lymphedema
Tiina Lahtinen-Suopanki

VIII Nordic Congress of
Lymphology
Felix Konferansesenter
Aker Brygge
8-10 September 2022

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The role and treatment of the fascial system as a part of edema treatment

Treatment of the fascial system:

- An essential part of lymphedema treatment
- A big role in postoperative myofascial pain and movement restrictions
- Plays a part with body awareness after painful and frightening experiences via interoceptive information

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Fascia and fascial system

Fascial Nomenclature: Update on Related Consensus Process.
Schleip et al. 2019. Clinical Anatomy 32:929-933

“a fascia” is recommended for communication of histological and topographical aspects on a mesoscopic and microscopic scale

“the fascial system” is recommended for the description of functional properties on a macroscopic scale. Such functional properties include force transmission, sensory functions (proprioception, interoception, and nociception), fluid transmission, as well as the regulation of wound healing and fibrotic pathological processes

Connective tissues

“The fascial system”

“A fascia”

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What kind of a fascia?

Superficial fascia

Visceral fascia:
Investing fascia
Insertional fascia

Stecco Carla Functional Atlas of human fascial system 2015

Deep fascia:
Aponeurotic fascia
Epimysial Fascia

Neural fascia:
Neural sheath
Meningeal fascia

Different functions – various symptoms when dysfunction

Carla Stecco 2019
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What is fascia?

Fascia is a well innervated complex structure composed of different cells surrounded by an abundant extracellular matrix, and each component has its own function:

CELLs define the metabolic properties

RESEPTORs adapt the fascia to different conditions

WATER and HA define the gliding capacity

NERVE ELEMENTs define the sensitive role

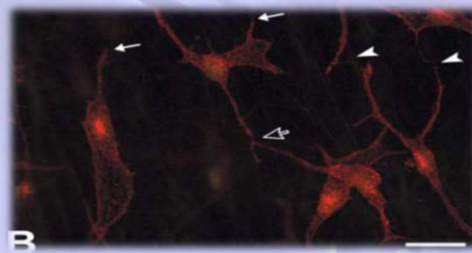
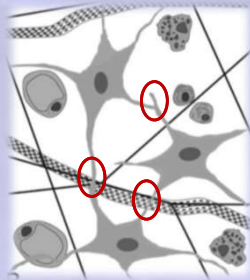
COLLAGEN- and ELASTIN FIBERs provide mechanical properties

Fede C. Winter School Padova University 2021

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Fibroblasts produce the fibrous component : collagen and elastin fibers, maintain structural integrity and organization of tissues.
Fibroblasts are stimulated by tensional changes of the tissue.



Langevin ym.2004: Fibroblasts form a body-wide cellular network.
Histochem Cell Biol (2004) 122:7–15

Dynamic fibroblast cytoskeletal response to subcutaneous tissue stretch *ex vivo* and *in vivo*, Langevin et al. 2005, *Am J Physiol Cell Physiol* 288

**Fibroblasts are connected to each other to form
a whole-body network of cells.**

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Fibroblast receptors

Liao MH. 2014:
The stimulatory effects of alpha1-adrenergic receptors on TGF-beta1, IGF-1 and hyaluronan production in human skin fibroblasts. Cell Tissue Res

Adrenergic receptors (AR) belong to the sympathetic autonomic nervous system and endocrine system. They are directly and indirectly involved in adapting fibroblast function: They increase TGF- β 1 production, ECM production, and fibroblast motility.

Fede C. ym. 2016:
Hormone Receptor Expression in Human Fascial Tissue. Eur J Histochem

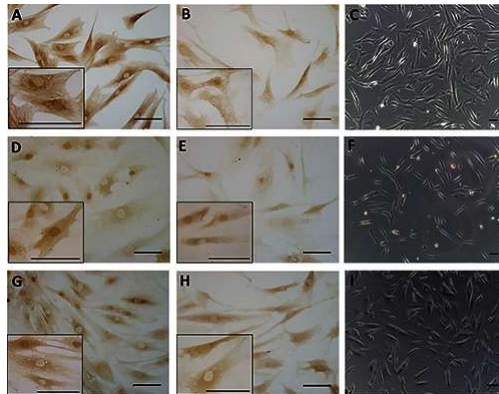
Fibroblasts in muscle fascias contain estrogen and relaxin hormone receptors. Estrogen and relaxin play a role in ECM neoplasia, inhibiting fibrosis and inflammation; significant factors for fascial stiffness. Dysfunctions on hormone levels can dysregulate the ECM.

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Fede C. ym.2016:
Expression of the Endocannabinoid Receptors in Human Fascial Tissue. Eur J Histochem

Fascial mRNA and CB1 and CB2 protein receptors are located in fibroblasts. CB receptors in fascial fibroblasts may be involved in modulating fascial fibrosis and inflammation.

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ER α (A,D,G) and RXFP1 (B,E,H) receptor expression in fibroblasts isolated from three different fascial districts: the rectus sheath of the abdomen (A-C), the crural fascia of the leg (D-F), and the fascia lata of the thigh (G-I). Higher magnification images are shown in the insets. Bright-field images are shown in C,F,I. Scale bars: 100 μ m.

This work is the first demonstrating sex hormone receptor expression in fascial fibroblasts and it helps to explain how hormonal factors are linked to myofascial pain.

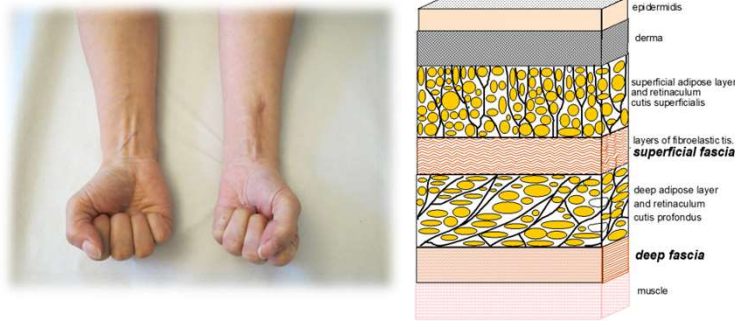
If verified, this new concept may lead the way to novel pharmaceutical or mechanical approaches that could complement existing treatments of myofascial pain.

Fede Caterina et al
2016.Hormone Receptor Expression in Human Fascial Tissue. Eur J Histochem.

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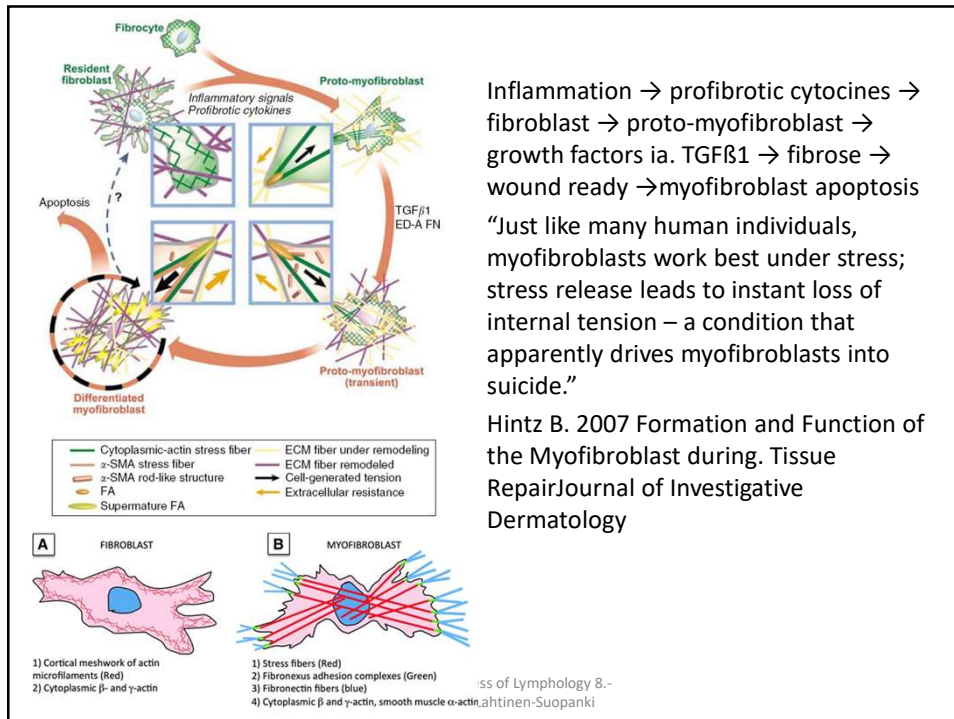
Myofibroblasts are specialized connective tissue cells that are able to contract and maintain tension in wound healing. They are activated as a result of inflammation, long-term tension and the activation of the sympathetic nervous system, e.g. in connection with stress. *They can affect the biomechanical properties of the fascia in the long run.*



Schleip R. ym. 2019 Fascia Is Able to Actively Contract and May Thereby Influence Musculoskeletal Dynamics: A Histochemical and Mechanographic Investigation. Front. Physiol

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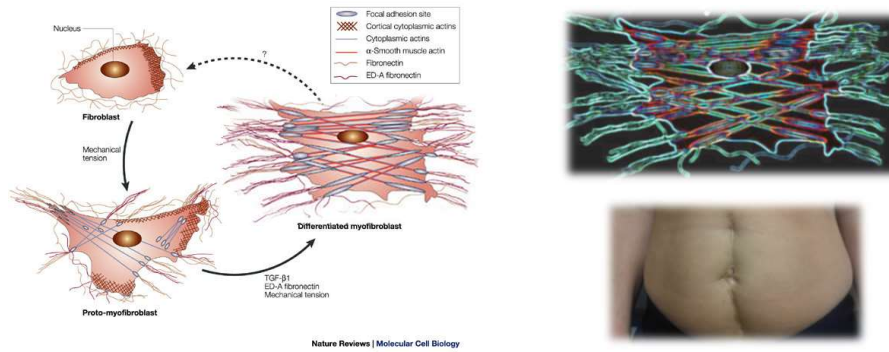
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The “dark side” of the myofibroblast:

The presence of myofibroblasts in tissues increases *matrix stiffness* in both chronically inflamed and cancer-associated tissues

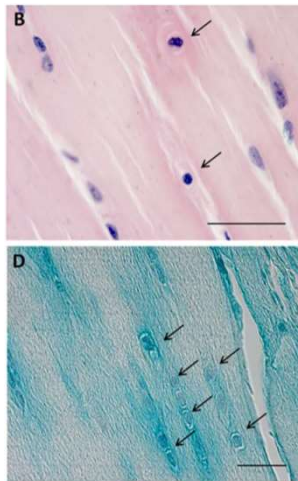


Myofibroblasts and mechano-regulation of connective tissue remodelling
 Tomasek et al 2002 Nature Reviews Molecular Cell Biology
 Cellular control of connective tissue matrix tension, Langevin et al. 2013, J Cell Biochem. 2013

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Fasciocytes are fibroblasts, that are specialized to produce hyaluronic acid → gliding



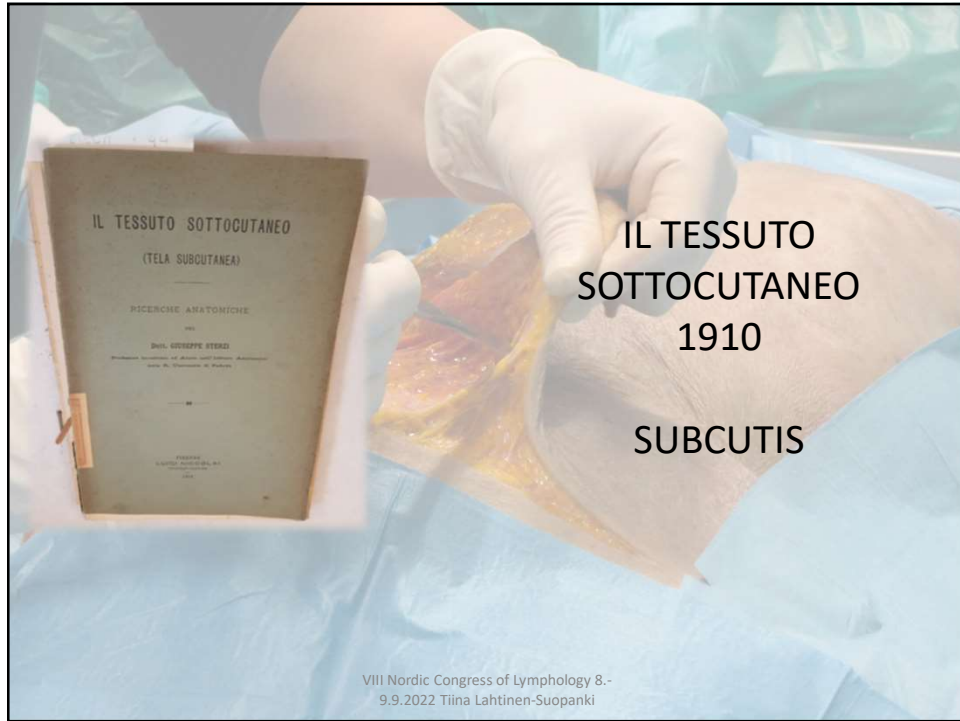
About 30% of healthy fascias fibroblasts are fasciocytes (proportion depends on their anatomical location). They are round and surrounded by abundant layer of HA.

Fasciocytes are stimulated by shearing forces to produce lubricant for tissue gliding.

Stecco C ym. 2018: The Fasciocytes: A New Cell Devoted to Fascial Gliding Regulation. Clinical Anatomy 31:667–676

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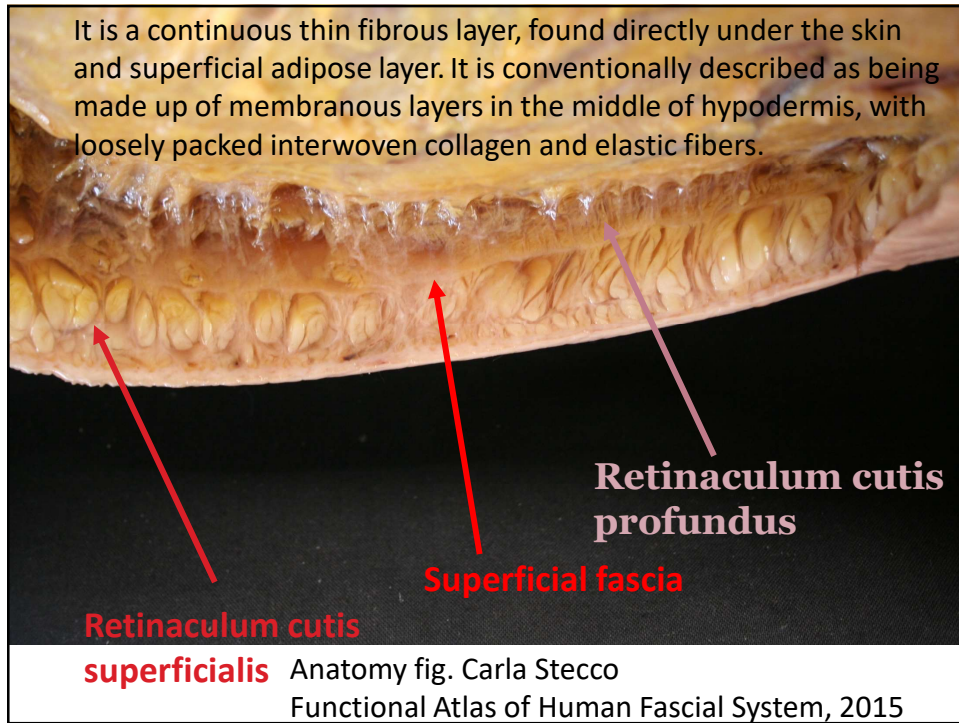
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FASCIA REDEFINED: ANATOMICAL FEATURES AND TECHNICAL RELEVANCE IN FASCIAL FLAP SURGERY
 Carla Stecco • Cesare Tiengo • Antonio Stecco • Andrea Porzionato • Veronica Macchi • Robert Stern • Raffaele De Caro

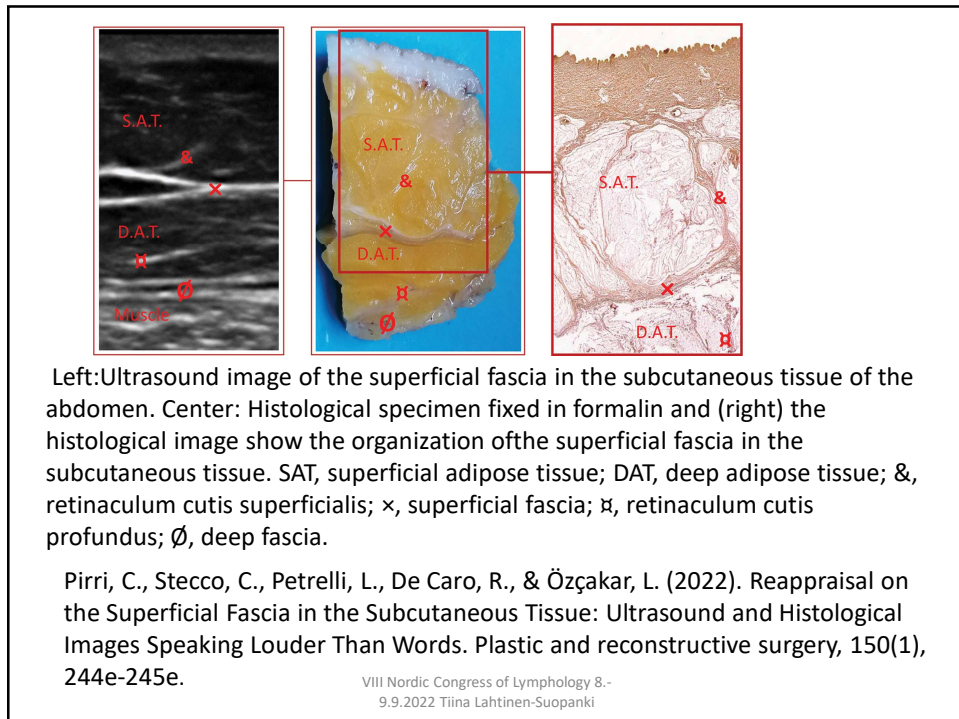
Basic pattern (a, d) of organization of subcutaneous layers in the limbs (a–c) and in the trunk (d–f). These general models correspond well to ultrasound (b, e) and histological (c, f) images. **The superficial fascia divides in all the body the subcutaneous tissue into two adipose layers, the SAT (superficial adipose tissue) and the DAT (deep adipose tissue) in the body. Fibrous septa connect the superficial fascia to skin and to deep fascia, forming a three dimensional network around fat lobules.** The deep fascia shows different features according to the particular region: in the limbs it is formed by two or three fibrous sublayers separated by HA, in the trunk the deep fascia is thinner consisting of only one fibrous layer.

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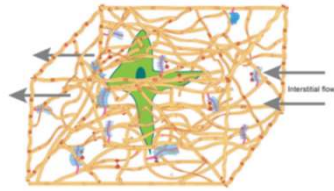
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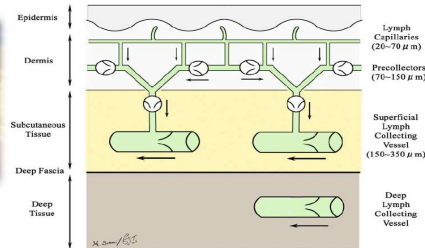
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The Superficial fascia: Vessels and Lymph drainage

The superficial fascia can split and form compartments around major subcutaneous veins and lymphatic vessels to protect and keep the vessels open during movements.



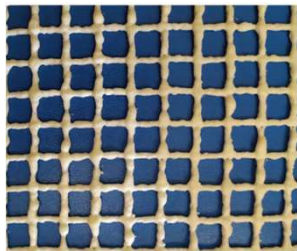
Swartz M. & Fleury M. 2007: Interstitial flow and its effects in soft tissues. Annu. Rev. Biomed. Eng. 2007



Suami H et al. 2008 The lymphatic anatomy of the breast and its implications for sentinel lymph node biopsy: a human cadaver study. Ann Surg Oncol.

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Scheme of superficial fascia, behaviour of elastic fibres in relaxation state (A) and in traction state (B)



The network organization of the elastic fibres in the superficial fascia creates a sort of elastic containment for lymphatic vessels and veins. The elastic fibres disposition, that is more transversally oriented than longitudinal, could explain, in a translational point of view, the application of manual therapy or lymphatic drainage, being easier in transversal skin pinching than longitudinal.



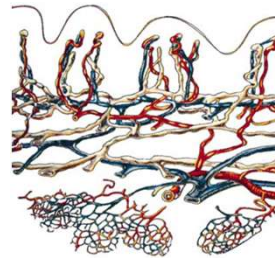
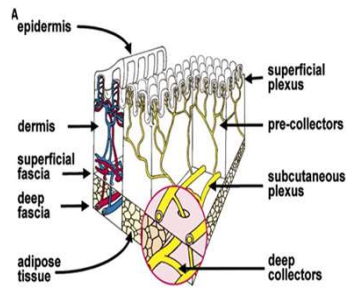
Pirri, C. et al (2022). Elastic Fibres in the subcutaneous tissue: Is there a difference between superficial and muscular fascia? A cadaver study. Skin Research and Technology, 28(1), 21-27.

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Superficial fascia and lymphatic drainage

A first plexus extended into the dermal papillae, a second plexus inside the superficial fascia. In the SAT and DAT the lymph vessels have a more vertical course, following the retinacula cutis. Furthermore, the lymphatic vessels were found also in the SAT, with a vertical course, following the retinacula cutis, and close to the blood vessels in the DAT. Carla Stecco et al 2022.



Mariani ym.2001. Radioguided Sentinel Lymph Node Biopsy in Breast Cancer Surgery

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Giovanna Albertin
Department of Neuroscience section of human anatomy
Padova university
Winter School of fascial anatomy 2022

Conclusion:

the lymphatic vessels of subcutis follow the conformation of the subcutaneous tissue

- a) lymphatic vessels are along the fibrous septa
- b) lymphatic vessels accompany blood vessels
- c) in the superficial fascia the lymphatic vessels follow the collagen bundles and elastic fibers

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(a)

(b)

Lymphokinetic Motion and Pressure Gradient

Blood capillaries → Interstitial Fluid → Lymph capillaries → Lymph veins → Lymph ducts → Large circ. Veins

Highest pressure (at Blood capillaries) Lowest pressure (at Large circ. Veins)

<https://i.pinimg.com/736x/3d/4b/61/3d4b61fcdfa2c6a3547fe09384970e77--osmotic-pressure-lymph-nodes.jpg>

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(b)

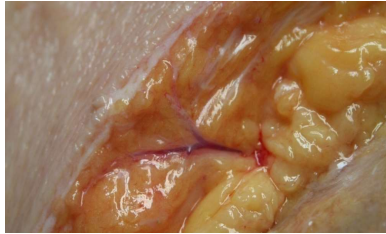
attenuated cytoplasm collagen and elastin fibers
large irregular lumen anchoring filaments
overlapping junctions
interstitial pressure increase
macromolecules fluid

Skobe M.&Detmar M.2000. Structure, Function, and Molecular Control of the Skin Lymphatic System.
Journal of Investigative Dermatology Symposium Proceedings, Vol 5

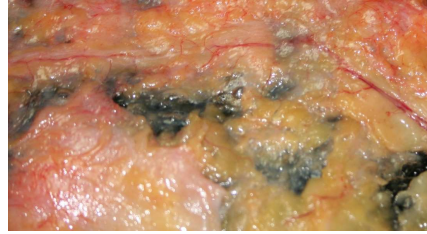
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The superficial fascia and the vessels



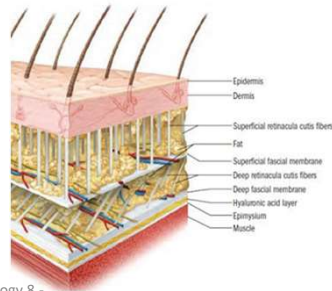
Perforantes vessel crossing the SF



Vascular plexus inside the fascia

The superficial vascular plexus and numerous lymphatic ducts can be recognised inside the superficial fascia .

The perforating vessels cross the superficial fascia to reach the skin.



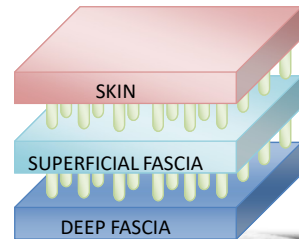
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The retinacula cutis

The retinacula cutis anchors skin to underlying tissues and the superficial fascia to the deep fascia → a flexible and yet resistant mechanism of transmission of the mechanical loads from multi-directional forces.

Regional specializations determine the variations in mobility of the skin with respect to underlying tissues, for example “watersheds” fusion lines of superficial and deep fascia.



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The superficial fascia can be divided in various compartments by superimposing the longitudinal and transversal lines of adhesion of the superficial and deep fascia: the quadrants
 Carla Stecco 2015 Functional atlas of human fascial system p.32.

Lymphatic watersheds.

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Skin angiosomes, or blood vessel “quadrants,” are almost identical to peripheral nerve areas.

The retinaculum cutis structures attach the skin to the superficial fascia and the superficial fascia to the deep fascia, leaving a superficial and deep layer of fat in between.

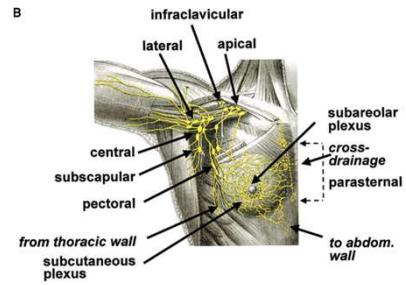
The pictures show superficial blood circulation, and note! there are 5x more blood vessels than what local tissues need - the rest is for thermoregulation

Pictures: PRINCIPLES, TECHNIQUES, AND BASIC SCIENCE
 CHAPTER 4 THE BLOOD SUPPLY OF THE SKIN AND SKIN FLAPS
 GEOFFREY IAN TAYLOR, RUSSELL J. CORLETT, AND MARK W. ASHTON

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Superficial fascia in connection with the deep fascia



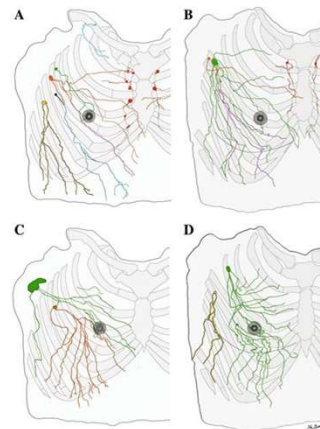
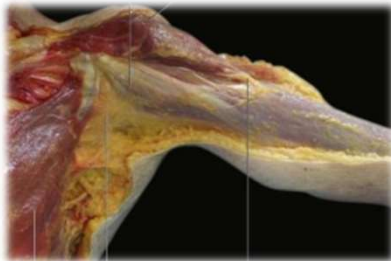
Axillary fascia; superficial fascia connecting to deep, epimysial fascia of the pectoralis major muscle.
 Winter School Fascial Anatomy and Physiology, Carla Stecco 2021

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The Lymphatic Anatomy of the Breast and its Implications for Sentinel Lymph Node Biopsy: A Human Cadaver Study. Suami H., et al. Annals of Surgical Oncology · April 2008

All superficial lymph vessels in these dissections entered a lymph node in the axilla, which was always close to the lateral edge of the pectoralis minor muscle. The findings were similar in both sexes.



Anatomy fig. Carla Stecco
 Functional Atlas of Human Fascial System, 2015

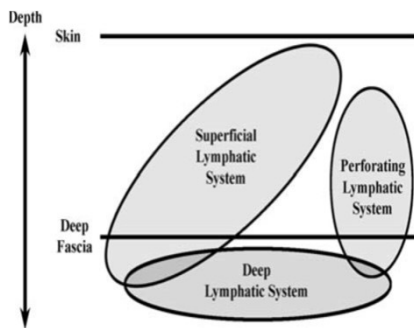
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The deep fascia and lymph



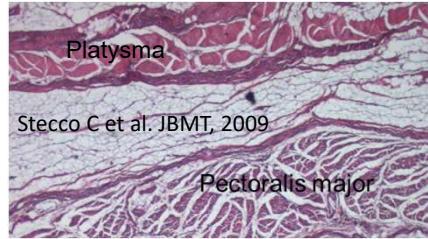
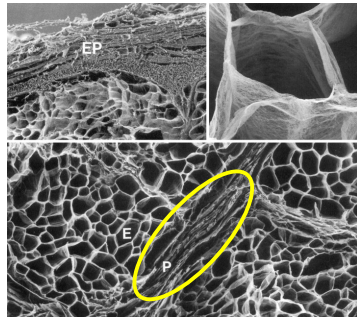
Fascia superficialis in the neck and thoracic area. Stecco C et al. JBMT, 2009

Perforating lymphatics that pierce the deep fascia are critical when discussing breast lymph drainage. The lymphatic system is classified conventionally into the superficial system and the deep system because of their relationship to the deep fascia. The perforating system is connected to the deep lymphatic system and these collecting vessels have the same appearance as the superficial lymphatics as they course with the internal thoracic blood vessels. Suami H. et al 2008

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Epimysium – perimysium-endomysium

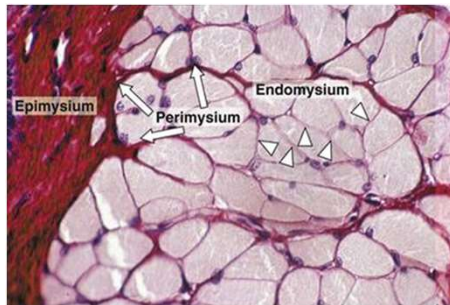


M Kjaer 2004
"Role of Extracellular Matrix in Adaptation of Tendon and Skeletal Muscle to Mechanical Loading"

"Lymph vessels penetrate the perimysium and connect to larger lymphatics that are closely associated with paired arterioles and collecting venules. The variously sized lymphatic vessels located inside the muscle lack smooth muscle in their walls, thus relying on muscular movements and pulsation of arterioles to propel lymph centrally. "Ch.2.3 Lymphatics in skeletal muscle" Korthuis 2011.

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The perimysium forms intramuscular neurovascular tracts. They envelope and protect blood vessels, nerves and lymph vessels. The neurovascular tracts can also be attached to the intermuscular septa, interosseal membranes and periosteum thus creating continuity between epimysial and aponeurotic fasciae.

Preservation of muscle fascia to decrease lymphedema after complete axillary and ilioinguinofemoral lymphadenectomy for melanoma" care was taken not to disrupt the muscle fascia at the site of dissecting the lymph node and the results showed a lower incidence of permanent edema with no risk of reoccurrence. Lawton G.,et al 2002 J Am College Surg

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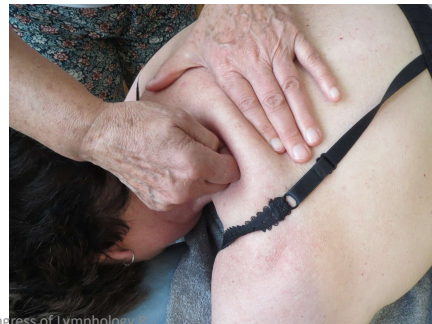
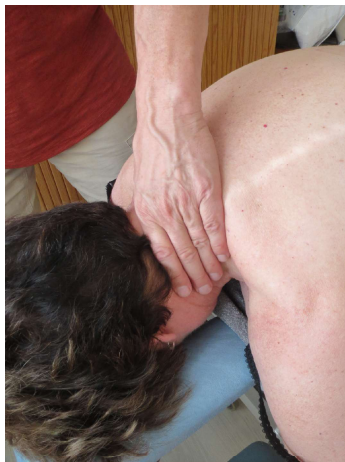
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Lymph drainage and treating the deep fascia in the thoracic outlet area



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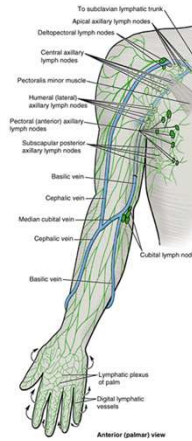
> 4500 mamillary cancer patients in Finland/year. 10–30 % of axillary lymph evacuation patients develop upper extremity lymphedema and 4–10 % after sentinel node resection.

Superficial fascia of the axilla
Connections between brachialis fascia and superficial fascia



Anatomy: Carla Stecco

Deltoideus Fat lobule



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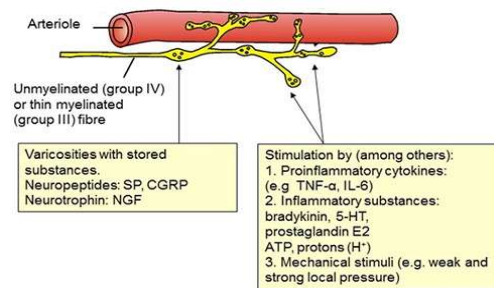
One of our new results is that the superficial and deep fascia are penetrated throughout by a network of small nerve fibers ($33.0 \pm 2.5/\text{cm}^2$, mean size $19.1 \pm 7.2 \mu\text{m}$ in the superficial fascia, and $19.0 \pm 5.0/\text{cm}^2$, mean diameter $15.5 \pm 9.4 \mu\text{m}$, in the deep fascia).

Fede C et al Fascia and soft tissues innervation in the human hip and their possible role in post-surgical pain. J Orthop Res. 2020 Jul;38(7):1646-1654.

The chronic stress can affect the basal tone of the fascial tissue, by the activation of the autonomic nervous system: influence of the sympathetic nervous system on the TGF- β 1 expression, which in turn stimulates myofibroblast contractility (Bhowmick et al, 2009; Schleip et al, 2019).

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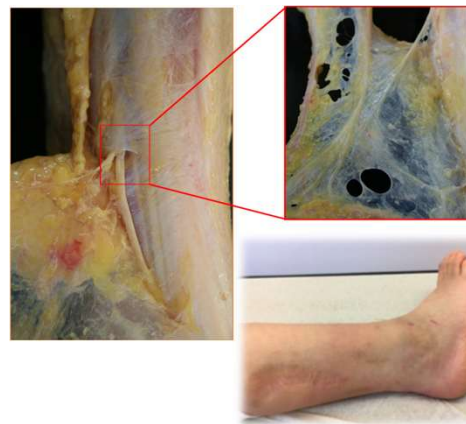
“The relative percentage of autonomic innervation in SF samples was equal to 33.82%, not so distant to the amount reported by Mense, who affirmed that approximately 40% of the entire fascia innervation consisted of postganglionic sympathetic fibers (2019). Probably, the majority of these fibers are vasoconstrictors; however, some of the sympathetic endings seem to serve an unknown function as they do not terminate on the vessels” (Fede et al, 2022)



Mense S.2019

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Fascial structures surround nerves and their dynamics depend on the state of its surroundings.

Even mild nerve compression is sufficient to cause intraneural inflammation, which can lead to neuropathic pain and explain the sensitization to pain sensation.

Sensory nerves penetrate deep and superficial fascia, changes in which can cause nerve irritation.


When the peripheral nerve is irritated, inflammatory mediators induce ectopic activation in the dorsal root ganglion.

This lowers the irritation threshold of nearby nerve cells, which spreads the pain to a wider area.

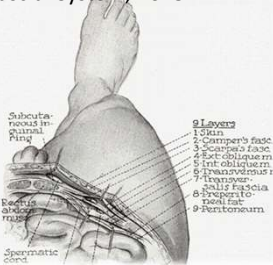
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Deep fascia continuity



Anatomy fig. Carla Stecco
Functional Atlas of Human Fascial System, 2015




In the abdominal region:
 Anterior: The fascia of the *oblique* muscles is in continuity with the *fascia lata* via the inguinal ligament
 Posterior: The fascia of the *oblique* and *transversus abdominis* muscles is in continuity with the *thoracolumbar* fascia
 The internal organs are anchored posteriorly by the mesenteries, therefore there is continuity with the prevertebral fascia.

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In the study of 29 postmastectomy patients and 20 healthy controls it was showed that the study group patients had a wide spread bilateral hypersensitivity on the neck – shoulder –axillary area. Local and referred pain from myofascial trigger points. The results indicate peripheral and central sensitization. Myofascial Trigger Points in Neck and Shoulder Muscles and Widespread Pressure Pain Hypersensitivity in Patients With Postmastectomy Pain: Evidence of Peripheral and Central Sensitization Fernández-Lao, Carolina PT ym.Clin J Pain. 2010

Moderate or severe pain in 10-20% ca mammae patients. Sensory disturbances are often connected with the symptoms indicating neuropathic pain. 2-3years post op appr. 50% of patients have constant pain QST in differentiating neuropathic pain.
 The Relationship Between Sensory Loss and Persistent Pain 1 Year After Breast Cancer Surgery. Andersen KG J Pain. 2017



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Approximately 90% of afferent information from free nerve endings is transmitted via unmyelinated, slow C-fibers and the rest via thinmyelinated A-delta fibers. A-delta and C-fibers convey all kind of information about the physiology of the body: mechanical, thermal, chemical, metabolic and hormonal (Schleip & Jäger 2012).


How knowledge of fascia and fascial system can help to understand pain accompanied by widespread symptoms connected with autonomic dysfunctions?

80% of the receptors in myofascial tissues are free nerve endings which are located in the superficial and deep fascia, epimysium surrounding the muscle and perimysium and endomysium inside the muscle.

Prolonged painful stimulus / input develops a "vicious circle" at the spinal level and increased efferent activity of the sympathetic nervous system. It causes spasms of peripheral blood vessels and in turn causes dystrophic changes in peripheral tissues

Treating the dysfunctional fascial structure can help with:

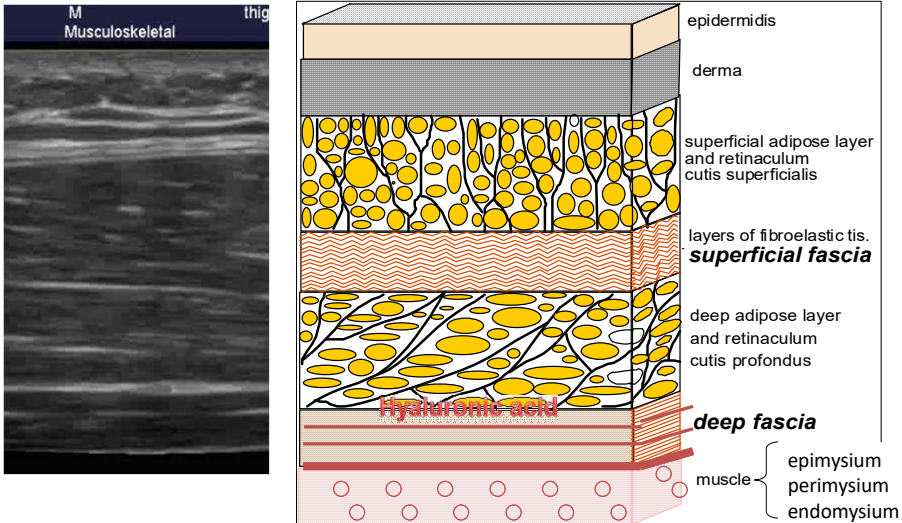
- lymphatic edema
- changes in the subcutis
- skin sensitivity
- physiological afferent communication to the paravertebral ganglia to normalize the efferent response (Stecco L & Stecco C 2017)



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Gliding properties of fascial layers.
Division of HA in the muscular fascia



M Musculoskeletal thigh

epidermis

derma

superficial adipose layer and retinaculum cutis superficialis

layers of fibroelastic tis. **superficial fascia**

deep adipose layer and retinaculum cutis profundus

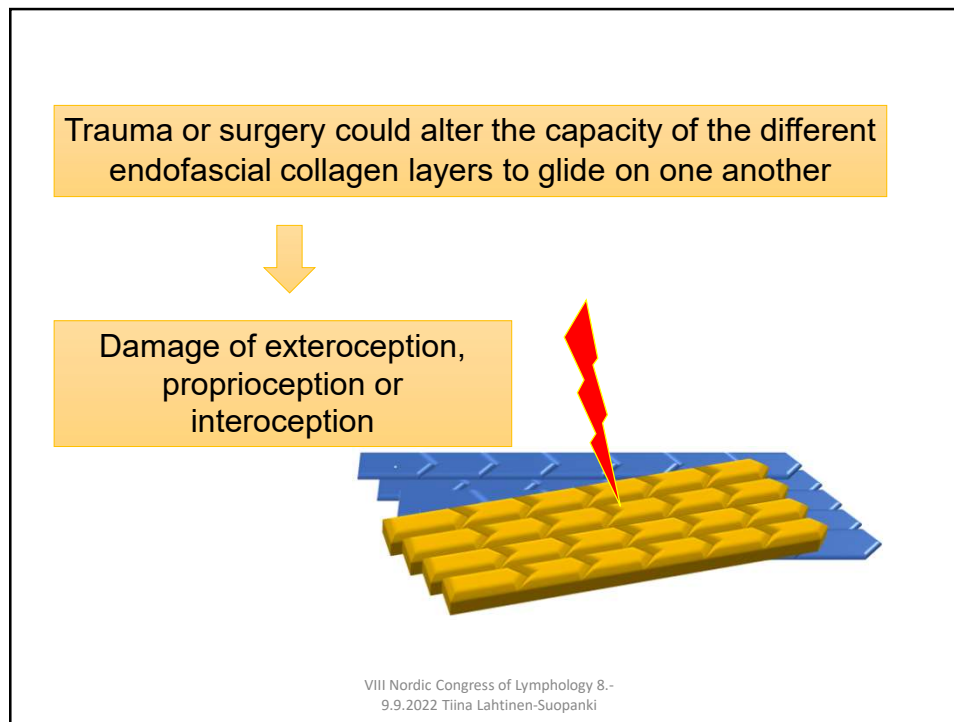
deep fascia

muscle { epimysium perimysium endomysium

Hyaluronic acid

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An evaluation tool for myofascial adhesions in patients after breast cancer (MAP-BC evaluation tool): Development and interrater reliability. De Groef A et al. 2017

In the first phase, literature described breast scar tightness in 46% and 29% of patients with breast cancer at 6 months and 12 months after surgery, respectively.

Axillary scar tightness was described in 46% and 37% patients at 6 months and 12 months after surgery, respectively.


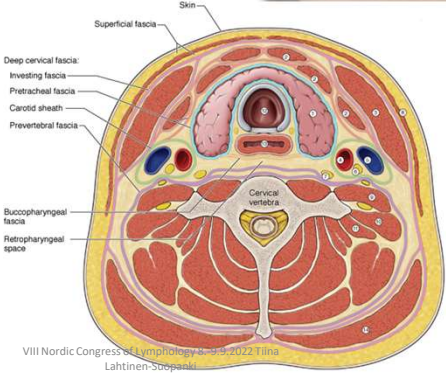
Restricted myofascial tissue gliding was described at the surgical scar (78%), drain sites (29%), axilla and upper arm (83%), axilla and lateral chest wall (61%), posterior axilla/scapula (55%), neck (33%) and other surgical sites (39%).

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"Many studies have evaluated the major complications of thyroidectomy, such as hypoparathyroidism and recurrent laryngeal nerve injury, but postoperative adhesive symptoms have been overlooked in those previous studies. Many patients complain of adhesive symptoms including swallowing difficulty or a pulling sensation during neck extension. Moreover, internal adhesion scars after neck surgery are often externally visible. Pictured at 3th month."

Bae et al 2013. Antiadhesive effect and safety of sodium hyaluronatecarboxymethyl cellulose membrane in thyroid surgery.

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BG et al 2015 Lymphedema Outcomes in Patients with Head and Neck Cancer. Otolaryngol Head Neck Surg. "The most common sites of HNL were in the neck (90%) and submental region (89%), whereas facial and intraoral edema presented in 53% and 18% of patients, respectively."

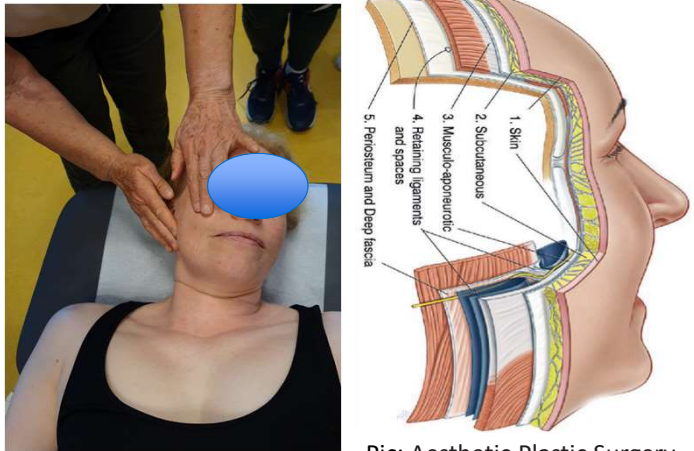
Choi, Yuri et al. (2014). Impact of Postthyroidectomy Scar on the Quality of Life of Thyroid Cancer Patients. Annals of dermatology.

Although facial and intraoral edema are less common compared with other affected areas of the head and neck, the functional effects to respiration, swallowing, speech, and vision can be significant. More than 1/3 of our patients reported functional complaints of which more than 2/3 comprised swallowing. Unfortunately, HNL remains under-recognized and undertreated.



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Pic: Aesthetic Plastic Surgery, Surgical Anatomy of the Lower Face: The Premasseter Space, the Jowl, and the Labiomandibular Fold, 32(2), 2008, 185–195, Mendelson, Freeman et al.

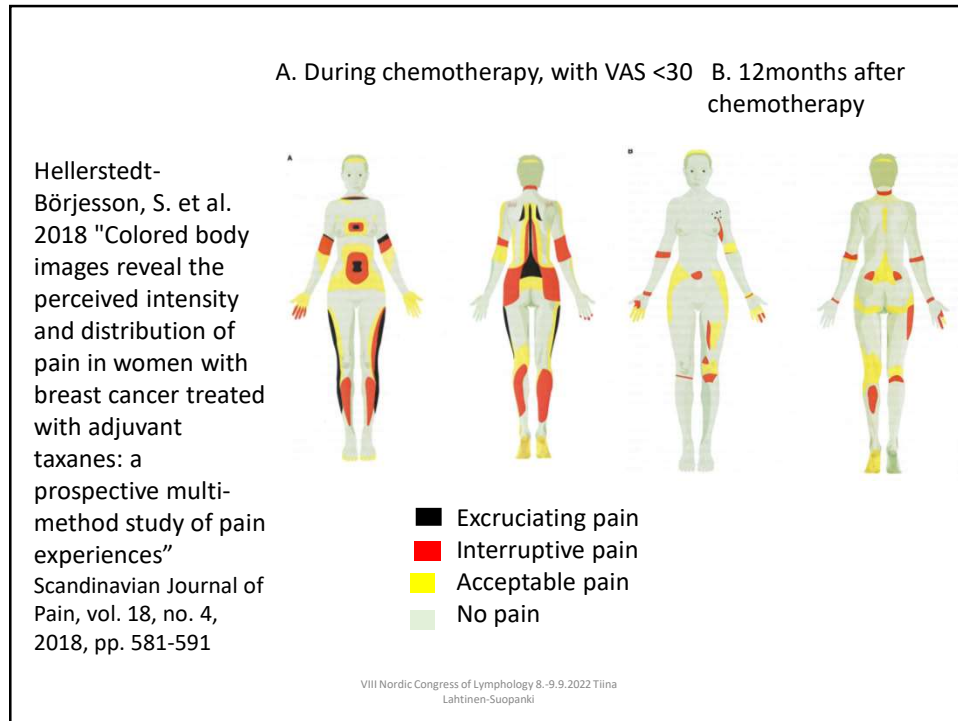
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Experiences

But I would describe it as the most impressive touch, because in FM, my touch and the patient's sensations are of great importance together (I argue that bigger than, for example, in a massage alone).

In most cases, a relieving effect of pain/tightness /swelling is obtained, as well as an improvement in body perception AND a nervous balance of alertness AND the experience that their symptoms have been heard and seen.

Patients often come in very anxious and leave calm and "as different people" after FM treatment. They may be asymptomatic for a long time.

I use it whenever I do something manual. In other words, for several patients, yes, I would say about 80-90%

Actually, after surgical procedures, I would find the use of FM very useful. Much has been used for breast cancer patients and sarcoma / lymphoma / gynecological cancer patients. Sometimes, for example, a very tense lymphedema arm has been made to soften and thus reduced the swelling. Radiation-treated areas should always be treated. Occasionally, in various cases of cancer symptoms have been treated at any which part (depending on the patient's body life history).

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