An often overlooked Functional Parameter as to Proprioception in the Locomotor Apparatus

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THE ARCHITECTURE OF THE CONNECTIVE TISSUE IN THE MUSCULOSKELETAL SYSTEM
A TRANS-BORDER APPROACH OF THE SPATIAL ORGANIZATION OF ‘PROPRIOCEPTORS’, PLACED IN THE CONTEXT OF ‘FASCIAL ANATOMY’
EVERYTHING YOU ALWAYS WANTED TO KNOW OF
........ IN DETAIL ....
IS IN THE CONGRESS BOOK
The anatomy of fasciae

Connective tissue and its functional organization in the human body

Architecture of connective tissue in the Musculoskeletal System

The substrate of proprioception in joint regions 1988
The anatomy of fasciae

Connective tissue and its functional organization in the human body

Architecture of connective tissue in the Musculoskeletal System

The substrate of proprioception in joint regions 1988

AND BACK FROM CONCEPTS TO FACTS – DEDUCTION -
How to define fasciae?

PHILOSOPHICAL AND METHODOLOGICAL INTRODUCTION
WHAT IS IN A NAME?

WARNING! A ‘name’ is very important. Names might obscure facts and induce views. Think on the so-called ‘gill arches’ or ‘pharyngeal arches’ in the human embryo. A name might even narrow your mind!
THE ANATOMIST GOING BACK TO THE FUTURE ?

In an effort to rephrase, redefine our traditional anatomical issues and items as to the anatomy of the connective tissue ‘skeleton ‘in the human body.
TROUBLES OF TERMINOLOGY
What in a name is!

- The Locomotor System?
  + sensu stricto or sensu lato?

- The Musculo-Skeletal System?
  + And never the twain shall meet? (McBeth)
  + What about the Connective Tissue Skeleton?

- Ligaments? How and What do you mean?

- Last but not least:
  What about Fasciae?
FASCIA OR APONEUROSIS?
WHAT’S IN A NAME?
(**CLASSICAL**) ANATOMY DESTRUCTS MORE IN YOUR MIND THAN YOU ARE AWARE OF ..!

- The ‘anatomist’ cuts, dis-sects, separates: capsules, ligaments, fasciae, muscles, bones.
- Anatomical figures / images = “(self) made” structures.
- Continuity has gone!
- That continuity was ORIGINAL!

DISSECTION AS A SCIENTIFIC METHOD MIGHT NEARLY HAVE GONE LOST, THE DISSECTING MENTALITY HAS NOT!
WE ALL ‘THINK’ IT. OR TEND TO THINK LIKE THAT.
Continuity and Connectivity – The inner tissue – Connective tissue as a matrix

PHILOSOPHICAL AND METHODOLOGICAL INTRODUCTION
Erich Blechschmidt (1904-1992) introduced the principle of Limiting tissues versus/and Inner tissue.

The classical triad Ectoderm, Mesoderm and Endoderm should be interpreted as such: ‘meso(derm)’ as the ‘inner’
INNER TISSUE, **THE MATRIX TISSUE**

**Limiting Tissues and Inner Tissues: A General Description**

In any tissue, all cells are always linked kinetically to one another through the movements of materials. Cells absorb nutrients from interstices and from neighboring cells and, by means of this material uptake, exert a reciprocal attraction to each other. On the other hand, they also exert a mutual repulsion through the release of metabolic by-products. The changing interplay between uptake and release, between attraction and repulsion, is the precondition for cells ordering themselves in particular arrangements and maintaining certain forms.

Even in the earliest stages of development, one finds two characteristically different tissues: **limiting tissue** and **inner tissue**. The former is the boundary between fluid on one side and inner tissue on the other, whereas the latter is enclosed on all sides by limiting tissue and is therefore permanently inside the body. In **histology**, limiting tissue is commonly called **epithelium** and many derivatives of inner tissue are identified as **connective tissue**. Inner tissue could therefore be described as **undifferentiated connective tissue**. Corresponding to their different locations, limiting and inner tissue have different significance for growth.

**Fig. 3.1.** Schematic diagram of the two basic tissues: limiting tissue and inner tissue. 1) fluid, 2) cells of limiting tissue, 3) basement membrane, 4) inner tissue. Close stipple: glycocalyx. Loose stipple: intercellular material of inner tissue.
TENDENCIES IN THE INNER OR MATRIX TISSUE

- Phenomenologically one could describe two organizing tendencies in the primordial Inner tissue of Mesenchyme:
  + Concentration, centering
  + Decentration, peripherizing
As to the connective tissue this leads to two **functional** principles:
- ‘connecting’, binding,
- ‘disconnecting’, creating room

As extreme examples:
- *Desmal* sutures in the skull
- *Synovial* joints (articulations) *

Superimposed on that the **CONTINUITY** of the original mesenchym as the matrix tissue:
- “Enveloping Connective tissue skeleton”
  *Which actually are neither joints nor ‘hinges’, but actually ‘dis-joints*
Connection and disconnection –
Two types of fasciae

PHILOSOPHICAL AND METHODOLOGICAL
INTRODUCTION
FASCIA OR APONEUROSIS?
WHAT IN A NAME IS!
‘CLEAN ANATOMY’. AWAY WITH THE ‘ENVELOP’
‘IMPOSSIBLE ANATOMY’ (‘MUSCULOSKELETAL’)
FASCIA ANTEBRACHII: Fascia of … Aponeurosis?
DISTAL: MUSCLE UNITS GLIDING ALONG EACH OTHER AND UNDERNEATH THE ANTEBRACHIAL FASCIA (‘SLIDING’)

THE ANTEBRACHIAL FASCIA AS INSERTING AREA FOR UNDERLYING MUSCLE FASCICLES (‘TRACTION’)

GLIDING AND LOADING – 2 TIMES FORCE TRANSMISSION
Two functional appearances

CONNECTIVE TISSUE IN
THE MUSCULOSKELETAL SYSTEM
‘DISSECTING WITH ANOTHER MIND’ IN THE LATERAL ELBOW REGION.... !

- View LEFT fore arm and elbow
- * is lateral humeral epicondyle
- Connective tissue sparing dissection
‘ALTERNATIVE’ * DISSECTION

- ‘Cleaning’ muscle and muscle parts where ‘gliding’ still is possible
  DISTAL
-Sharply removing muscle fascicles from the regular dense CT
  PROXIMAL

* OR: ‘COMPLEMENTARY’
'ALTERNATIVE' DISSECTION

- "Cleaning" muscle and muscle parts where "gliding" still is possible
- Sharply removing muscle fascicles from the regular dense CT PROXIMAL

*
‘ALTERNATIVE’ DISSECTION

- Muscle belly of 3rd finger extensor in the proximal region ‘released’ from ‘enveloping’ fascia..
- and from ‘surrounding’ and ‘enveloping’ regular dense CT of INTERmuscular septa
‘ALTERNATIVE’ DISSECTION

- Muscle belly of 3rd finger extensor has been removed
- Extensor carpi radialis brevis muscle ‘released’ from CT layers
Rd 'Regular dense' or 'Dense regular'? 

ALTERNATIVE DISSECTION

Rd Connective tissue skeleton around the humeroradial joint, diverging from the lateral humeral epicondyle and integrated part of the proximal extensor muscles.
CONSEQUENCES

- To the lateral humeral epicondyle (and cases) are converging and inserting
  - ... with muscle fascicles of the extensor muscles (in a pennate configuration)
Not \textit{in parallel} but \textit{in series}

\textbf{CONNECTIVE TISSUE IN THE MUSCULOSKELETAL SYSTEM}
‘THE ARTISTS IMPRESSION’: THIS IS NOT HOW ANTEBRACHIAL MUSCLES ORIGINATE FROM THE SKELETON!  

PROMETHEUS 2004
‘CLASSICAL ANATOMY’: COLLATERAL LIGAMENTS AND MUSCLES AS SEPARATE IN PARALLEL STRUCTURES
WHAT IS IN A MAN’S MIND?

RADIAL COLLATERAL LIGAMENT MADE BY SHARP DISSECTION

DRAWING OF CAPSULAR ‘LIGAMENTS’
HOW TO MAKE COLLATERAL LIGAMENTS?

BY SHARP DISSECTION
Connective and muscle tissue not \textit{IN PARALLEL} (like ligaments) but \textit{IN SERIES}!

But like this!

Not in this way!
M. Supinator

Aponeurose

*
BUT LIKE THIS

Aponeurosis

M. Supinator

M. Supinator

Annular ligament
THIS IS NOT HOW AN ANNULAR LIGAMENT LOOKS LIKE!  PROMETHEUS 2004
ANNULAR LIGAMENTS ARE MADE BY SHARP DISSECTION
THE CONCEPT OF THE LATERAL COLLATERAL FORCE TRANSMISSION SYSTEM LCFTS

Slice

MRI (in vivo)
‘NEW’ SITUATION:
- Connective and muscular tissue organized in series
- Ligaments are ‘functional’ in ‘’ every’ joint position
Architectural units of connective and muscular

CONNECTIVE TISSUE IN THE MUSCULOSKELETAL SYSTEM
PROXIMALLY
Septa, walls or cases of connective tissue with muscle parts inserting to them *in series.*
*Intermuscular septa*
Transmission of forces occurs here in a **TRANS-muscular order!**

DISTALLY
*Muscles with tendons*
ARCHITECTURAL ‘UNITS’?

- Integrating the usual categories of **muscles** versus **ligaments** that is usually linked with the category of **dynamic** versus **static** force transmission
- Which means:
  + Transmission of **compression** forces
    via **bones and joint surfaces**
    versus
  + Transmission of **tensile forces**
    via **muscle and connective tissue**
  - With ligaments as ‘exceptional’
ARCHITECTURAL ‘UNITS’?

NOT:  

OR

But a muscle - connective tissue - bone - unit ……  
- Call it a ’DYNAMENT’

…… with which you may ‘construct’ every structure in the Locomotor System?
ARCHITECTURAL UNITS IN THE MUSCULO-SKELETAL SYSTEM? ‘DYNAMENTS’?

Not: 

OR
LIGAMENTS * AS ‘EXCEPTIONAL’
AND MEMBRANES AND SO ON
The substrate of proprioception

THE ARCHITECTURE OF CONNECTIVE TISSUE
AS INSTRUMENT FOR PROPRIORCEPTION
The ‘muscle man’ is just a structural concept. There also exist another functional architecture which often is ‘trans-muscular’. How about the brain?
USUAL CONCEPT: JOINT RECEPTORS VERSUS MUSCLE RECEPTORS?

- Joint receptors for statesthesia en kinesthesia, muscle receptors for muscle motor control.

- Joint receptors in CAPSULES / LIGAMENTS:
  - (Paciniform) Lamellated corpuscles (LC), Ruffini like Corpuscles (RC), FNE.

- Muscle receptors in MUSCLES:
  - Muscle spindles (MS), Golgi Tendon Organs (GTO) and Free Nerve Endings (FNE).
This concept has been and continuously is challenged by the results of clinical experiments and experimental findings e.g. phenomena after the extirpation of joint capsules as well as the phenomenon of ‘kinesthetic acuity’
LOCOMOTION AND LOCOMOTOR SYSTEM?
AND WHAT ABOUT MUSCULOSKELETAL SYSTEM

Brains know nothing about the muscles i.e. about their effects!

❖ And about … motions ?
And about … actions ?
Muscles do not have functions! Muscles have effects or mechanisms. That is where they are named after.

FUNCTIONS are WHAT the Locomotor System ACHIEVES with the muscles, joints etc. For example walking, stabilizing, grabbing, respiration. etc.

 Those functions on their turn are hierarchically framed in the context of ACTION for example ‘taking something from the table or writing’.

“RESPIRATORY MUSCLES DO NOT EXIST”
Only in the ventral horns of the medulla something like ‘muscle zones’ are topologically represented

Does the ‘homunculus motoricus’ posses muscles?

At the side line: Models for ‘functional physiotherapy’
PROPRIOCEPTION?
(STATESTHESIA AND KINESTHESIA)

- Statesthesia and kinesthesia: to be informed about position and acceleration of the body (parts) in space.
- Sense (as a system) and sense (as an organ, equipment) are not synonymous (s.l. and s.s.)
- Locomotion sense ≠ Locomotor apparatus sense
- In the case of PROPRIOCEPTION the anatomical equipment are the MECHANORECEPTORS
MECHANORECEPTORS: NERVE ENDINGS, BALLS AND SPINDLES

FNE Free Nerve Endings(s)

Paciniform ‘lamellated’

Ruffini shaped Tendon spindle / GTO
MECHANORECEPTORS:

- Pacinian Corpuscle
- Paciniform Lamellated Corpuscles (bodies)
- Tendon spindles / Golgi Tendon Organs - GTO´s
- Ruffini Corpuscles / Spraylike endings
.. A spindle shaped mechanoreceptor constituted by specialized muscle fibers and therefore adjustable as to length and tension.
NOT MUSCLES BUT UNITS OF CONNECTIVE AND MUSCULAR TISSUE

- Four superficial lateral forearm muscles:
  - ECU, EDL, EDC en ECR (and ANC)
- Three deep lateral fore arm muscles:
  - EI, EDP en SUP
NOT MUSCLES BUT UNITS OF CONNECTIVE AND MUSCULAR TISSUE

- Transmuscular units a.o. .
- Epicondylar muscle - CT - unit
  + ANC, ECU (1), EDL, EDC, ECR (partly) en SUP
- Transmuscular units a.o.
- Epicondylar muscle - CT - unit
+ ANC, ECU (1), EDL, EDC, ECR (partly) en SUP
Spatial distribution of mechanoreceptors as functional parameter

THE ARCHITECTURE OF CONNECTIVE TISSUE AS INSTRUMENT FOR PROPRIOCEPTION
SPECTRUM OF MECHANORECEPTIVE SUBSTRATE 1

- **WITHIN** the septa hardly any substrate is present
- At the **TRANSITION** of muscle tissue to the septa so-called proximal GTO’s are present.
At the **TRANSITION** of muscle tissue to the septa so-called proximal GTO’s are present.

- In some muscles those proximal GTO’s quantitatively dominate the distal GTO’s (e.g. in ECU, SUP)

- Classification? Ruffini corpuscle of GTO?
The innervation pattern of the proximal antebrachial fascia and supinator septum resembles that of a ‘ligament’.
At the transition of connective tissue and skeletal elements the whole spectrum of FNE’s is present, nociceptive as well as (putatively) mechanoreceptive substrate

Lamellated corpuscles at ‘unexpected’ locations
Spatial distribution of muscle spindles and GTOs

- Non-evenly distributed over the muscles
- Organized according to CT (septum)–muscle– CT (tendon)–units i.e. to ARCHITECTURE = FORCE
m. ECR

22.38
21.63
9.0
14.13

102.2
343.3
281.3
261.6

m. ECU

Number of muscle spindles
Number of muscle spindles per gram muscle

m. supinator

m. ext. indicis
Muscle spindles follow a non homogenous, eccentrical distribution pattern

‘Monitor zones’ in line with the architecture of ‘connective tissue – muscle – connective tissue – units’

Patterns of muscle spindle organization:

Quantitative parameters per muscle are not sufficient to describe their functional pattern
Proprioception not a matter of anatomy but of architecture?

THE ARCHITECTURE OF CONNECTIVE TISSUE AS INSTRUMENT FOR PROPRIOCEPTION
A NEW CLASSIFICATION?
OR NO CLASSIFICATION?

The whole spectrum of mechanoreceptive substrate in a joint region is represented by:

\[ \text{MS} + \text{GTO} + \text{LC} + \text{FNE} \]

That is:

- Muscle triplet MS, GTO/RC en FNE combined with
- Joint triplet RC, LC en FNE
A NEW CLASSIFICATION? OR NO CLASSIFICATION?

- Mechanoreceptors do not need to be classified anatomically as to proprioception (in particular not as ‘joint receptors’ vs. ‘muscle receptors’)
- Besides physiological parameters it is the context that determines whether a certain mechanoreceptor is activated or not.
- And that context is architectural
- The architecture is instrumental in the process of proprioception
MECHANORECEPTORS ‘KNOW NOTHING ABOUT’....

- .... muscles
- .... neither of ligaments .... nor capsules ..
- they only ‘know’ about reacting to deformation in their deformable environment
- “This means that in vivo the peri-articular connective tissue (which not necessarily has to be iuxta-articular) may be stressed or loaded by replacement of skeletal parts guided by the tension (or changes in that) of the muscular tissue inserting to it” (Van Mameren)

FASCIAL ARCHITECTURE IS INSTRUMENTAL IN PROPRIOCEPTION
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