Sono's Anatomy

Focus on Spasticity
Targeting Botulinum Toxin
Children & Adults

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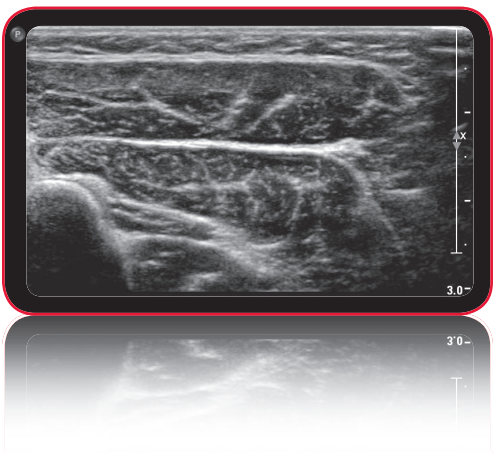


Questions & Answers
52 Targets for Injection
Instruments for
Therapy Evaluation
Comprehensive Literature

B – 50 muscles and 2 salivatory glands

Origin
Spinous process of fourth to seventh cervical and first to third thoracic vertebrae

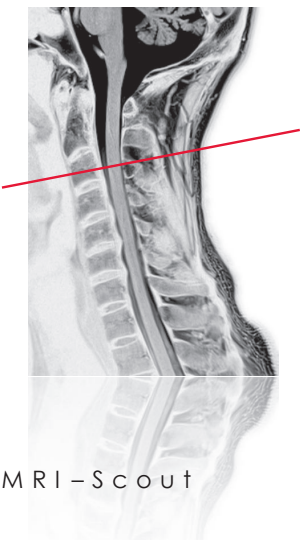
Insertion
Lateral half of superior nuchal line of occipital bone, mastoid process

Innervation
Rami dorsales (C1-C8)

Function
Unilateral: rotates head ipsilaterally
Bilateral: extends head

Control of Injection
Palpation, sonography, EMG

Comment
Strongest of the head-rotating muscles. Often spontaneously sore or pressure sensitive. In cases of atrophy or poor treatment results, electromyographic or sonographic control of injections should be used. 2-6 injection sites.



MRI – Scout

splenius capitis

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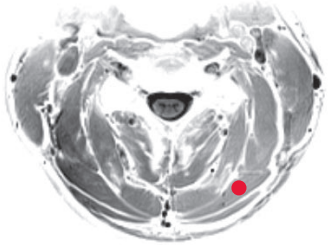

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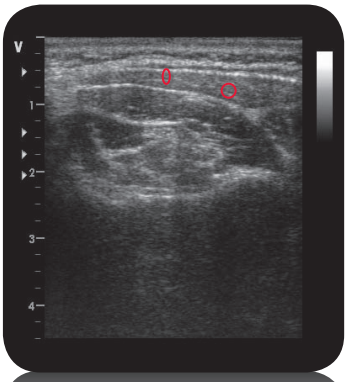

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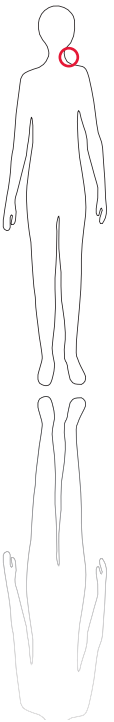


Origin
Transverse and spinous processes of second to seventh cervical vertebrae

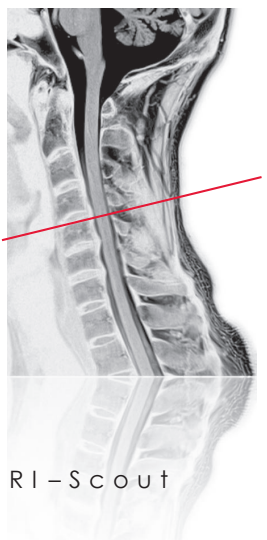
Insertion
Linea inferior ossis occipitalis

Innervation
Nervi cervicales (C1-C7)

Function
Unilateral: contralateral flexion of head
Bilateral: retroflexion of head

Control of Injection
Palpation, sonography, EMG

Comment
Because the semispinalis is deep-seated there is a risk of inadvertent cisternal puncture. To avoid this, locate the tendinous junction of the trapezius muscle with the skull and insert the needle about 1-3 cm below this area and 1-3 cm paramedially through the trapezius and the splenius. Use sonography!



MRI – Scout

semispinalis capitis

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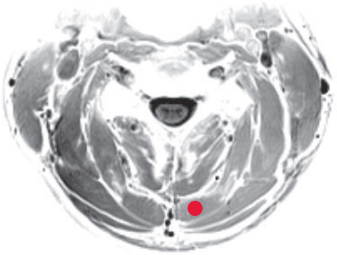

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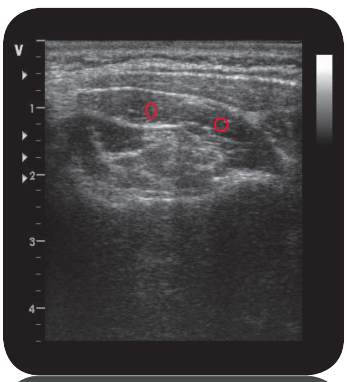

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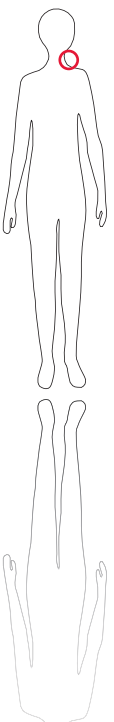


Origin
Pars sternalis: manubrium sterni
Pars clavicularis: sternal third of clavicle

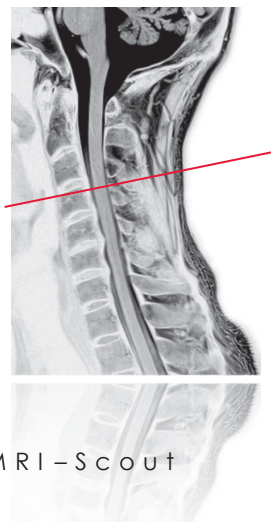
Insertion
Mastoid process, superior nuchal line of occipital bone

Innervation
N. accessorius, plexus cervicalis (C1-C2)

Function
Unilateral: anterior flexion and contralateral rotation of head
Bilateral: anterior shift of head, raises face

Control of Injection
Palpation, sonography, EMG

Comment
Bilateral injections frequently induce diffculties in swallowing. Place 1 or 2 injections in the upper third of the muscle near the mastoid process. Hypertrophy and atrophy can be cosmetically relevant. Especially in patients with atrophy, short neck or adiposity it is advisable to inject under electromyographic or sonographic control.



MRI – Scout

sternocleido-mastoideus

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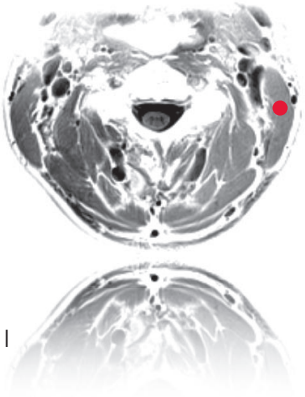

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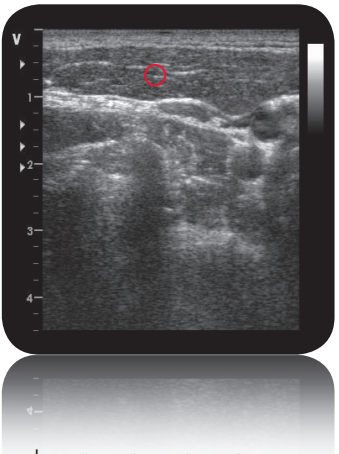

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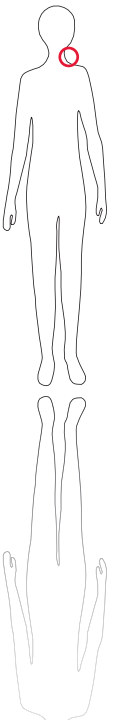


Origin
Anterior tubercle of transverse processes of, respectively, third to sixth (anterior) and second to seventh (medius) cervical vertebrae

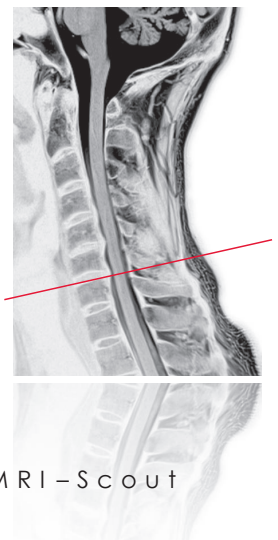
Insertion
First and second rib ventral, scalene tubercle

Innervation
Plexus cervicalis and brachialis

Function
Unilateral: ipsilateral flexion of head
Bilateral: anteversion of head
Auxiliary respiratory muscles: raise cranial ribs

Control of Injection
EMG (for activation of muscles ask patient to breath in deeply) or sonography

Comment
Often pressure sensitive and palpable



MRI – Scout

scalenus anterior et medius

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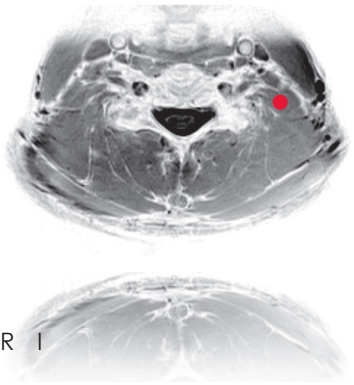

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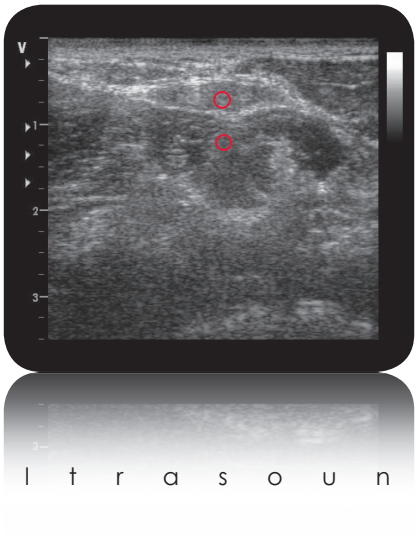

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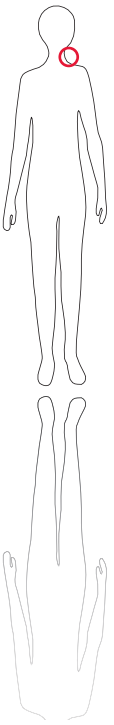


Origin
Arcus zygomaticus

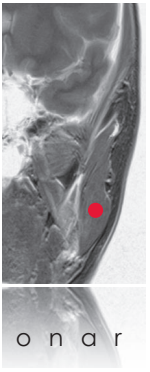
Insertion
Lateral surface of ramus to angle of mandible

Innervation
N. massetericus division of trigeminal nerve

Function
Closes jaws

Control of Injection
Palpation while patient firmly bites teeth together. Sonography, EMG

Comment
The superficial part of the muscle is more prominent and runs at an angle. The deep-seated part runs vertically and always should be co-treated in cases of trismus; 1-2 injection sites.



Coronar MRI

Injection

masseter

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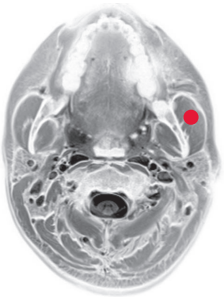
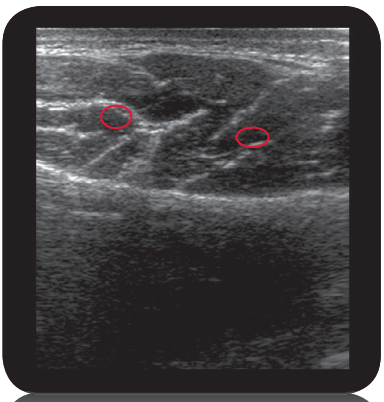
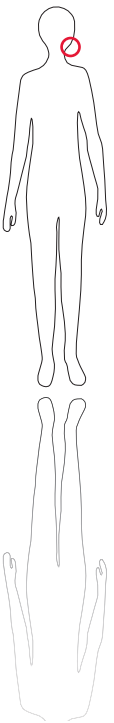


Axial MRI



Ultrasound



Origin
Lamina lateralis of pterygoid process

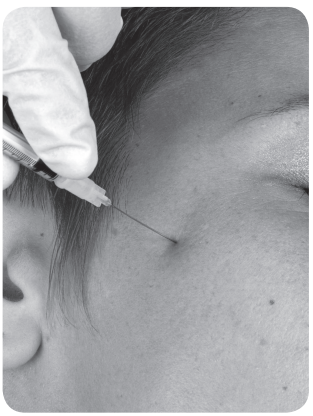
Insertion
Fovea pterygoidea of processus condylaris mandibulae

Innervation
N. pterygoideus lateralis division of trigeminal nerve

Function
Opens jaws, moves mandible forward and from side to side.

Control of Injection
EMG-controlled injection has gained wide acceptance and is now considered state of the art. Uncontrolled injection is no longer acceptable.

Comment
Strongest jaw opener, in synergy with digastricus venter anterius; one injection site seems to be sufficient.



Injection

pterygoideus lateralis

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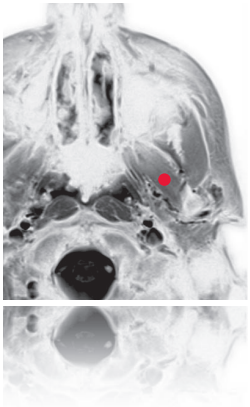

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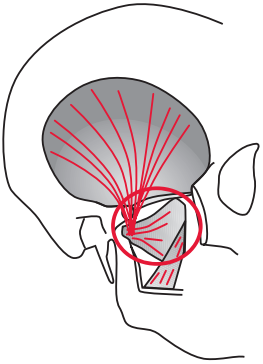

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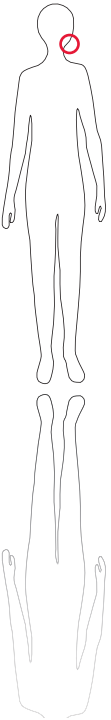


Origin
Massa lateralis atlantis and transverse processes of second to fourth cervical vertebrae

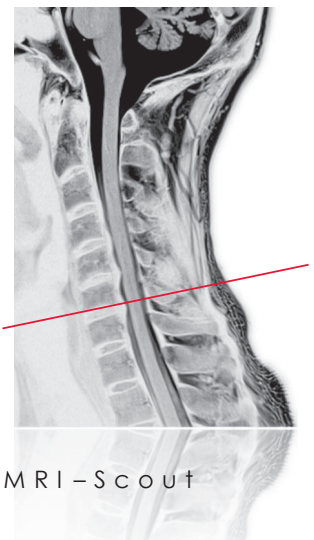
Insertion
Margo medialis scapulae between angulus superior and spine

Innervation
Rami dorsales (C2-C5), N. dorsalis scapulae

Function
Lateral movement and ipsilateral rotation of head
Raises shoulder blade

Control of Injection
Sonography, Palpation, EMG

Comment
Frequently treated muscle in case of elevated shoulder. Often pressure sensitive and easily palpable. 2-4 injection sites.



MRI – Scout

levator scapulae

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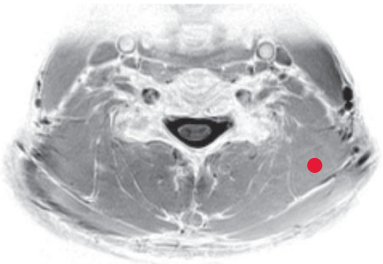

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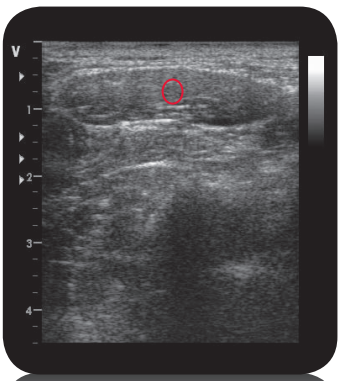

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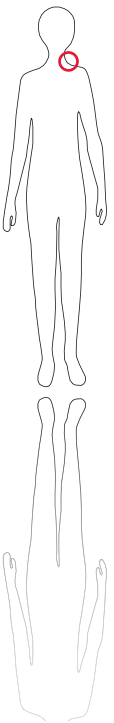

Origin
Ventro-medial part of clavicula, membrana sterni. Cartilage of 2nd to 6th rip. Rectus sheath.

Insertion
Christa tuberculi majoris humeri

Innervation
Nn. pectorales

Function
Adduction and medial rotation of the upper arm at the shoulder joint. The clavicular head flexes the humerus (anteversion), the sternocostal head extends the humerus (retroversion).

Control of Injection
Palpation, sonography

Comment
Important muscle for upper extremity spasticity and for the indication painful shoulder.
2-3 injection sites.

pectoralis major

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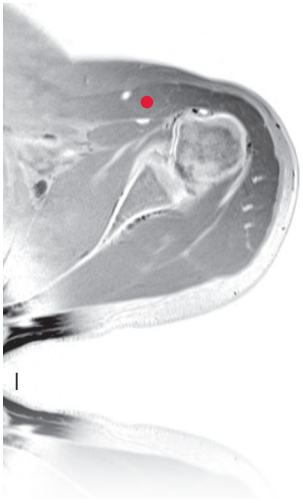

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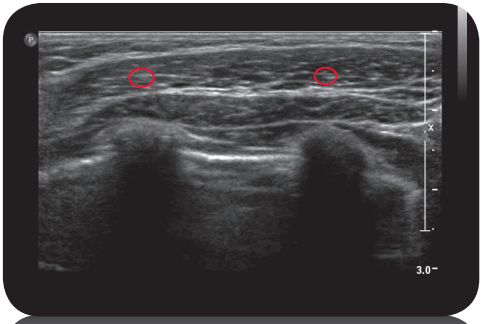

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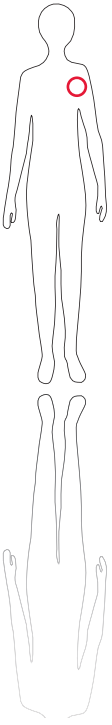

ORIGIN
Dorsal surface of inferior scapular angle, medial third of lateral scapular margin

INSERTION
Christa tuberculi minoris humeri

INNERVATION
N. thorakodorsalis or Nn. subscapulares (C5-C6)

FUNCTION
Adduction, extension and medial rotation of the humerus at the shoulder joint.

Control of Injection
Palpation, sonography, EMG

Comment
A spastic teres major may impede the scapula's rotation, thus hindering elevation of the arm at the shoulder joint. This condition can be improved by injecting the muscle with BoNT.

teres major

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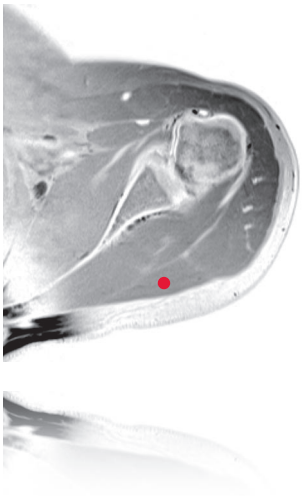

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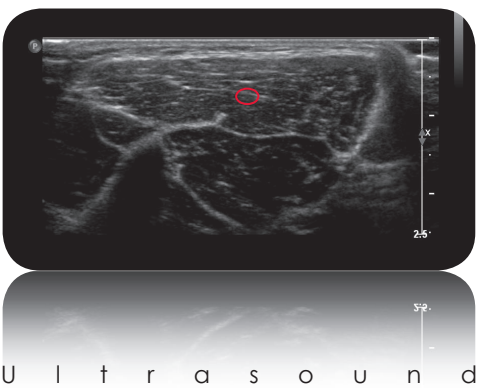

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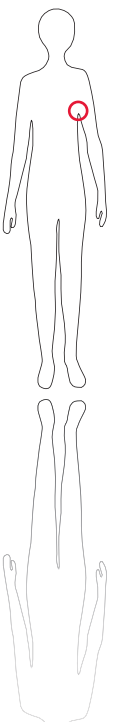

Origin
Spinous processes of all thoracic vertebrae

Insertion
Medial margin of acromion, spine of scapula

Innervation
N. accessorius, cervical plexus (C2-C4)

Function
Fixes scapula and draws scapula backward; depresses scapula

Control of Injection
The muscle is easy to palpate. Insert the needle tangentially.

Comment
This is a rare indication, often accompanied by a compensatory increase of muscle tone. Use 2-4 injection sites, insert needle tangentially.

trapezius

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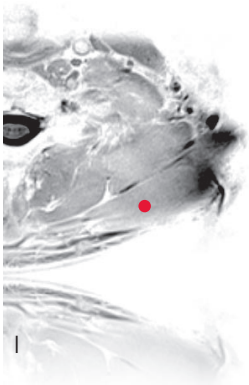

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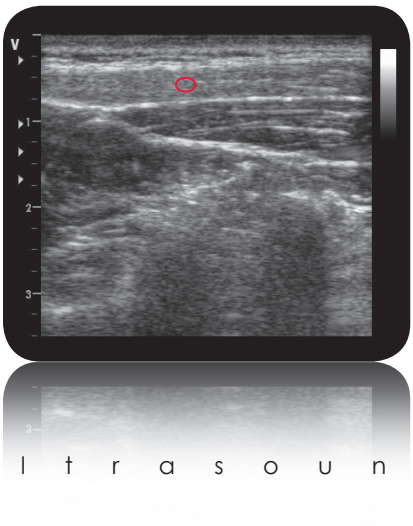

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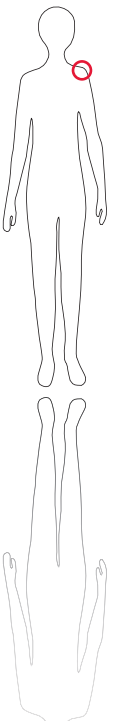
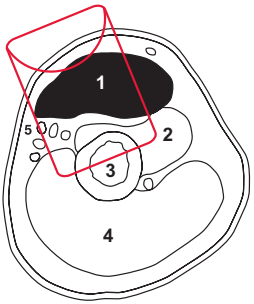




L e g e n d
1: M. triceps brachii 2: M. brachialis 3: Humerus 4: M biceps brachii 5: vessel-nerve bundle

O r i g i n
Caput breve: Processus coracoideus scapulae
Caput longum: Tuberculum supraglenoidale scapulae

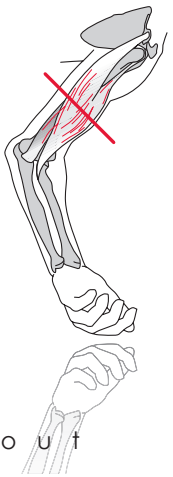
I n s e r t i o n
Tuberositas radii and aponeurosis M. bicipitis brachii

I n n e r v a t i o n
N. musculocutaneus (C5-C7)

F u n c t i o n
Flexion of elbow, supination of forearm, anteversion of shoulder.

Control of Injection
Sonography, electrical stimulation, EMG

C o m m e n t
Strong flexor of elbow. Short and long head can not be differentiated by sonography. Due to location of motor end plates in lower third, injection should be performed there. Strong supinator. When to be injected, both functions of biceps have to be weighted carefully against each other, i.e. reduced elbow-flexion vs. reduced supination.



S c o u t

biceps brachii

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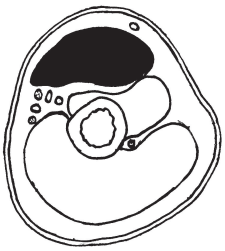
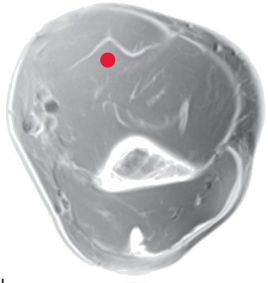
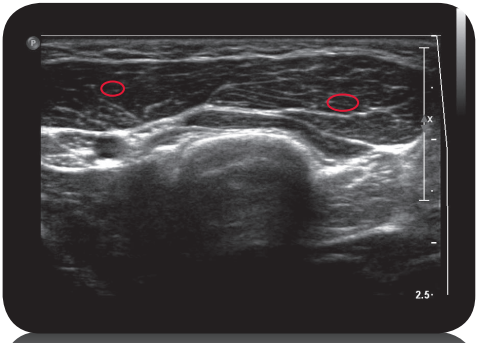


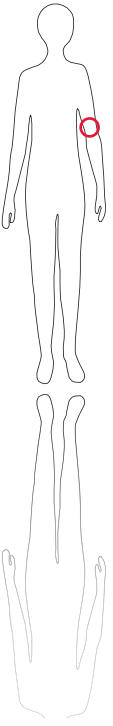
Cross Section

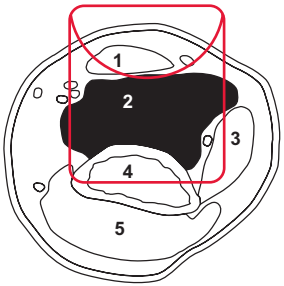


MRI



Ultrasound





L e g e n d
1: M. biceps brachii 2: M. brachialis 3: M. brachioradialis 4: Humerus 5: M. triceps brachii

O R I G I N
Distal anterior face of humerus.

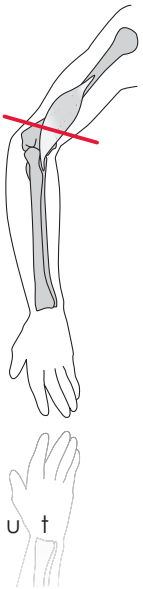
I N S E R T I O N
T.u. and articular capsule

I n n e r v a t i o n
N. musculocutaneus (C5-C7)

F u n c t i o n
Flexion of elbow, tonically stabilizes elbow joint

C o n t r o l o f I n j e c t i o n
Sonography, electrical stimulation, EMG

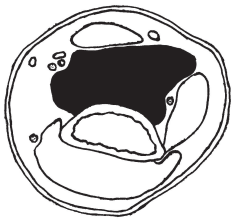
C o m m e n t
Strong flexor of elbow. Do not inject without injection of biceps because of important stabilizing effect on elbow joint.



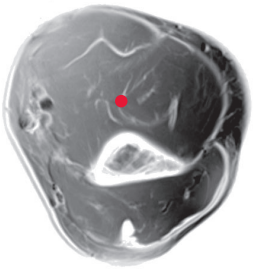
S c o u t

brachialis

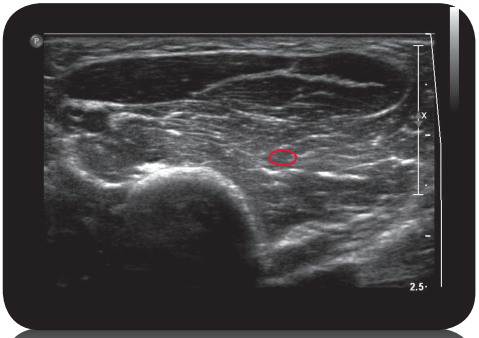
* * *



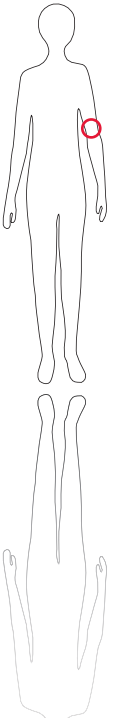
Cross Section

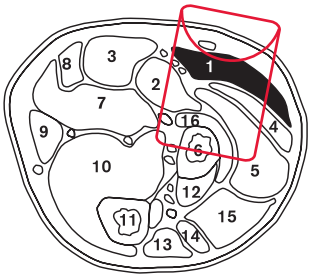


MRI



Ultrasound





L e g e n d
1: M. brachioradialis 2: M. pronator teres 3: M. flexor carpi radialis 4: M. extensor carpi radialis longus 5: M. extensor carpi radialis brevis 6: Radius 7: M. flexor digitorum superficialis 8 : M. palmaris longus 9: M. flexor carpi ulnaris 10: M. flexor digitorum profundus 11: Ulna 12: M. abduktor pollicis longus 13: M. extensor carpi ulnaris 14: M. extensor digiti minimi 15: M. extensor digitorum 16: M. supinator

O r i g i n
Proximal two thirds of lateral supracondylar crest of humerus,
lateral intermuscular septum of arm

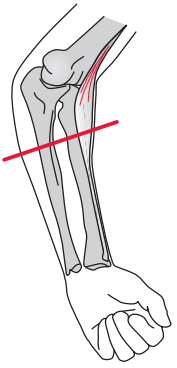
I n s e r t i o n
Styloid process of radius

I n n e r v a t i o n
N. radialis (C5-C6)

F u n c t i o n
Strong flexor of elbow, important for fast movements

C o n t r o l o f I n j e c t i o n
Palpation, Sonography

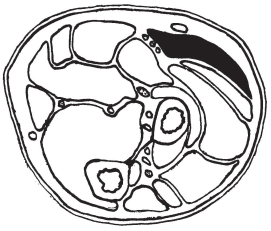
C o m m e n t
Rather small elbow flexor, 1-2 injection sites.



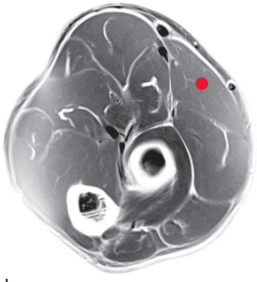
S c o u t

brachioradialis

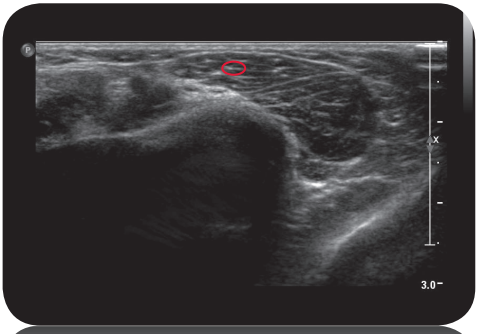
**



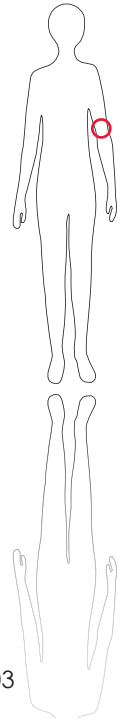
Cross Section

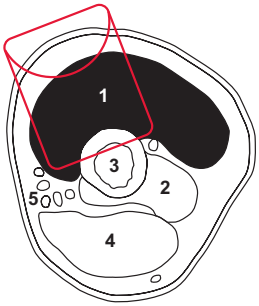


MRI



Ultrasound





Legend
1: M. triceps brachii 2: M. brachialis 3: Humerus 4: M biceps brachii 5: nerve-vessel-bundle

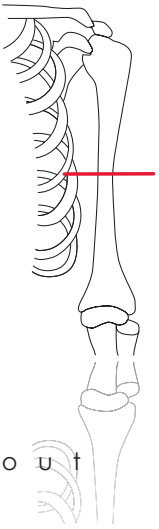
Origin
Caput longum: Tuberculum infraglenoidale scapulae
Caput laterale: Proximal half of lateral and dorsal humerus

Insertion
Olecranon and fascia antebrachii

Innervation
N. radialis (C5-T1)

Control of Injection
Sonography, palpation, EMG, electrical stimulation

Function
Extension of elbow. Long head also extends the arm at the shoulder joint.



Scout

triceps

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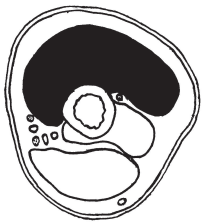
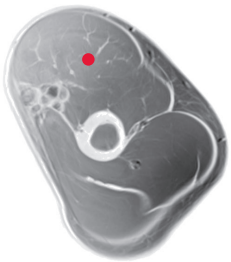
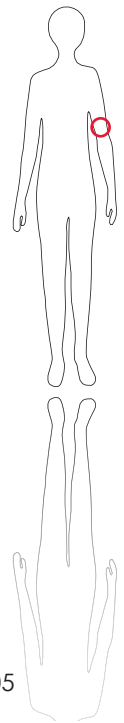


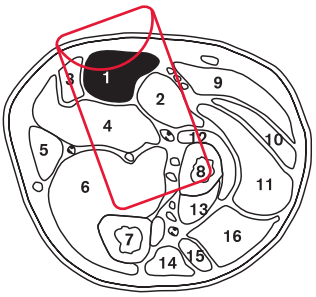
Cross Section



MRI

Ultrasound





Legend
1: M. flexor carpi radialis 2: M. pronator teres 3: M. palmaris longus 4: M. flexor digitorum superficialis 5: M. flexor carpi ulnaris 6: M. flexor digitorum profundus 7: Ulna 8: Radius 9: M. brachioradialis 10: M. extensor carpi radialis longus 11: M. extensor carpi radialis brevis 12: M. supinator 13: M. abduktor pollicis longus 14: M. extensor carpi ulnaris 15: M. extensor digiti minimi 16: M. extensor digitorum

Origin
Medial epicondyle of humerus

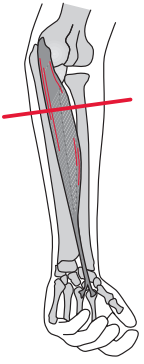
Insertion
Base of second and third metacarpal bone

Innervation
N. medianus (C6-C8)

Function
Palmar flexion of wrist joint. Weak radial abduction when wrist is extended. Strong ulnar abduction when wrist is flexed. Pronation and elbow flexion.

Control of Injection
Sonography, electrical stimulation

Comment
Very common indication; involved in most pronation and flexion deformities; 1-2 injection sites.



Scout

flexor carpi radialis

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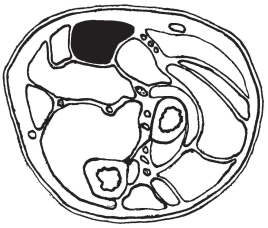
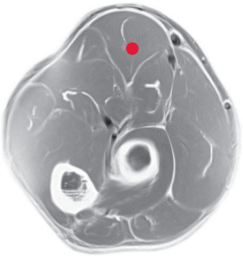
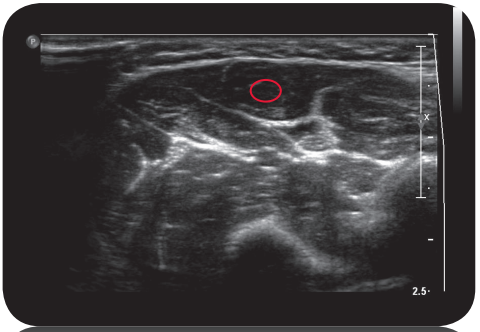


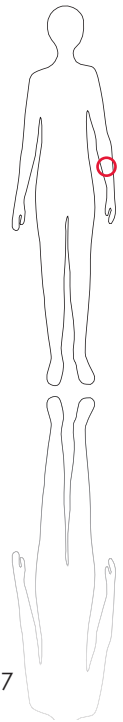
Cross Section

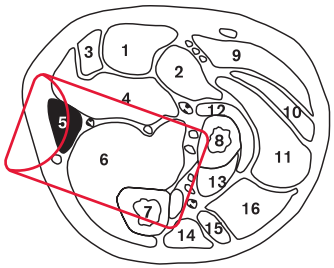


MRI



Ultrasound





Legend
1: M. flexor carpi radialis 2: M. pronator teres 3: M. palmaris longus 4: M. flexor digitorum superficialis 5: M. flexor carpi ulnaris 6: M. flexor digitorum profundus 7: Ulna 8 : Radius 9: M. brachioradialis 10: M. extensor carpi radialis longus 11: M. extensor carpi radialis brevis 12: M. supinator 13: M. abduktor pollicis longus 14: M. extensor carpi ulnaris 15: M. extensor digiti minimi 16: M. extensor digitorum

Origin
Medial epicondyle of humerus, olecranon, proximal two thirds of posterior ulna

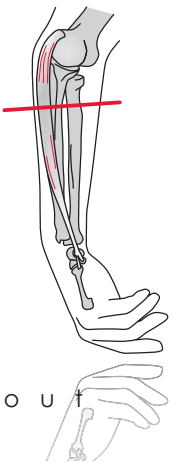
Insertion
Hamate bone, fifth metacarpal, pisiform bone

Innervation
N. ulnaris (C8-T1)

Function
Palmar flexion and ulnar abduction of the hand at the wrist joint

Control of Injection
Sonography, electrical stimulation

Comment
Do not inject too close to the elbow; insert needle at a flat angle under the skin; 1-2 injection sites.



Scout

flexor carpi ulnaris

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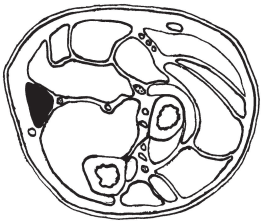
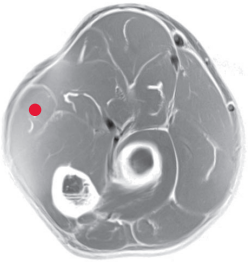
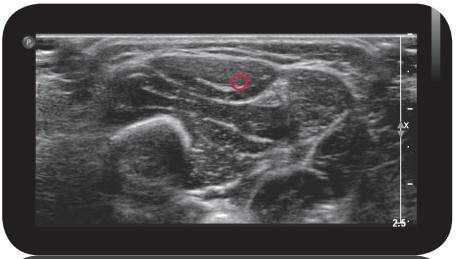


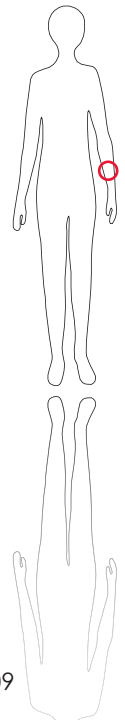
Cross Section

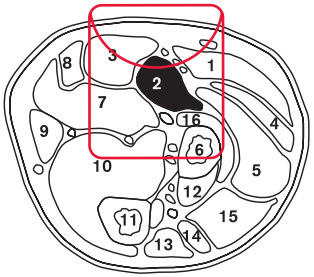


MRI



Ultrasound





Legend
1: M. brachioradialis 2: M. pronator teres 3: M. flexor carpi radialis 4: M. extensor carpi radialis longus 5: M. extensor carpi radialis brevis 6: Radius 7: M. flexor digitorum superficialis 8: M. palmaris longus 9: M. flexor carpi ulnaris 10: M. flexor digitorum profundus 11: Ulna 12: M. abduktor pollicis longus 13: M. extensor carpi ulnaris 14: M. extensor digiti minimi 15: M. extensor digitorum 16: M. supinator

Origin
Medial epicondyle of humerus, antebrachial fascia, coronoid process of ulna

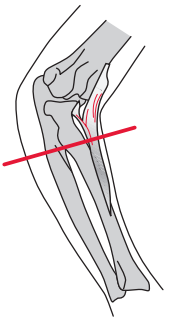
Insertion
Dorsal surface of medial one third of radius

Innervation
N. medianus (C5-C6)

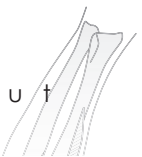
Function
Pronates lower arm, flexes elbow

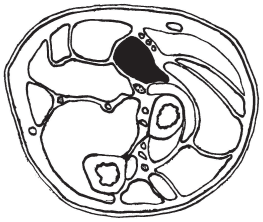
Control of Injection
Sonography, electrical stimulation

Comment
This is the most important pronator; inject together with flexor carpi radialis to treat typical pronation and flexion malpositions of the wrist joint; one to two injection sites near the elbow joint.



Scout

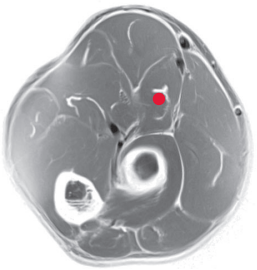




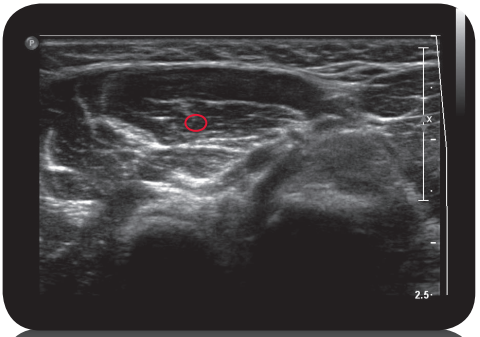
pronator teres

* * *

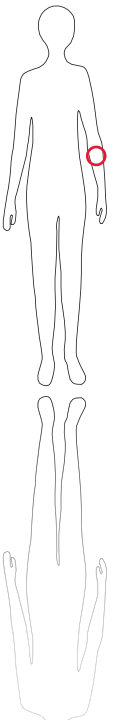
Cross Section

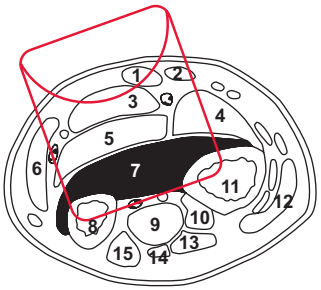


MRI



Ultrasound





Legend
1: M. palmaris longus 2: M. flexor carpi radialis 3: M. flexor digitorum superficialis 4: M. flexor pollicis longus 5: M. flexor digitorum profundus 6: M. flexor carpi ulnaris 7: M. pronator quadratus 8: Ulna 9: M. extensor indicis 10: M. extensor pollicis longus 11: Radius 12: M. extensor pollicis brevis 13: M. extensor digitorum 14: M. extensor digiti minimi 15: M. extensor carpi ulnaris

Origin
Distal palmar face of ulna

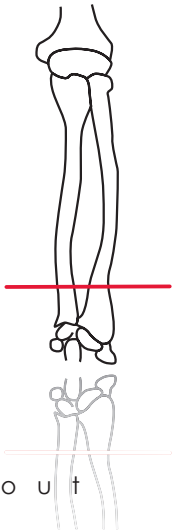
Insertion
Distal palmar face of radius

Innervation
Anterior interosseus nerve of N. medianus (C6-C8)

Function
Pronation of forearm

Control of Injection
Sonography, electrical stimulation

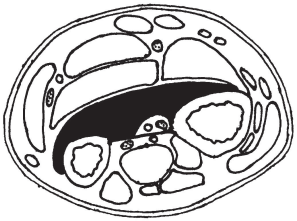
Comment
To be injected in addition to pronator teres when severe pronation is observed. Easily identified by sonographic guidance due to radioulnar fiber orientation in the transversal plane.



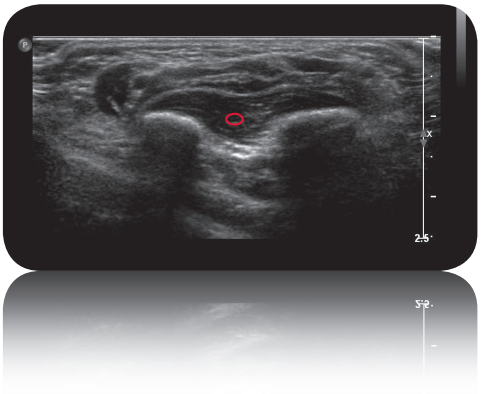
Scout

pronator quadratus

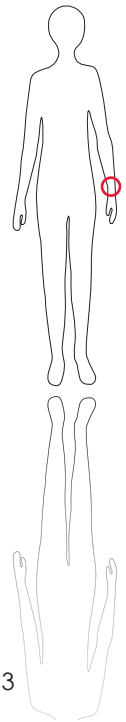
*

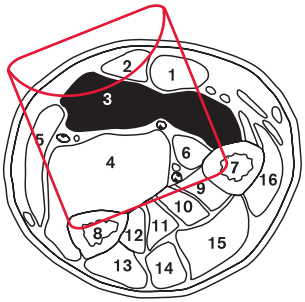


Cross Section



Ultrasound





Legend
1: M. flexor carpi radialis 2: M. palmaris longus 3: M. flexor digitorum superficialis 4: M. flexor digitorum profundus 5: M. flexor carpi ulnaris 6: M. flexor pollicis longus 7: Radius 8: Ulna 9: M. abduktor pollicis longus 10: M. extensor pollicis brevis 11: M. extensor pollicis longus 12: M. extensor indicis 13: M. extensor carpi ulnaris 14: M. extensor digiti minimi 15: M. extensor digitorum 16: M. extensor carpi radialis brevis

Origin
Medial epicondyle of humerus to palmar surface of radius

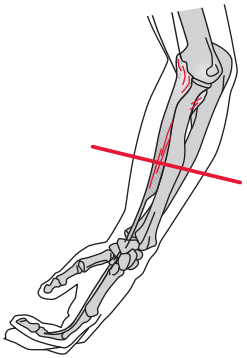
Insertion
Lateral margin of middle phalanges of the four fingers

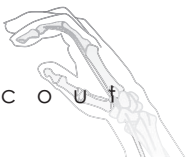
Innervation
N. medianus (C7-T1)

Function
Flexes middle phalanges of the four fingers and flexes wrist joint

Control of Injection
Sonography, electrical stimulation.

Comment
Very common indication; use 2-4 injection sites, one per fascicle. Control of injection with above methods helps to identify individual fascicles: the medial and deep-seated fascicles are those for the second and third finger, the lateral and superficially seated are for the fourth and fifth finger.





Scout

flexor digitorum superficialis

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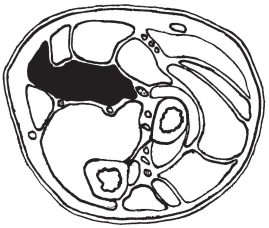
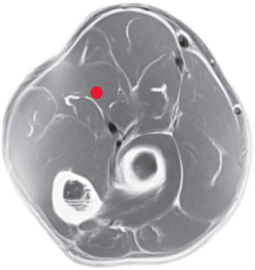
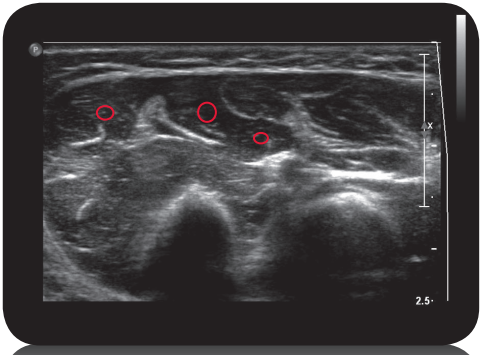


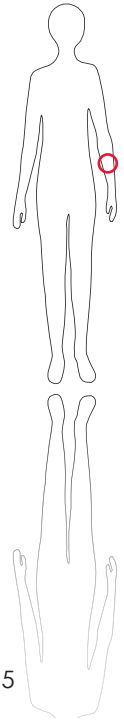
Cross Section

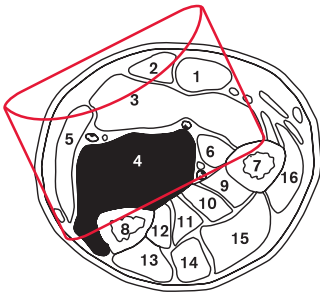


MRI



Ultrasound





Legend
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Origin
Proximal three quarters of palmar surface and medial area of ulna, interosseous membrane, antebrachial fascia

Insertion
Base of second to fifth distal phalanges

Innervation
N. medianus, N. ulnaris (C7-T1)

Function
Flexes all joints of second to fifth fingers, palmar flexion of wrist joint

Control of Injection
Sonography, electrical stimulation

Comment
Inject from the volar (i.e. flexor) side of the proximal ulna. With the help of above control techniques it is possible to differentiate between fascicles for second and third fingers and between fascicles for fourth and fifth fingers. 2-4 injection sites, one per fascicle.

Scout

flexor digitorum profundus

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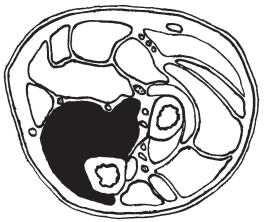
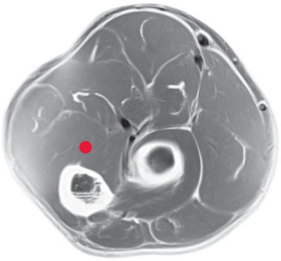
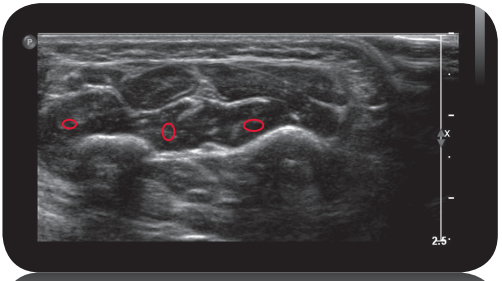


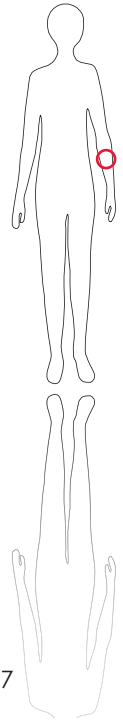
Cross Section

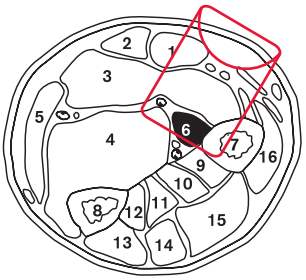


MRI



Ultrasound





Legend
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Origin
Anterior surface of radius, interosseous membrane

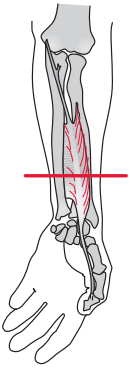
Insertion
Palmar base of distal phalanx of thumb

Innervation
N. medianus (C7-T1)

Function
Flexes thumb, supports flexion of wrist joint

Control of Injection
Sonography, electrical stimulation

Comment
Active or passive flexion of the thumb identifies the muscle involved. One to two injection sites.



Scout

flexor pollicis longus

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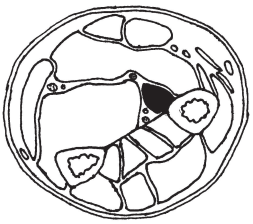
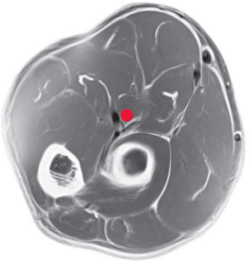
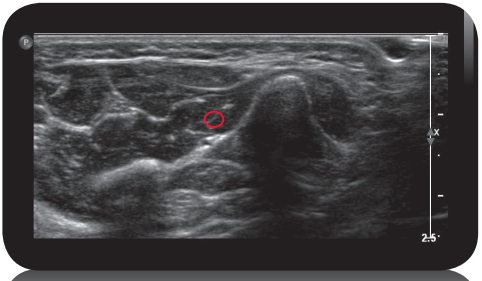


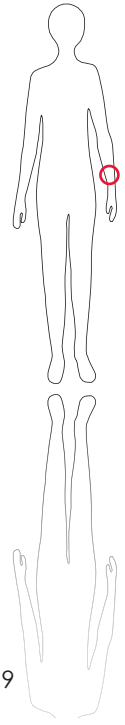
Cross Section



MRI



Ultrasound



Origin
Retinaculum flexorum, Os trapezium, Os trapezoideum, Os capitatum

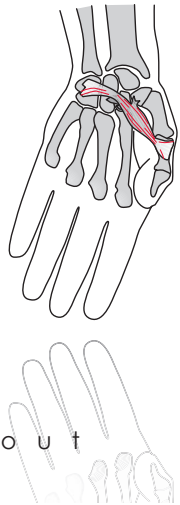
Insertion
base of proximal phalanx of thumb

Innervation
Recurrent branch of median nerve (C8,T1)

Function
flexes the thumb at the first metacarpophalangeal joint

Control of Injection
sonography, electrical stimulation

Comment
Inject this muscle when you see inadequate flexion in the first metacarpophalangeal joint, as e.g. in thumb-in-palm deformity. Frequent indication for better hygienic care and improved grasping movements.



Scout

flexor pollicis brevis

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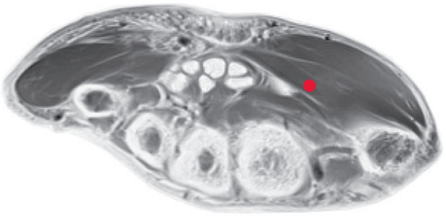
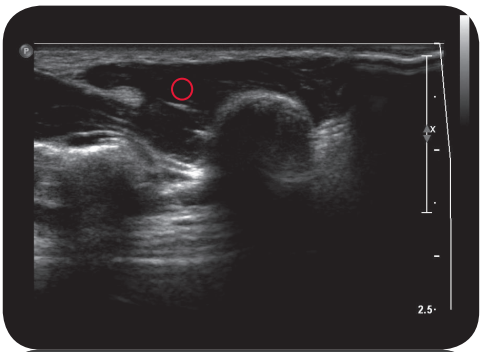
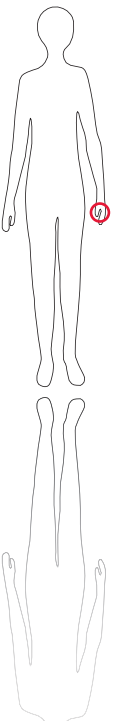
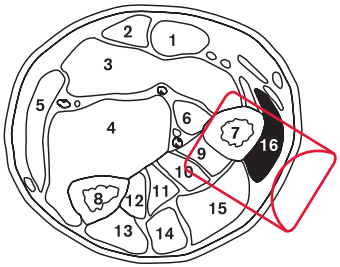


M R I



U l t r a s o u n d





Legend
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Origin
Lateral margin of humerus, lateral epicondyle of humerus, annular ligament of radius

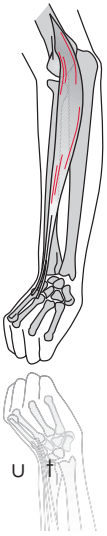
Insertion
Base of second and third metacarpal bone

Innervation
N. radialis (C6-C7)

Function
Dorsiflexion and radial abduction of wrist joint; minor involvement in flexion of elbow joint

Control of Injection
Stimulation, EMG or sonography

Comment
Forms muscle depression on the extensor side of the lower arm together with extensor digitorum communis. 1-2 injection sites. Treatment of radiohumeral epicondylitis (tennis elbow) to ease myofascial pain.



Scout

extensor carpi radialis

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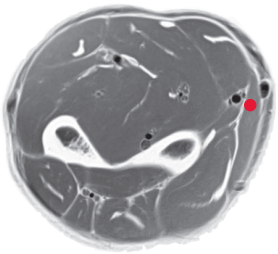
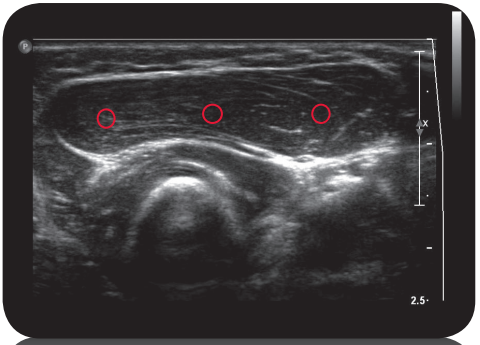
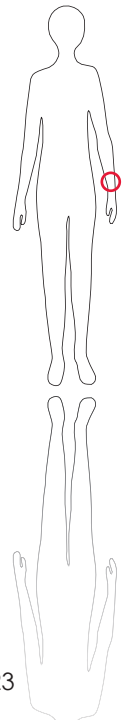
Cross Section

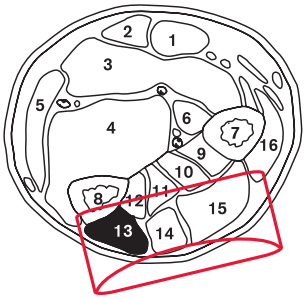


MRI



Ultrasound





Legend
1: M. flexor carpi radialis 2: M. palmaris longus 3: M. flexor digitorum superficialis 4: M. flexor digitorum profundus 5: M. flexor carpi ulnaris 6: M. flexor pollicis longus 7: Radius 8: Ulna 9: M. abduktor pollicis longus 10: M. extensor pollicis brevis 11: M. extensor carpi pollicis longus 12: M. extensor indicis 13: M. extensor carpi ulnaris 14: M. extensor digiti minimi 15: M. extensor digitorum 16: M. extensor carpi radialis brevis

Origin
Medial epicondyle of humerus

Insertion
Base of second and third metacarpal bone

Innervation
N. medianus (C6-C8)

Function
Palmar extension and ulnar abduction of wrist joint.

Control of Injection
Sonography, electrical stimulation

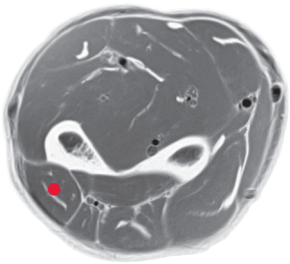
Comment
Rare indication. Can be involved in extension deformities, 1-2 injection sites.

Scout

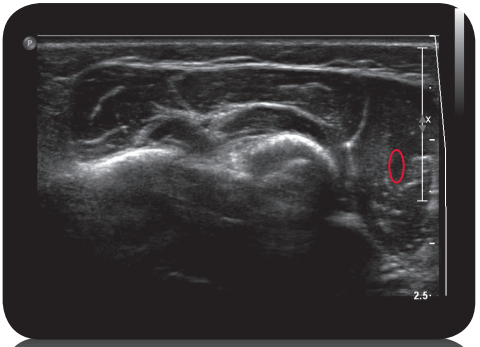
extensor carpi ulnaris

*

Cross Section



MRI



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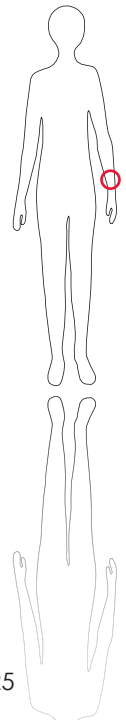

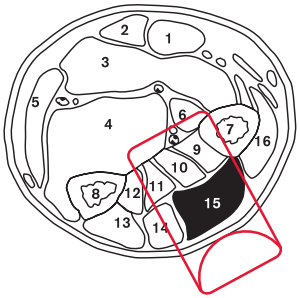

Legend
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Origin
Lateral epicondyle of humerus

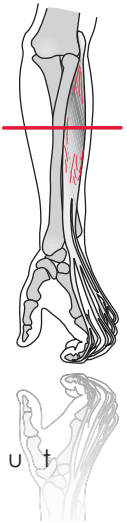
Insertion
Dorsiaponeurosis of second to fifth fingers

Innervation
N. profundus division of radial nerve (C6-C7)

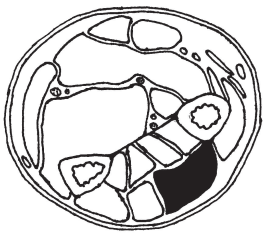
Function
Together with lumbrical and interosseous muscles, the extensor digitorum flexes metacarpophalangeal joints and extends middle and distal phalanges

Control of Injection
Sonography, electrical stimulation

Comment
Forms muscle depression together with extensor carpi radialis; 1-4 injection sites; fascicles should be differentiated using any of the suggested methods for injection control. Fascicles of the third and fourth fingers tend to respond with prolonged paresis; use low doses.



Scout



extensor digitorum communis

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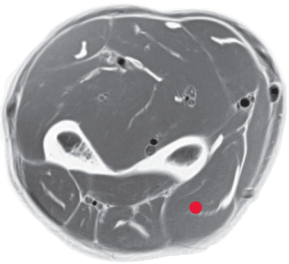
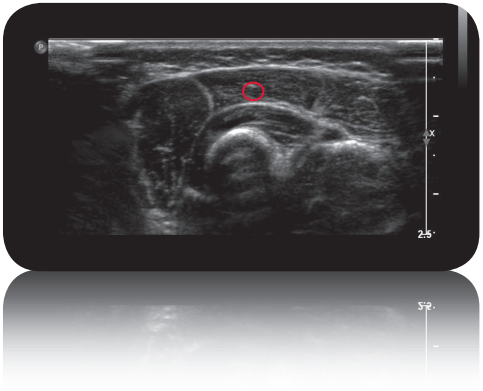
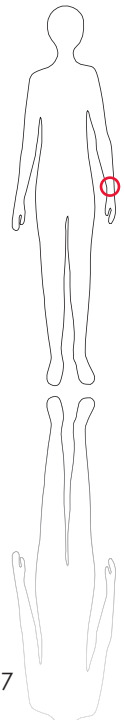
Cross Section



MRI



Ultrasound



Origin
Tendons of flexor digitorum profundus

Insertion
Dorsal aponeuroses of the four fingers

Innervation
Deep branch of ulnar nerve, median nerve

Function
Extend distal and middle phalanges, flex metacarpophalangeal joints of the four fingers

Control of Injection
Palpation is sufficient. Inject from dorsally.

Comment
One injection site per interosseus space.

lumbricales

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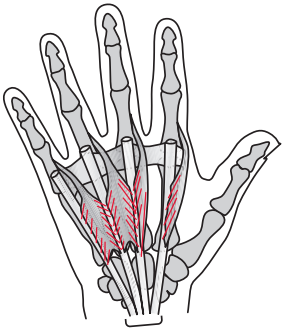
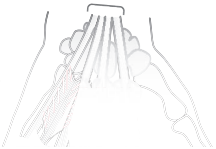
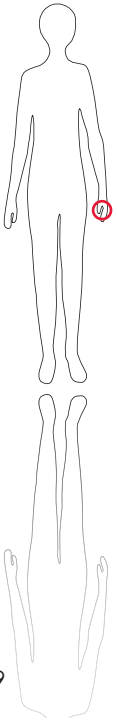
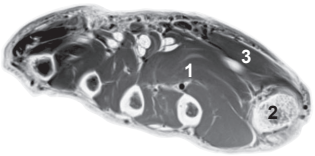
M R I





S c o u t





Legend
1: M. adductor pollicis 2: proximal phalanx of thumb 3: M. opponens pollicis

Origin
Capitate and second and third metacarpal bones

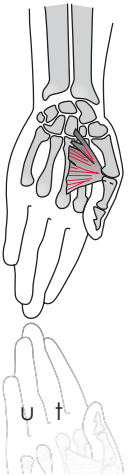
Insertion
Base of proximal phalanx of thumb

Innervation
Deep branch of ulnar nerve

Function
Adducts thumb

Control of Injection
Sonography, electrical stimulation

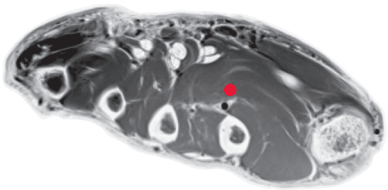
Comment
Important muscle for thumb-in-palm deformity. Using sonography, you can inject the muscle from dorsally which is less painful!



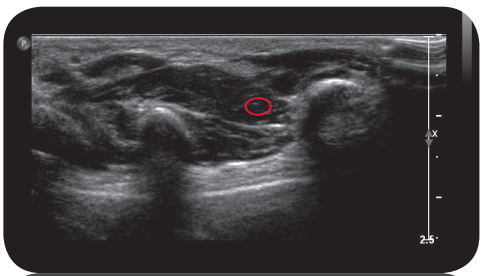
Scout

adductor pollicis

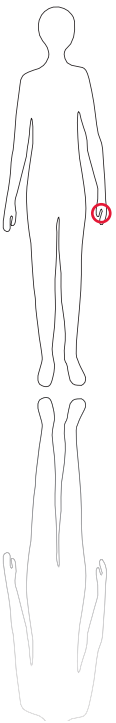
**

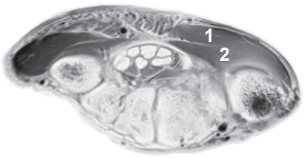


M R I



U l t r a s o u n d





Legend
1: M. opponens pollicis
2: M. flexor pollicis brevis

Origin
Flexor retinaculum, tubercle of trapezium

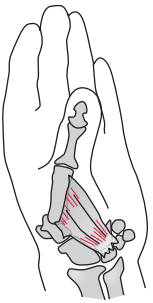
Insertion
Radial side of first metacarpal bone

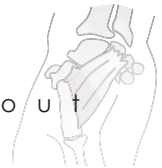
Innervation
Median nerve

Function
Opposes carpometacarpal joint (flexion, abduction and slight rotation)

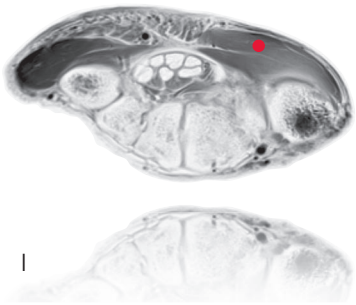
Control of Injection
Palpation, sonography

Comment
1 injection site

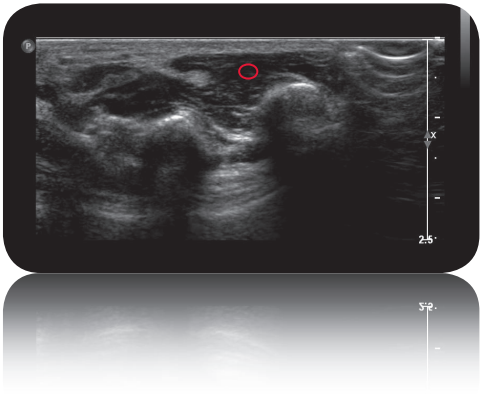




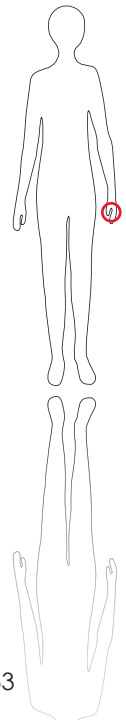
opponens pollicis

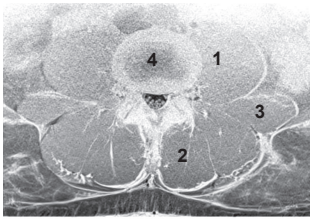


M R I



U l t r a s o u n d





L e g e n d
1: M. iliopsoas 2: M. erector spinae 3: M. quadratus lumborum 4: Intervertebral disc L3-L4

O r i g i n
Corpora and transverse processes of first to fifth lumbar vertebrae

I n s e r t i o n
Trochanter minor femoris

I n n e r v a t i o n
Plexus lumbalis (L1-L4)

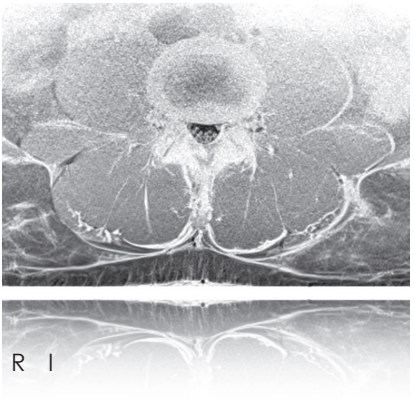
F u n c t i o n
Flexion, abduction and external rotation of hip joint

Control of Injection
Sonography or other imaging techniques (CT, MRI)

C o m m e n t
In patients with increased lumbolordosis, this is the leading muscle in hip flexion. Use 1-3 three injection sites with dorsal access.

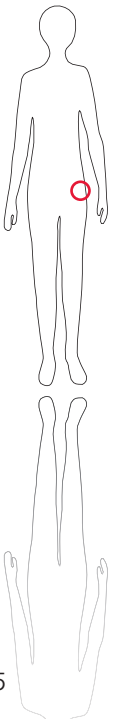
iliopsoas - m. psoas

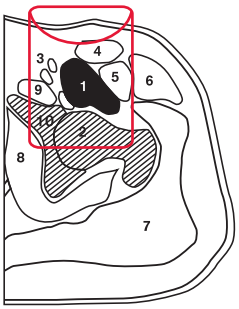
**



M R I

S c o u t





L e g e n d
1: M. iliopsoas 2: Caput femoris 3: A./V./N. femoris 4: M. sartorius 5: M. rectus femoris 6: M. tensor fascia latae 7: M. gluteus medius et maximus 8: M. obturatorius internus 9: M. pectineus 10: Fossa acetabuli

O r i g i n
Fossa iliaca; base of sacrum

I n s e r t i o n
Trochanter minor femoris

I n n e r v a t i o n
Plexus lumbalis (L1-L4)

F u n c t i o n
Flexion, abduction and external rotation of hip joint

C o n t r o l o f I n j e c t i o n
Sonography, EMG

C o m m e n t
Ventral access from below the inguinal ligament; 1-2 injection sites.

iliopsoas - m. iliacus

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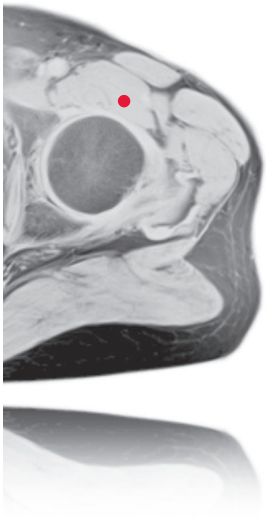
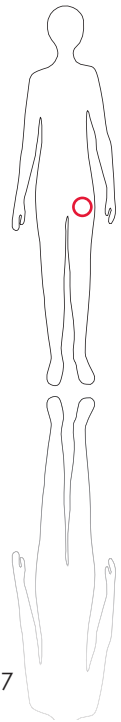
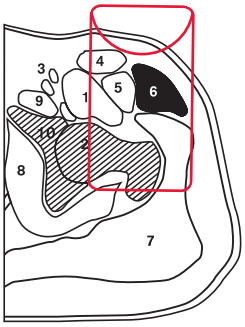


M R I

U l t r a s o u n d





Legend
1: M. iliopsoas 2: Caput femoris 3: A./V./N. femoris 4: M. sartorius 5: M. rectus femoris 6: M. tensor fascia latae 7: M. gluteus medius et maximus 8: M. obturatorius internus 9: M. pectineus 10: Fossa acetabuli

Origin
iliac crest

Insertion
iliotibial tract

Innervation
N. glutealis sup. (L4-L5)

Function
flexes and medially rotates thigh, important for trunk stabilization

Control of Injection
Sonography, EMG

Comment
Can significantly contribute to thigh flexion, e.g. in windswept hip deformity

tensor fasciae latae

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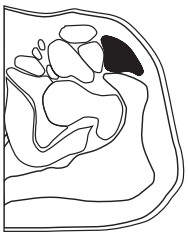
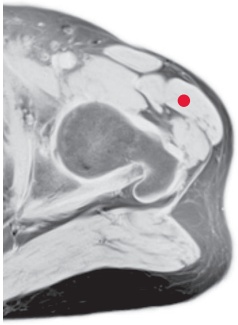
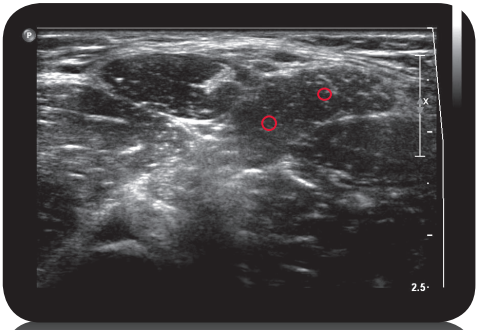


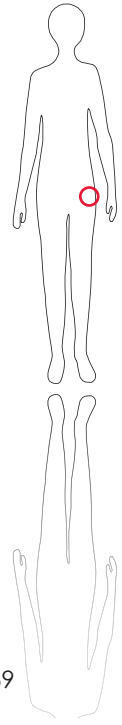
Cross Section

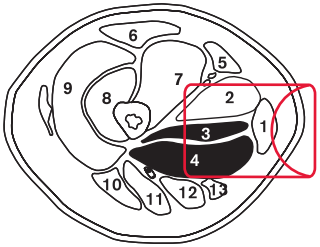


MRI



Ultrasound





Legend
1: M. gracilis 2: M. adductor longus 3: M. adductor brevis 4: M. adductor magnus 5: M. sartorius 6: M. rectus femoris 7: M. vastus medialis 8: M. vastus intermedius 9: M. vastus lateralis 10: caput brevis 11: caput longum des M. biceps femoris 12: M. semitendinosus 13: M. semimembranosus

Origin
Ramus ossis ischii and Tuber ischiadicum

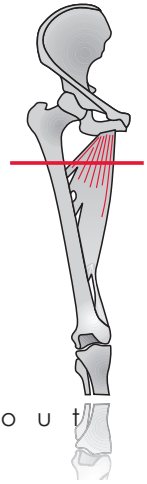
Insertion
Proximal linea aspera, epicondylus medialis femoris

Innervation
Posterior branch of obturator nerve

Function
Adduction and extension of hip, lateral rotation (proximal portion), medial rotation (distal portion)

Control of Injection
Sonography, EMG, electrical stimulation

Comment
Of all adductors, the adductor magnus is the strongest one. In addition, it stabilizes the hip during extension. The adductor brevis is decidedly smaller and less forceful and can be considered subsidiary. Adductor magnus and brevis can not be differentiated with ultrasound.



Scout

adductor magnus et brevis

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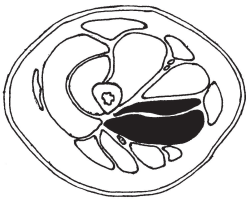
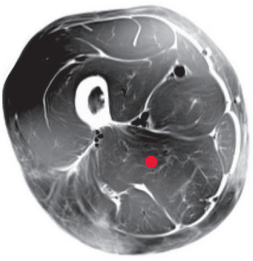
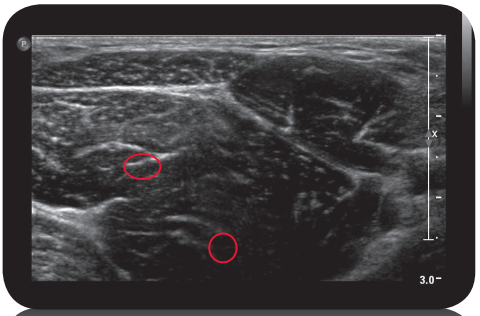


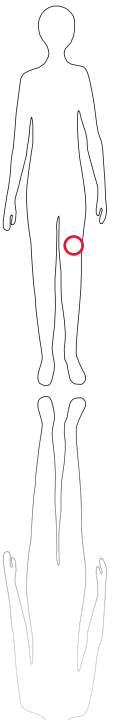
Cross Section

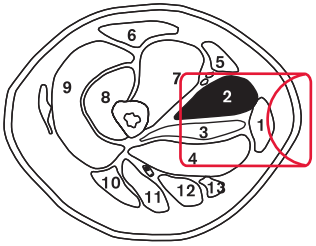


MRI



Ultrasound





Legend
1: M. gracilis 2: M. adductor longus 3: M. adductor brevis 4: M. adductor magnus 5: M. sartorius 6: M. rectus femoris 7: M. vastus medialis 8: M. vastus intermedius 9: M. vastus lateralis 10: caput brevis 11: caput longum des M. biceps femoris 12: M. semitendinosus 13: M. semimembranosus

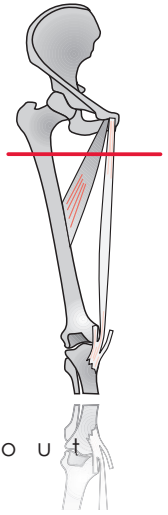
Origin
Ramus superior ossis pubis

Insertion
Medial third of linea aspera

Function
Function Adduction and flexion of hip

Control of Injection
Sonography, EMG, electrical stimulation, palpation

Comment
Relevant muscle for clinically significant adductor spasticity. Quite often treatment of this muscle is sufficient. Always consider to co-treat gracilis muscle.



Scout

adductor longus

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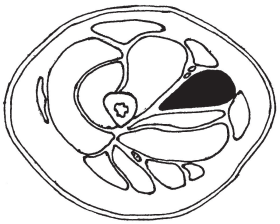
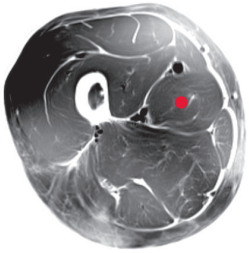
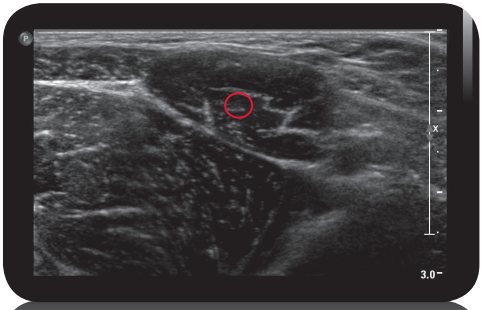


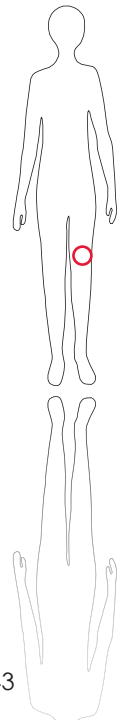
Cross Section

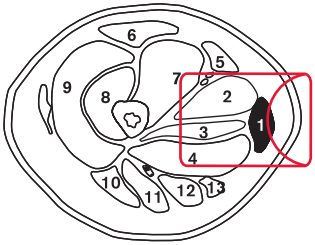


MRI



Ultrasound





Legend
1: M. gracilis 2: M. adductor longus 3: M. adductor brevis 4: M. adductor magnus 5: M. sartorius 6: M. rectus femoris 7: M. vastus medialis 8: M. vastus intermedius 9: M. vastus lateralis 10: caput brevis 11: caput longum des M. biceps femoris 12: M. semitendinosus 13: M. semimembranosus

Origin
Ramus inferior ossis pubis and Symphysis pubica

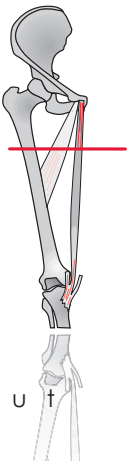
Insertion
Condylus medialis tibiae, Pes anserinus

Innervation
anterior branch of N. obturatorius

Function
Adduction and flexion of the thigh at the hip joint. Flexion and inward rotation of the leg at the knee

Control of Injection
Sonography, electrical stimulation, EMG

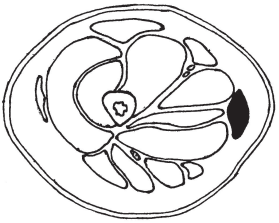
Comment
The gracilis comes into action as an adductor muscle when the knee is extended. It then also contributes significantly to knee flexion. This makes him an important candidate for treatment in standing and walking patients with adductor spasticity. It is less important for the improvement of hygienic care.



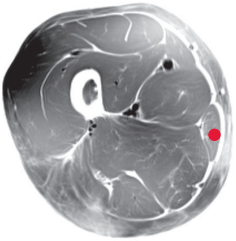
Scout

gracilis

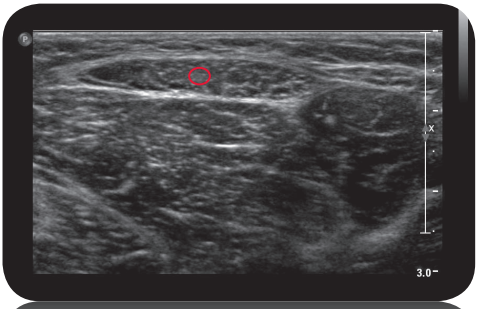
* * *



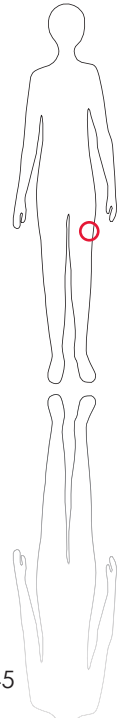
Cross Section

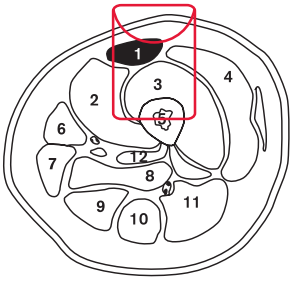


MRI



Ultrasound





L e g e n d
1: M. rectus femoris 2: M. vastus medialis 3: M. vastus intermedius 4: M. vastus lateralis 5: Femur 6: M. sartorius 7: M. gracilis 8: M. adductor magnus 9: M. semimembranosus 10: M. semitendinosus 11: M. biceps femoris 12: M. adductor longus

O r i g i n
Anterior inferior iliac spine, supra-acetabular sulcus (upper rim of acetabulum)

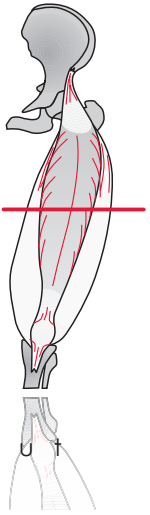
I n s e r t i o n
Patellar ligament, tuberosity of tibia

I n n e r v a t i o n
N. femoralis (L2-L4)

F u n c t i o n
Hip flexion, knee extension

C o n t r o l o f I n j e c t i o n
Sonography, electrical stimulation, EMG

C o m m e n t
Often involved in hip flexion and knee extension spasticity; use 2-4 injection sites along the muscle.



S c o u t

rectus femoris

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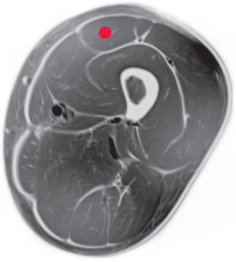
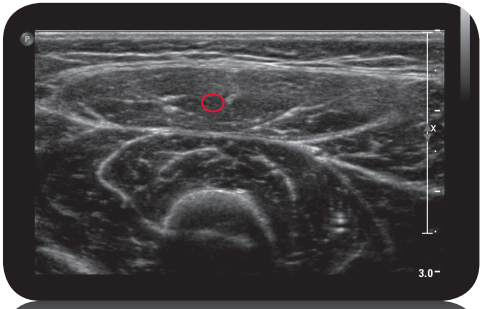
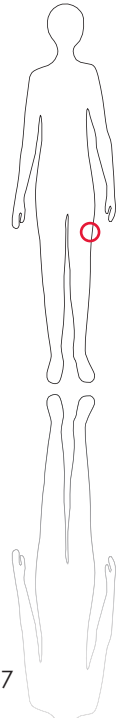
Cross Section

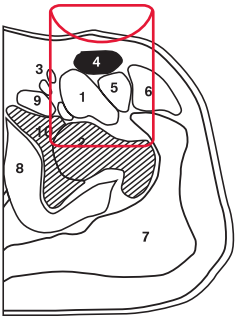


MRI



Ultrasound





Legend
1: M. iliopsoas 2: Caput femoris 3: A./V./N. femoris 4: M. sartorius 5: M. rectus femoris 6: M. tensor fascia latae 7: M. gluteus medius et maximus 8: M. obturatorius internus 9: M. pectineus 10: Fossa acetabuli

Origin
Spina iliaca anterior superior

Insertion
Condylus medialis tibiae, pes anserinus

Innervation
N. femoralis (L2-L4)

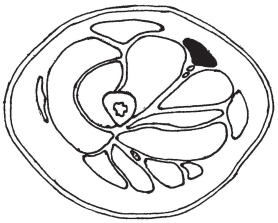
Function
Flexion, lateral rotation and abduction of the thigh at the hip joint. Flexion and medial rotation of the leg at the knee joint.

Control of Injection
Sonography, electrical stimulation, EMG

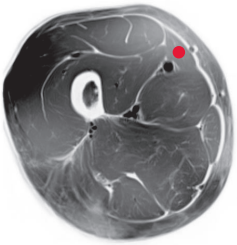
Comment
Rare target for intervention. Control muscle bulk with sonography before injection. 1-2 injection sites.

sartorius

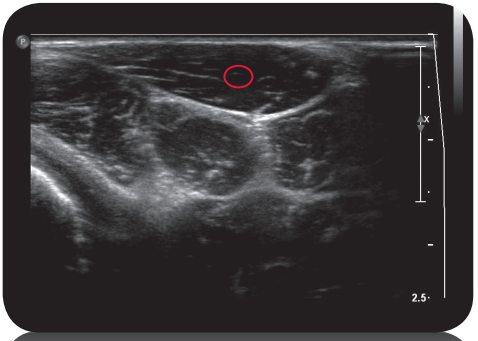
*



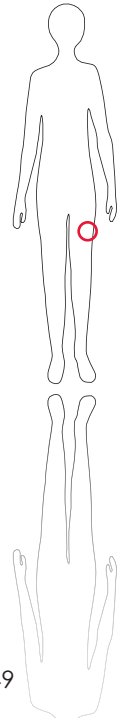
Cross Section

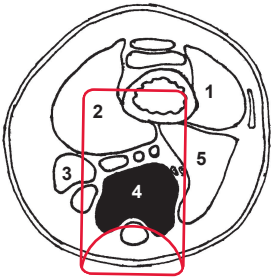


MRI



Ultrasound





Legend
1: M. vastus lateralis 2: M. vastus medialis 3: M. gracilis 4: M. semimembranosus 5: M. biceps femoris

Origin
Tuber ischiadicum ossis ischii

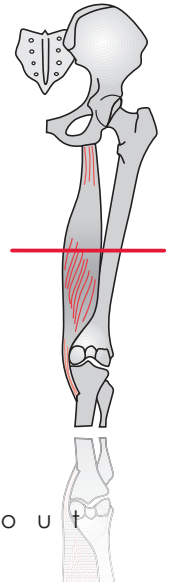
Insertion
Condylus medialis tibiae

Function
Extension and Adduction of the thigh at the hip joint. Flexion and medial rotation of the leg at the knee joint.

Innervation
N. ischiadicus (L5-S2)

Control of Injection
Sonography, electrical stimulation, EMG

Comment
Relevant for knee flexion spasticity, biggest muscle bulk in the lower part of the thigh.

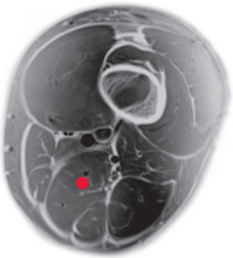


Scout

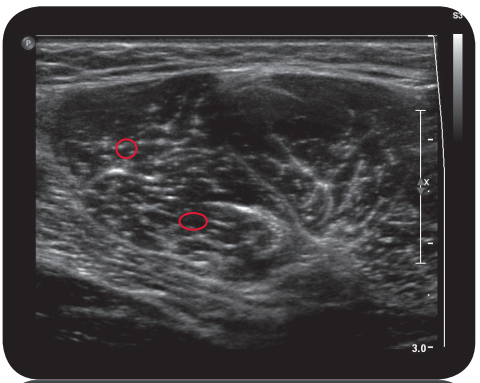
semimembranosus

**

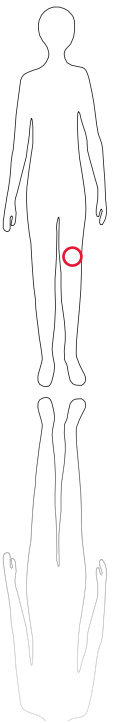
Cross Section

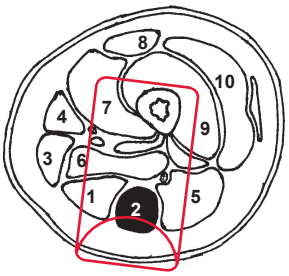


MRI



Ultrasound





L e g e n d
1: M. semimembranosus 2: M. semitendinosus 3: M. gracilis 4: M. sartorius 5: M. biceps femoris 6: M. adductor magnus 7: M. vastus medialis 8: M. rectus femoris 9: M. vastus intermedius 10: M. vastus lateralis

O r i g i n
Tuber ischiadicum ossis ischii

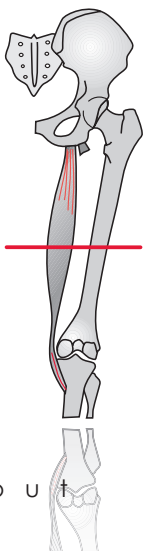
I n s e r t i o n
Condylus medialis tibiae

F u n c t i o n
Extension and Adduction of the thigh at the hip joint. Flexion and medial rotation of the leg at the knee joint.

I n n e r v a t i o n
N. ischiadicus (L5-S2)

Control of Injection
Sonography, electrical stimulation, EMG

C o m m e n t
Relevant muscle for knee flexion spasticity. Inject at the middle to upper third of the thigh where the semitendinosus
has its largest bulk.



S c o u t

semitendinosus

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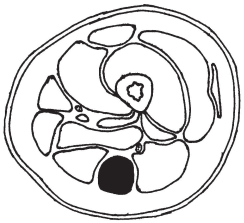
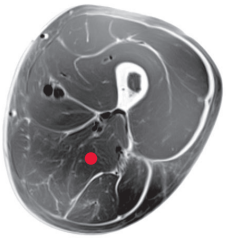
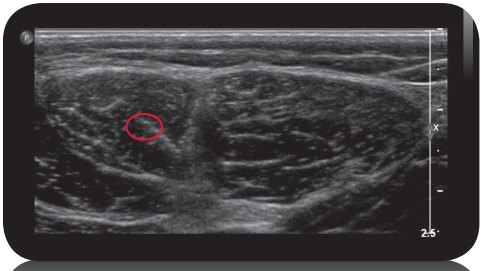


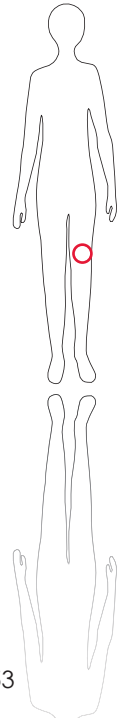
Cross Section

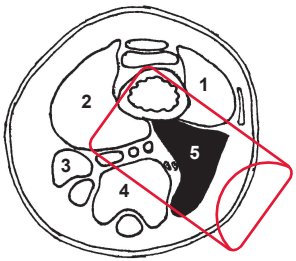


MRI



Ultrasound





Legend
1: M. vastus lateralis 2: M. vastus medialis 3: M. gracilis 4: M. semimembranosus 5: M. biceps femoris

Origin
Tuber ischiadicum ossis ischii (long head) and middle third of linea aspera (short head)

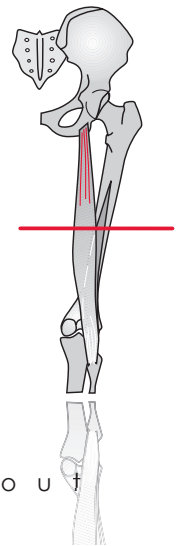
Insertion
Caput fibulae, Condylus lateralis tibiae

Innervation
long head: N. ischiadicus (tibial portion) short head: N. ischiadicus (peroneal portion) L5-S2

Function
Extension and lateral rotation of the thigh at the hip joint. Flexion and lateral rotation of the leg at the knee joint.

Control of Injection
Sonography, electrical stimulation, EMG

Comment
Not as important for knee flexion spasticity as the medial hamstrings due to its important contribution to lateral rotation of the leg at the knee.



Scout

biceps femoris

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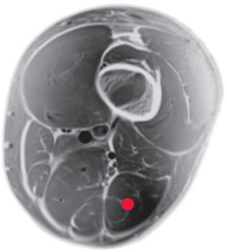
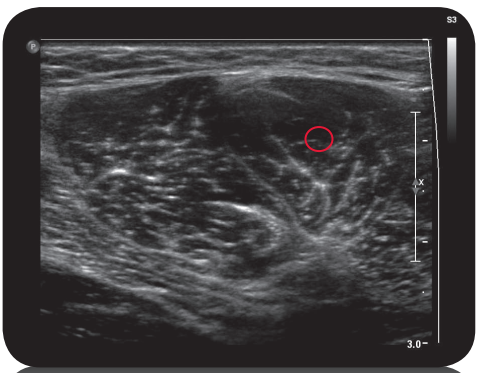
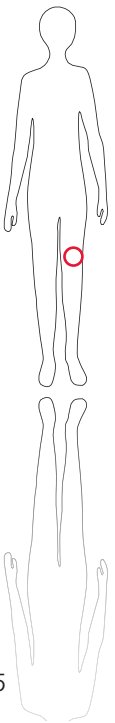
Cross Section

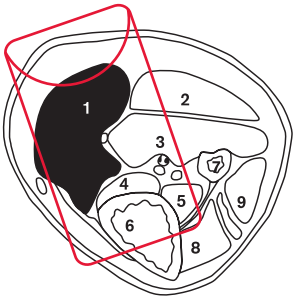


MRI



Ultrasound





Legend
1. medial head 2. lateral head 3: M. soleus 4: M: flexor digitorum longus 5: M. tibialis posterior 6: Tibia 7: Fibula 8: M: tibialis anterior 9: M. peronaeus longus et brevis

Origin
Epicondylus medialis femoris

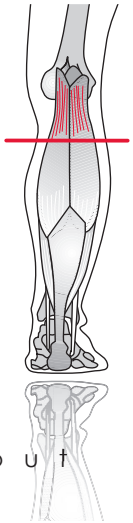
Insertion
Tuber calcanei by tendon calcaneus (Achilles tendon)

Innervation
N. ischiadicus, tibial portion (L5-S1)

Function
Flexion of the foot at the upper ankle joint, flexion of the leg at the knee

Control of Injection
Sonography, electrical stimulation

Comment
Phasically innervated, biarticular muscle. Most important for pes equinus in children with bilateral CP. The medial head is far more forceful that the lateral head.



Scout

gastrocnemius, medial head

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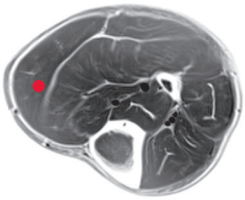
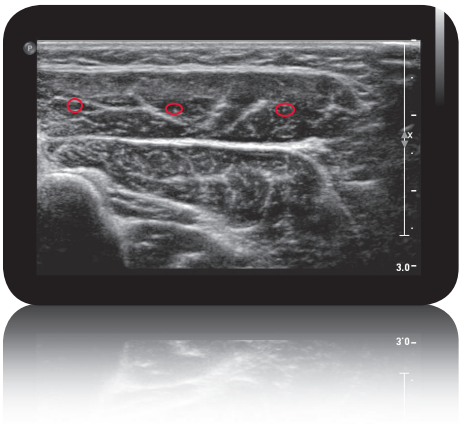
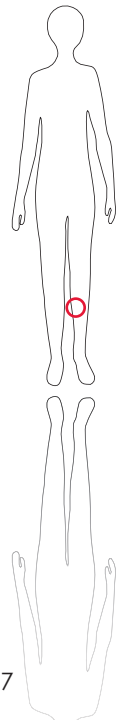
Cross Section

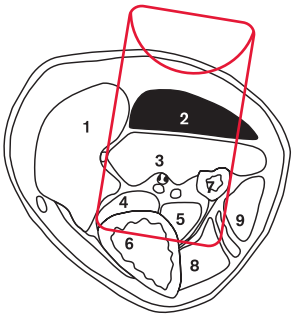


MRI



Ultrasound





Legend
1. medial head 2. lateral head 3: M. soleus 4: M. flexor digitorum longus 5: M. tibialis posterior 6: Tibia 7: Fibula 8: M. tibialis anterior 9: M. peronaeus longus et brevis

Origin
Epicondylus medialis femoris

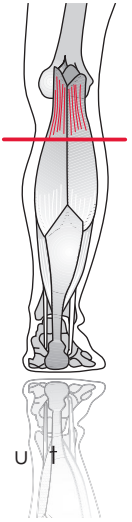
Insertion
Tuber calcanei by tendon calcaneus (Achilles tendon)

Innervation
N. tibialis (L5-S1)

Function
Flexion of the foot at the upper ankle joint, flexion of the leg at the knee

Control of Injection
Sonography, electrical stimulation.

Comment
Usually of only slight bulk and very small diameter, this muscle is seated in the middle of the lower leg. CAUTION: If inserted too deeply, the needle may pass through and beyond the muscle. It is not necessary to inject this muscle when treating pes equinovarus.
Use 1-2 injection sites.



Scout

gastrocnemius, lateral head

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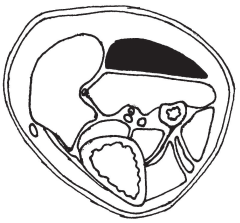
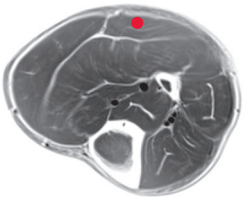
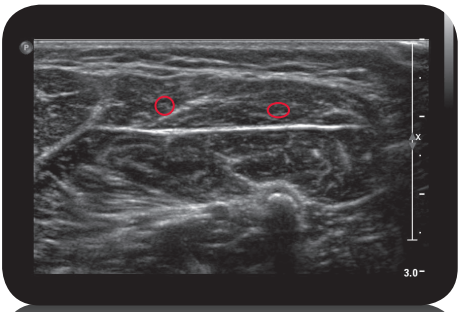


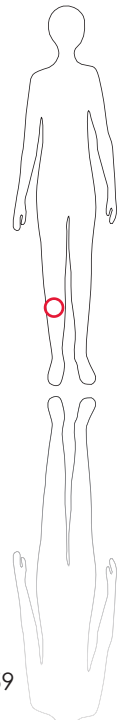
Cross Section

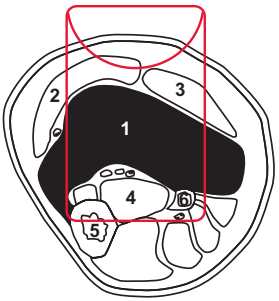


MRI



Ultrasound





L e g e n d
1: M. soleus 2: M. gastrocnemius medialis 3: M. gastrocnemius lateralis 4: M. tibialis posterior 5: Tibia 6: Fibula

O r i g i n
Dorsal surface of head of fibula, proximal third of fibula, tendinous arch of soleus, medial third of dorsal surface of tibia

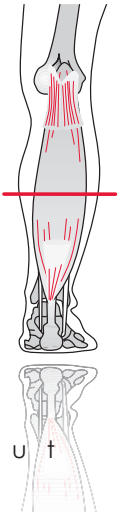
I n s e r t i o n
Tuber calcanei by tendon calcaneus (Achilles tendon)

I n n e r v a t i o n
N. tibialis (L5-S1)

F u n c t i o n
Flexion of the foot at the ankle joint

Control of Injection
Sonography, electrical stimulation

C o m m e n t
Tonically-innervated, mono-articular muscle. One to three injection sites



S c o u t

soleus

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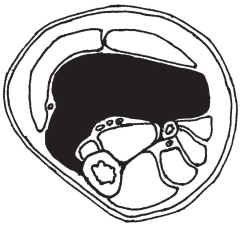
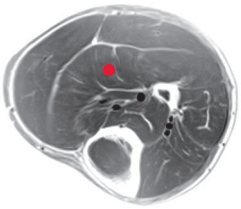
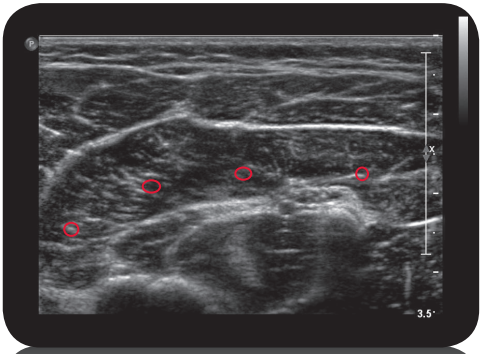


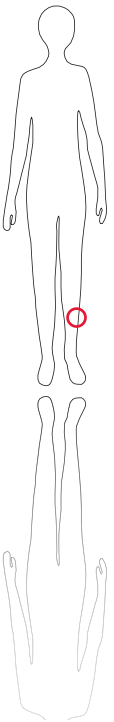
Cross Section

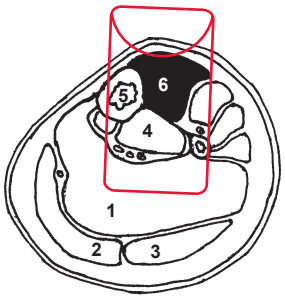


MRI



Ultrasound





Legend
1: M. soleus 2: M. gastrocnemius medialis 3: M. gastrocnemius lateralis 4: M. tibialis posterior 5: Tibia 6: M. tibialis anterior

Origin
Lateral condyle and lateral shaft of tibia, interosseous membrane, crural fascia

Insertion
Medial cuneiform bone (medial and plantar surface)

Innervation
N. peroneus profundus (L4-S1)

Function
Lifts medial side of foot; dorsiflexes ankle joint; supination of subtalar joint prepares initial heal contact during swing- to stance-phase transition

Control of Injection
Sonography, electrical stimulation

Comment
Too high doses may cause weakening of dorsiflexion and deterioration of gait. 1-2 injection sites.

tibialis anterior

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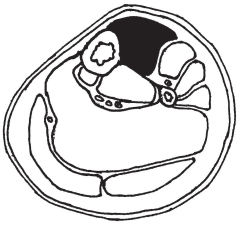
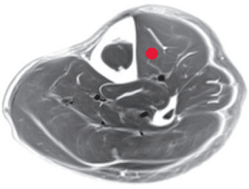
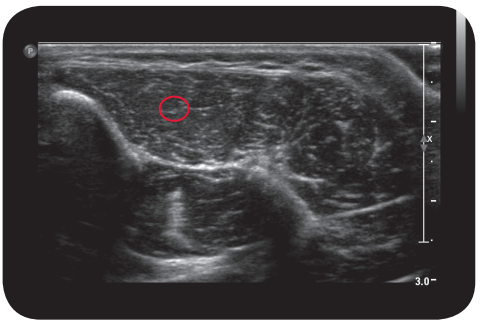


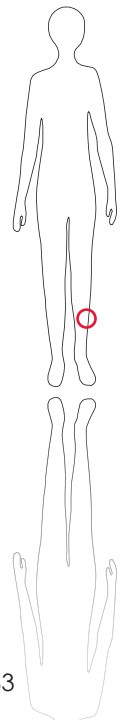
Cross Section

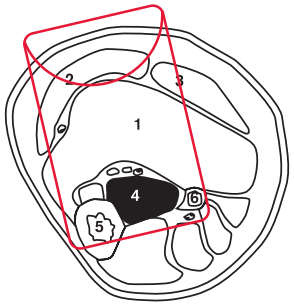


MRI



Ultrasound





Legend
1: M. soleus 2: M. gastrocnemius medialis 3: M. gastrocnemius lateralis 4: M. tibialis posterior 5: Tibia 6: Fibula

Origin
Interosseous membrane; dorsolateral surface of tibia; proximal two thirds of dorsomedial surface of fibula

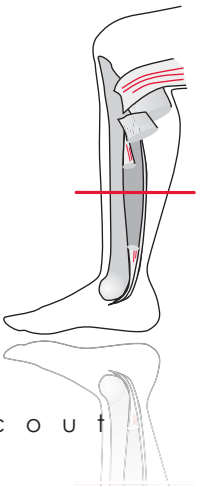
Insertion
Tuberositas os naviculare; Ossa cuneiformia; Base of os metatarsalia 2-4

Innervation
N. tibialis (L5-S1)

Function
Plantar flexion of ankle joint; supination of subtalar joint; tensor for arch of foot; push-off during transition from stance to swing phase

Control of Injection
Sonography, electrical stimulation

Comment
Leading muscle in equinovarus posture. Feathered muscle with largest muscle bulk proximally in between tibia and fibula. Can be reached in children through M. soleus, in larger patients through M. tibialis anterior with sonography guidance.
2-3 injection sites.



Scout

tibialis posterior

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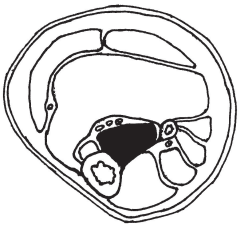
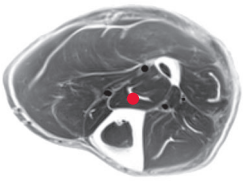
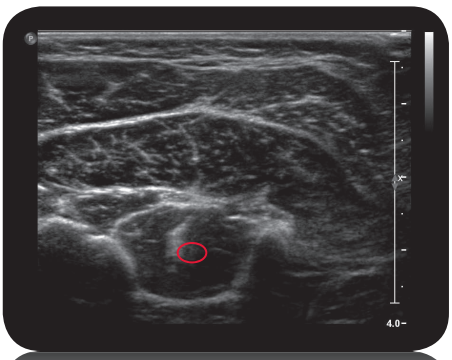


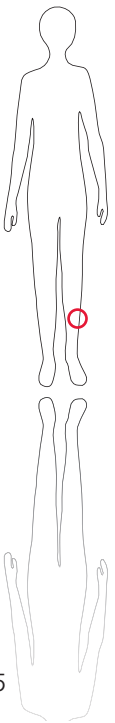
Cross Section

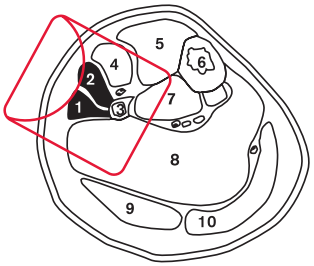


MRI



Ultrasound





O r i g i n
Caput fibulae and lateral fibula

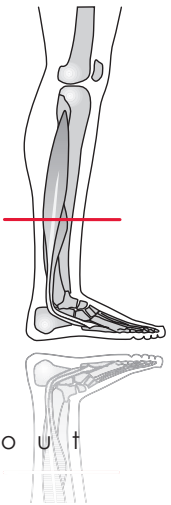
I n s e r t i o n
Caput longum: Os metatarsale I, Os cuneiforme mediale
Caput brevis: Os metatarsale V

I n n e r v a t i o n
N. peroneus superficialis (L4-S2)

F u n c t i o n
Flexion of the foot in the upper ankle joint. Eversion of the foot in the lower ankle joint

Control of Injection
Sonography, electrical stimulation

C o m m e n t
The peroneus is a strong pronating muscle in the lower ankle joint. Therefore, it can become a target for BoNT therapy in valgus deformities of the ankle. Keep in mind that spastic or shortened soleus or gastrocnemius may contribute to valgus deformity if the calcaneus bone is out of alignment.



S c o u t

peroneus longus et brevis

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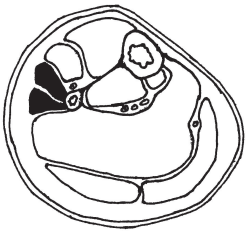
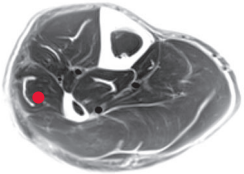
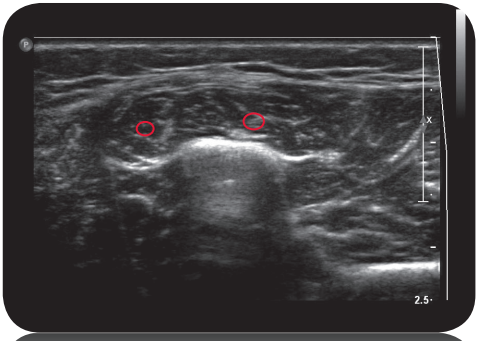


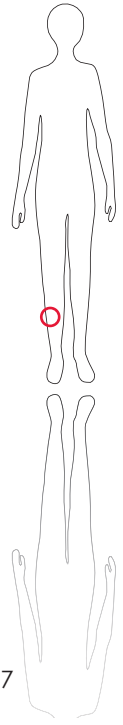
Cross Section

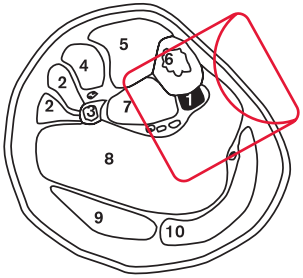


MRI



Ultrasound





Legend
1: M. flexor digitorum longus 2: M. peronaeus longus et brevis 3: Fibula 4: M. extensor digitorum longus 5: M. tibialis anterior 6: Tibia 7: M. tibialis posterior 8: M. soleus 9: M. gastrocnemius lateralis 10: M. gastrocnemius medialis

Origin
Medial and distal two thirds of dorsal surface of tibia; sheath of posterior tibial muscle

Insertion
Base of distal phalanges of second to fifth toes

Innervation
N. tibialis (L5-S2)

Function
Flexes second to fifth distal toe joints; involved in flexion of second to fifth metatarsophalangeal toe joints, plantar flexion of ankle joint and supination of subtalar joint

Control of Injection
Sonography, electrical stimulation

Comment
Leading muscle in claw-foot involving second to fifth toes; 1-2 injection sites.

flexor digitorum longus

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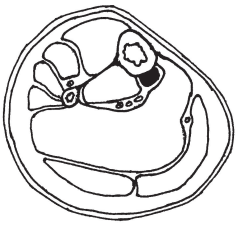
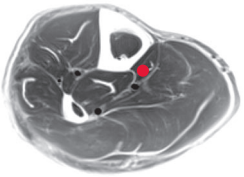
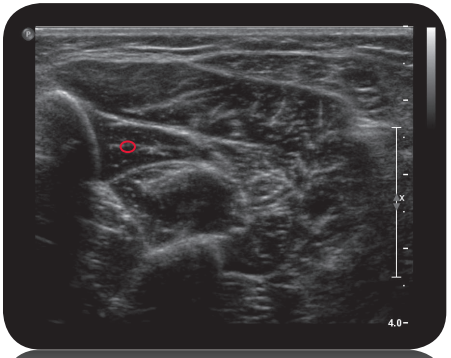


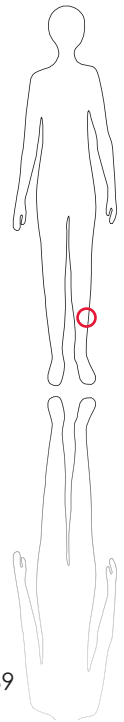
Cross Section

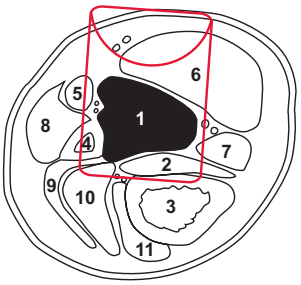


MRI



Ultrasound





Legend
1: M. flexor hallucis longus, 2: M. tibialis posterior, 3: Tibia, 4: Fibula, 5: M. pernoaeus longus, 6: M. soleus, 7: M. flexor digitorum longus, 8: M. pernoaeus brevis, 9: M. extensor digitorum longus, 10: M. extensor hallucis longus, 11: M. tibialis anterior

Origin
Distal two thirds of dorsal surface of fibula, interosseous membrane

Insertion
Base of distal phalanx of great toe

Innervation
N. tibialis (L5-S2)

Function
Flexes distal phalangeal joint of great toe; participates in flexion of metatarsophalangeal joint of great toe, plantar flexion of ankle joint and supination of subtalar joint

Control of Injection
Sonography, electrical stimulation

Comment
Leading muscle in great-toe clawfoot; one to two injection sites

flexor hallucis longus

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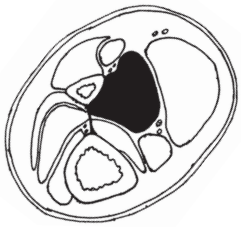
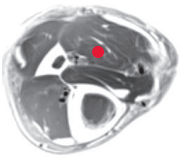
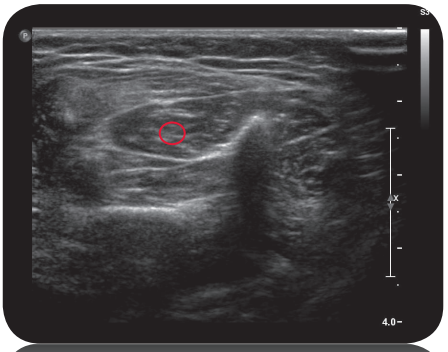


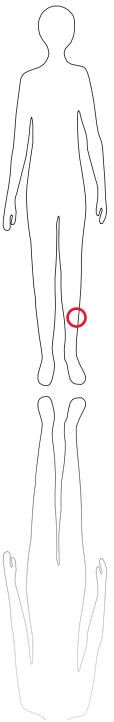
Cross Section



MRI



Ultrasound



A - flexor digitorum brevis

Origin
Plantar surface of tuber calcanei, plantar aponeurosis

Insertion
Middle phalanges of second to fifth toes

Innervation
N. plantaris medialis (L5-S1)

Function
Flexes proximal interphalangeal joints of second to fifth toes; tightens arch of foot

Control of Injection
Electrical stimulation, sonography

B - flexor hallucis brevis

Origin
Medial and plantar surface of cuboid bone

Insertion
Medial and lateral side of basal phalanx of great toe

Innervation
N. plantaris medialis (L5-S1)

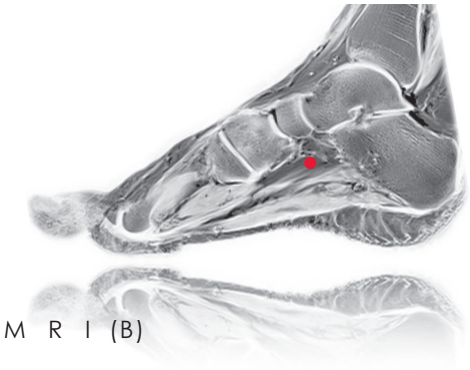
Function
Flexes metatarsophalangeal joint of great toe; tightens arch of foot

Control of Injection
Electrical stimulation, sonography

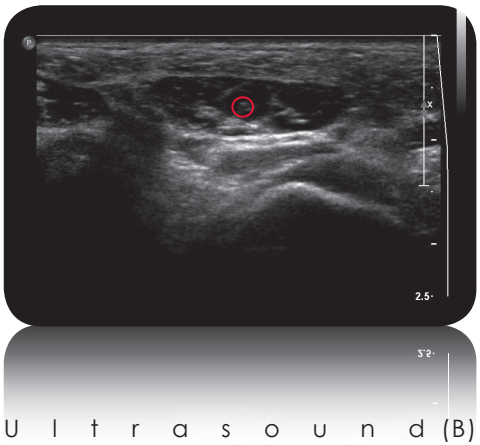
Comment
Facultatively involved in clawfoot. First insert needle swiftly through sole of foot, then locate target muscle more precisely. Analgosedation or nerve block of Nn. plantaris of tibial nerve, between medial malleolus and Achilles tendon might be necessary.

A - flexor
digitorum brevis
B - flexor
hallucis brevis

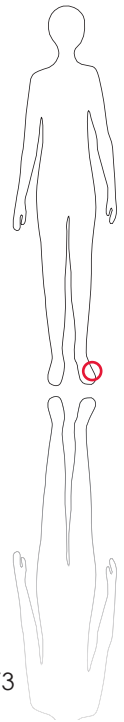
*

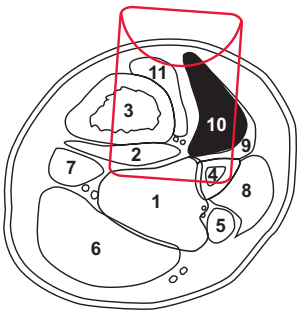


M R I (B)



U l t r a s o u n d (B)





Legend
1: M. flexor hallucis longus, 2: M. tibialis posterior, 3: Tibia, 4: Fibula, 5: M. pernoaeus longus, 6: M. soleus, 7: M. flexor digitorum longus, 8: M. peronaeus brevis, 9: M. extensor digitorum longus, 10: M. extensor hallucis longus, 11: M. tibialis anterior

Origin
Interosseous membrane, distal three quarters of proximal surface of fibula

Insertion
Base of distal phalanx of great toe

Innervation
N. peroneus profundus (L4-S1)

Function
Extends big toe; supports dorsal extension of ankle joint and supination of subtalar joint; prepares initial heal contact during swing- to stance-phase transition.

Control of Injection
Sonography, electrical stimulation

Comment
In tonic dorsal extension of the great toe ("striatal toe"), this is the leading muscle. Use 1-2 injection sites.

extensor hallucis longus

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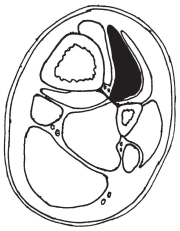
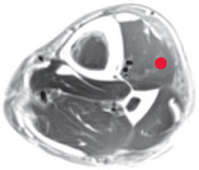
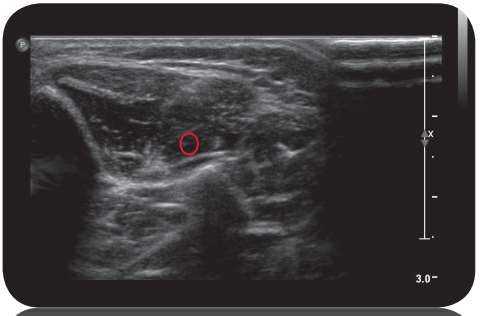


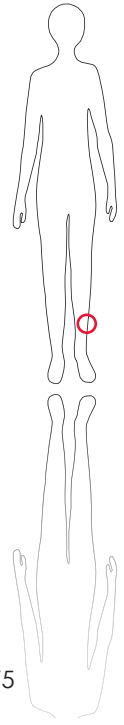
Cross Section



MRI

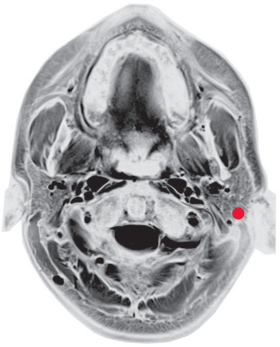


Ultrasound

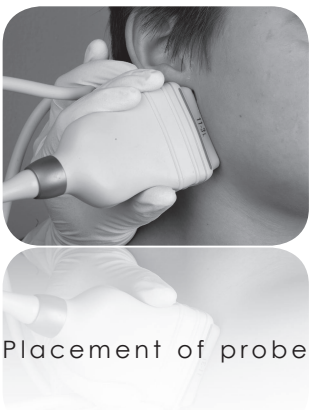


C o m m e n t

The parotid gland produces a primarily serous saliva, about 1/3 of the total daily amount. Secretion of saliva mainly occurs reflectory, for example, in response to a gustatory stimulus. The parotid gland has a preauricular (a) and a retromandibular (b) part. Due to their spatial extension, each of these parts should be injected.



M R I



Placement of probe

glandula parotis

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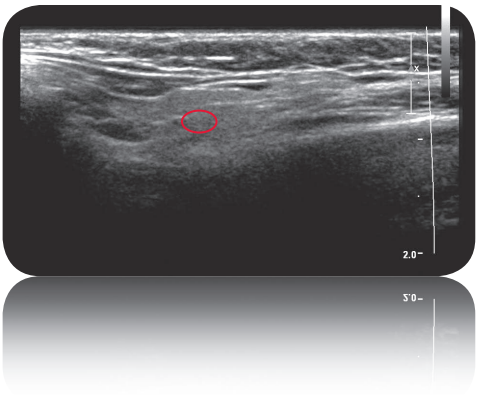

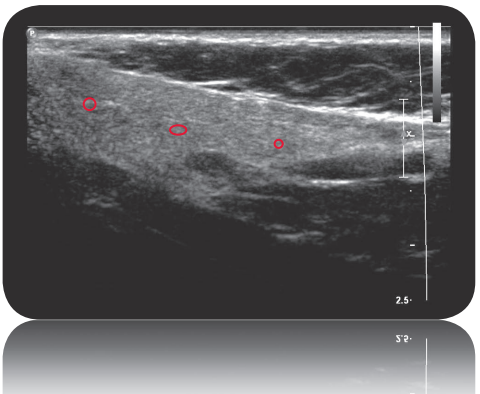

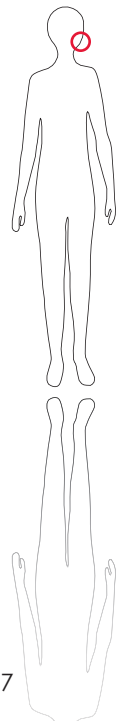

Ultrasound

Comment
The submandibular gland produces seromucous saliva. Its innervation is less dependent on gustatory stimuli than that of the parotid gland. Injection of the submandibular gland is always indicated if BoNT treatment of the parotid gland alone fails to control excessive salivary flow. Because the submandibular is more compact than the parotid gland, a single injection site is sufficient.

Placement of probe

glandula submandibularis

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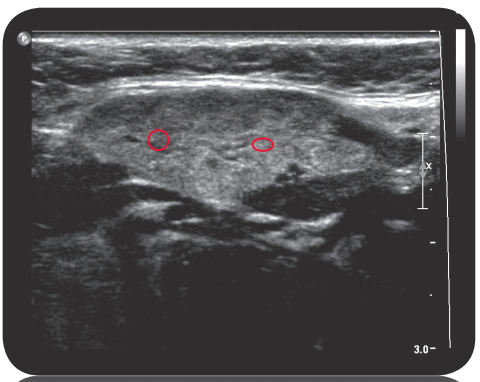

U l t r a s o u n d