

3rd Swiss Trauma & Resuscitation Day 2014

workshop 1

acute compartment syndrome

Introduction, Diagnostic Pathway

PD Dr. L.M. Benneker, Bern

Lower Extremity

Prof. Dr. A. Platz, Zurich

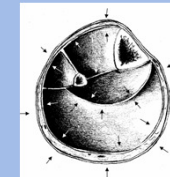
Upper Extremity

Dr. E. Benninger, St. Gallen

definition

„A compartmental syndrome is defined as a condition in which the circulation and function of tissues within a **closed space** are compromised by **increased pressure** within that space.”

(Matsen 1975)



epidemiology

- > Incidence: 0,3 (f) – 7,3 (m) / 100'000 p/y
- > 70% traumatic cause
- > 50% in long bone fractures
- > 7-17% of all fractures
- > 2nd most frequent complication in tibial shaft fractures

(McQueen 2000, Ozkayin 2002, Schmickal 1998, Sterk 2001)

pathophysiology

- > local perfusion: **(CP-IP)/R**
(CP capillary pressure, IP intersit. pressure, R resistance)
- > normal: **IP = 4-6 mmHg; CP 25 mmHg**
- > cell metabolism requires min. **5-7 mmHg oxygen tension**

compartment syndrome

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IP↑ → CPT↑ (autoregulation up to 30 mmHg IP possible)

→ tissue **hypoxia**

→ release of vasoactive substances (eg Histamin, Serotonin)

→ **permeability ↑**

→ exudation of proteins

→ edema and IP↑ (**circulus vitiosus**)

→ obstruction of capillaries

→ pH↓, necrosis...

IP ≥ 30 mmHg up to 4 h reversible damage!!!
hypotension increases CS (autoregulation↓)!!!
cave: Polytrauma (hypotension & hypoxia)!!!

Matsen 1980, Shrier 1995

diagnostics 6 P

- > **P**ressure in compartment
- > **P**ain out of proportion, with passive stretch
- > **P**aresthesia/anesthesia (vibration↓)
- > **P**aresis/paralysis
- > **P**ulses present
- > **P**ink/pale skin color



etiology

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> external compression

- casts etc
- circular burns
- pressure, perioperative positioning

> internal compression

- hematoma (fractures, AC, blunt trauma, postop)
- paravasal infusions/injections
- increased permeability
 - toxins (tetanus, snake bites..)
 - revascularisation injury
 - inflammations

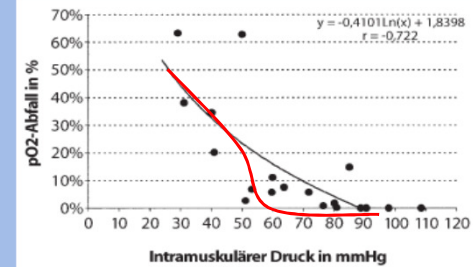


Abb. 1 ▲ Funktioneller Zusammenhang zwischen intrakompartimentellem Druck und pO₂-Wert-Abfall (in % des Ausgangswertes). n=20 Probanden mit externer Druckausübung auf den M. tibialis anterior

Willy 2001

general treatment



- > horizontal positioning
- > removal/loosening of dressings and casts
- > correction of volume deficiency
- > antiphlogistics
- > frequent controls
- > intermittant AV impuls compression (AV pump)
- > hyperbaric oxygenization

complications

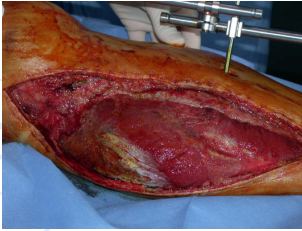


- > reperfusion injury, rhabdomyolysis (crush kidney)
- > myogenic contractions (Volkman's)
- > ischemic neurologic disorders
- > infections
- >`The average malpractice award in suits of this nature exceeds \$500,000`....

Workshop 1

Acute Compartment Syndrome:

Diagnostic pathway and how to salvage arm, hand, leg or foot !



Prof. Dr. Andreas Platz
Stadtspital Triemli, Zürich

3rd swiss trauma
& Resuscitation Day

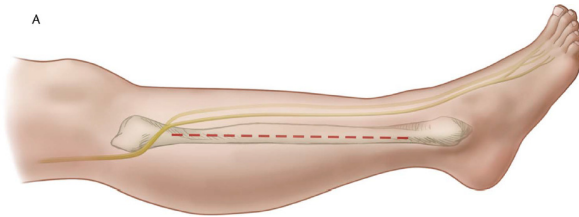
Bern, 28.2.2014

Compartment Syndrome of the lower leg

Single Incision or double Incision ?

Complications ?

Dermatofasziotomy (Single Incision)

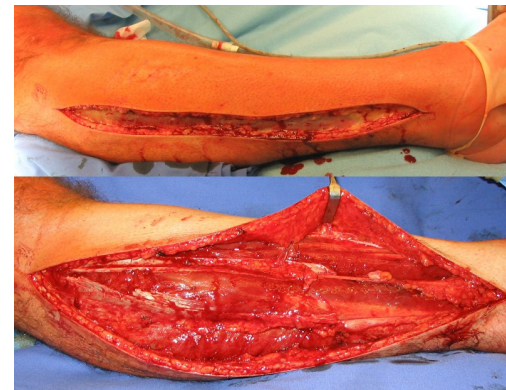


Single-Incision Fasciotomy for Compartmental Syndrome of the Leg in Patients With Diaphyseal Tibial Fractures

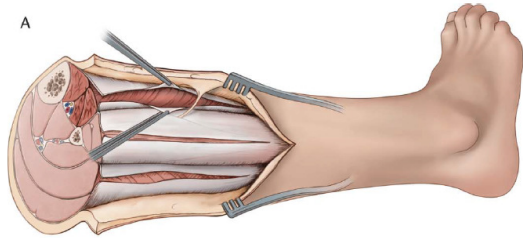
Rajshri Maheshwari, MD, Lisa A. Taitzman, MD, MPH, and David P. Barei, MD, FRCSC

J Orthop Trauma • Volume 22, Number 10, November/December 2008

Dermatofasziotomy (Single Incision)

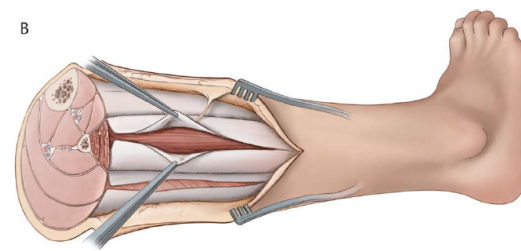


Dermatofasziotomy (Single Incision)



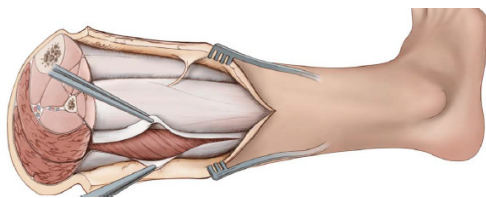
Release of the anterior compartment

Dermatofasziotomy (Single Incision)



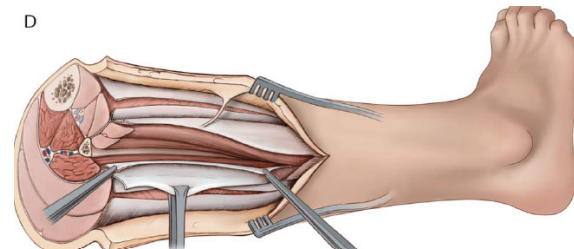
Release of the lateral compartment

Dermatofasziotomy (Single Incision)



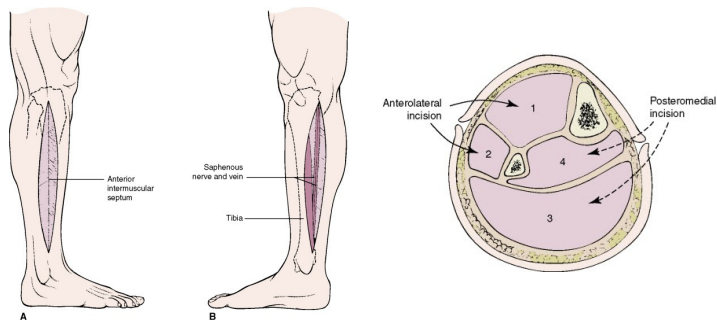
Release of the superficial posterior compartment

Dermatofasziotomy (Single Incision)



Release of the deep posterior compartment

Dermatofasziotomy (Double Incision)



Single Incision vs double Incision

- Single:** Only one wound
Needs more experience
- Double:** Better overview
Large wounds, problems with skin bridge
- Results:** ... The fasciotomy technique used did not show a significant correlation with outcome.

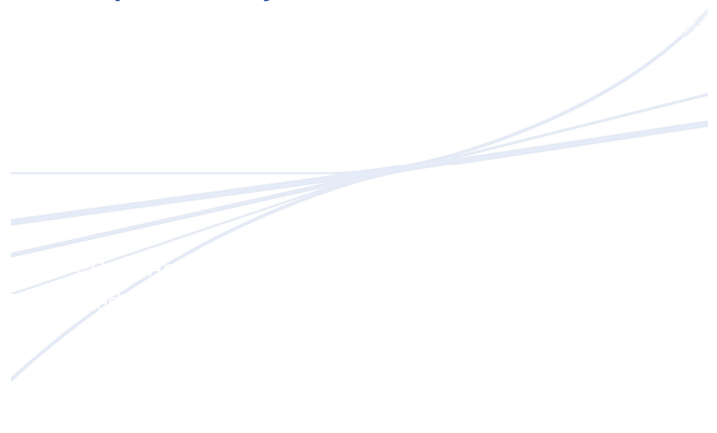
Acute Compartment Syndrome of the Lower Leg: Retrospective Study on Prevalence, Technique, and Outcome of Fasciotomies

Jeroen Heemskerck, Peter Kijslaar
Department of Surgery, University Hospital Maastricht, P.O. Box 5800, 6202 AZ Maastricht, The Netherlands

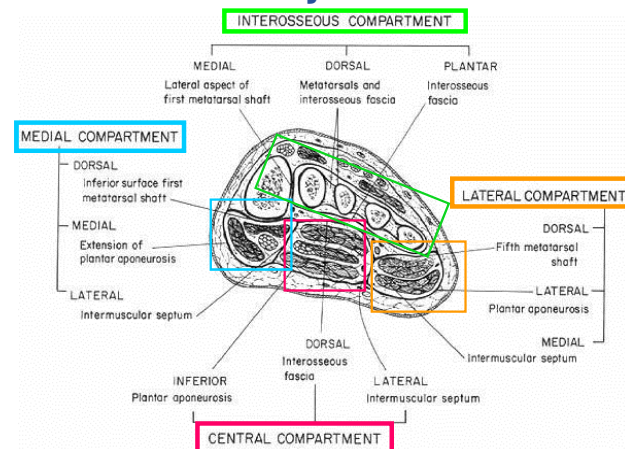


World J. Surg. 27, 744-747, 2003

Compartment Syndrome of the Foot



Fascial Anatomy of the Foot



Etiology

- crush injury, fracture
- reperfusion injury
- surgical procedures
- occlusive dressing



Clinical Presentation

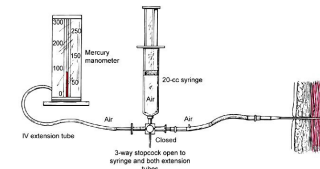
- History of injury / energy absorbed
- Swelling
- Pain
- Passive stretch
- Pallor, paresthesia, pulselessness, paralysis

Investigations

- 1 sample vs continuous monitoring
- Measure all four compartments (lower leg, foot)
- Don't delay getting measurements if diagnosis is obvious

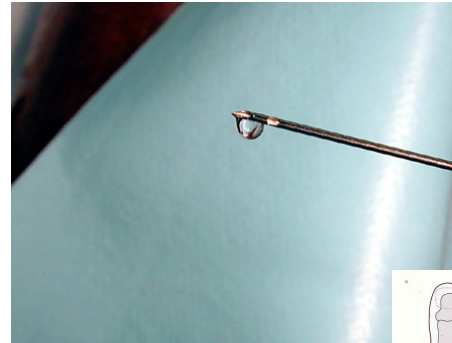
Investigations

- Compartmental pressure measurements
 - Whiteside technique
 - Arterial line setup
 - Commercially available monitors

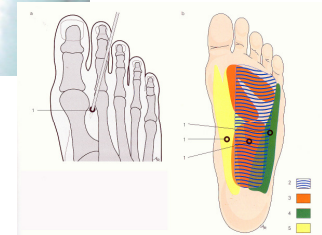




Stryker: Pressure device



The syringe is filled with fluid...



and then zeroed



Investigations: Technique

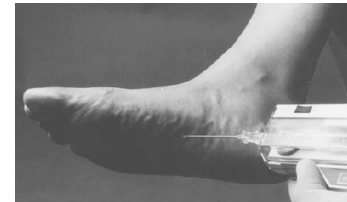


Interosseus
compartment

Lateral compartment



Investigations: Technique



Central compartment

Medial compartment

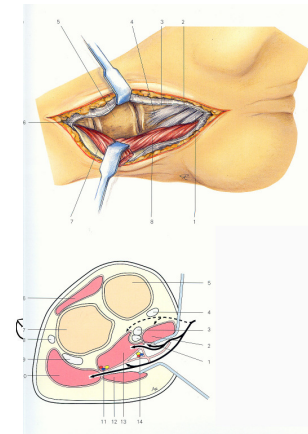


Treatment

- Remove dressings
- Do not excessively elevate the foot
 - Level of the heart
- Analgesia
- Have low threshold to proceed surgically

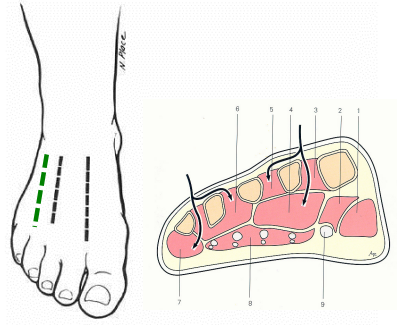
Treatment

- Emergency fascial release
- 3 incisions
 - 1 medial, 2 dorsal



Treatment

- Emergency fascial release
- 3 incisions
 - 1 medial,
 - 2 dorsal



Treatment

- Blunt and finger dissection
- Divide fascia
- Delayed closure
 - +/- skin grafting
- Prophylactic releases

Treatment



Accident



Delayed closure



Summary

Lower leg:

Single vs double incisions

Foot:

4 main compartments

- Be aggressive to prevent long term sequelae




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COMPARTMENT SYNDROME OF THE UPPER EXTREMITY


Emanuel Benninger
Shoulder and Elbow Surgery
Orthopaedics and Traumatology
KS St.Gallen

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VOLKMANN's Contracture




Hand Surgery 1st Edition

© 2004 Lippincott Williams & Wilkins




RICHARD VON VOLKMANN

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- 35 y old ♂
- Racebike fall
- 2° open fx
- Op:
 - Débridement
 - Osteosynthesis
- Postop:
 - Pain, tense arm
 - No compartment syndrome

St.Gallen Rorschach Flawil Shoulder and Elbow Surgery Dr. med. E. Benninger



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- Pain at 3mths
- Delayed union radius
- Radial malalignment
- Op:
 - Corrective ORIF
 - bone grafting
- Postoperative ↑ pain and signs for carpal tunnel syndrome



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Kantonsspital St.Gallen  Upper Extremity Compartment Syndrome 



- **Dx: acute forearm compartment syndrome**
- **Tx: volar muscle and carpal tunnel release**
- **Further course uneventfully**



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ETIOLOGY

- **Fractures**
 - Distal radius/diaphyseal forearm fx (adults)
 - Supracondylar humerus fx (children)
- **Soft tissue injury** (crush/penetrating/burns/snakebite/infections)
- **Bleeding disorders** (anticoagulans/hemophilia)
- **Iatrogenic**
 - Extravasation (especially: hand)
 - Regional anesthesia
 - Dressings/Casting
- **Arterial injury**

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CLINICAL EVALUATION

- **Pain out of proportion of injury and with passive stretching (earliest sign!!)**
- **5-Ps Symptoms to late and low sensitivity (16%¹)**
- **Palpation not very sensitive² for critical p rise**
- **P- measurements**

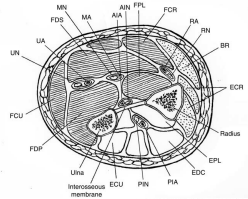
¹ Ulmer T. J Orthop Trauma 2002;16(8)
² Shuler FD, Dietz MJ. J Bone Joint Surg Am 2010;92(2)

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COMPARTMENTS ARM (6)

Anatomical Location	Compartment	Contents
Upper Arm (2)	Anterior	Flexors
	Posterior	Triceps
Forearm (4)	Anterior (2) (superficial/deep)	Flexors
	Posterior	Extensors
	Mobile wad	BR, Ext. carpi rad br/l



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COMPARTMENTS HAND (10)

Anatomical Location	Compartment/Content
Hand (10)	Hypothenar
	Thenar
	Adductor pollicis
	4 dorsal interosseous
	3 volar interosseous

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INVASIVE PRESSURE MEASUREMENT

- Always at heart level
- Local analgesia into skin only
- Needle insertion perpendicular to skin

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INVASIVE PRESSURE MEASUREMENT

- Dorsal interosseous compartment**
 - 1cm proximal to metacarpale head until it rests in the muscle belly
 - 0.5cm farther → palmar inteross. compartment
- Adductor pollicis compartment**
 - Dorsal, radial of metacarpale II in thumb-index webspace

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INVASIVE PRESSURE MEASUREMENT

- **Thenar/Hypothenar**
 - Junction glabrous/nonglabrous skin over maximum bulk of musculature (at least 0.5cm below fascia)

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INVASIVE PRESSURE MEASUREMENT

- **Forearm**
 - At junction of proximal to middle third
- **Volar compartment forearm**
 - Ulnar to the palmaris longus
 - Depth of 1-2cm
 - Confirm with external compression or passive extension of fingers


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Volar compartments


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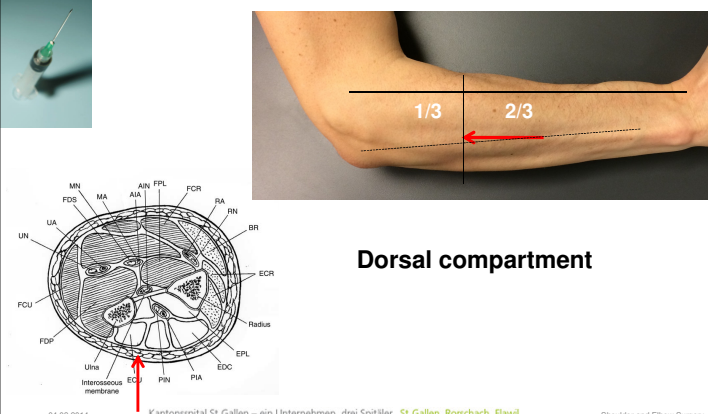
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INVASIVE PRESSURE MEASUREMENT

- **Dorsal compartment forearm**
 - Proximal radial aspect of the pronated forearm
 - Needle insertion just radial of ulnar border to a depth of 1-2cm

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The diagram shows a dorsal view of the forearm with a horizontal line at the proximal radius. A vertical line divides the forearm into 1/3 and 2/3 segments. A red arrow points to the proximal radial aspect. Below is an anatomical cross-section of the forearm with a red arrow pointing to the dorsal compartment between the radius and ulna.

Dorsal compartment


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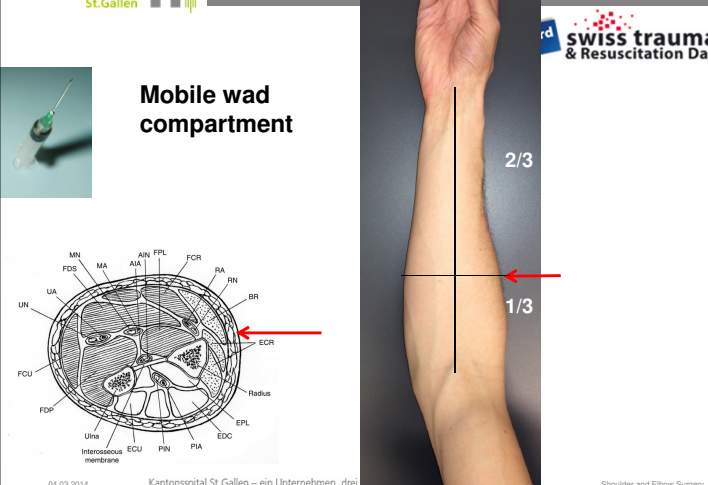
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INVASIVE PRESSURE MEASUREMENT

- **Mobile Wad compartment**
 - Most radial portion of forearm
 - Depth of 1-1.5cm

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The diagram shows a lateral view of the forearm with a vertical line. A horizontal line divides the forearm into 2/3 (proximal) and 1/3 (distal) segments. A red arrow points to the most radial portion of the forearm. Below is an anatomical cross-section of the forearm with a red arrow pointing to the mobile wad compartment on the radial side.

Mobile wad compartment

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INVASIVE PRESSURE MEASUREMENT

- Upper Arm

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THERAPY OF THE COMPARTMENT SYNDROME: URGENT RELEASE!

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COMPARTMENT RELEASE HAND

Hypothenar muscles

Dorsal interossei

Volar interossei

Adductor pollicis

Thenar muscles

Ouellette EA: Compartment syndromes in obtunded patients. Hand Clin 1998;14.

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COMPARTMENT RELEASE HAND

- Always combined with carpal tunnel release!

Grayson ligament

Neurovascular bundle (digital artery and nerve)


Cleland ligament


Transverse interosseous ligament

Cleland ligament

Ouellette EA: Compartment syndromes in obtunded patients. Hand Clin 1998;14.

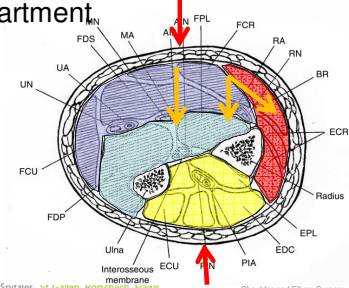
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COMPARTMENT RELEASE FOREARM

- First volar release, always superficial and deep flexor compartment
- Measure dorsal compartment
- Release in doubt

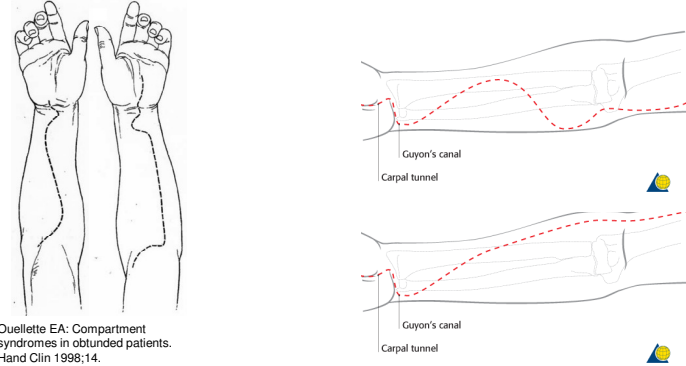


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COMPARTMENT RELEASE FOREARM



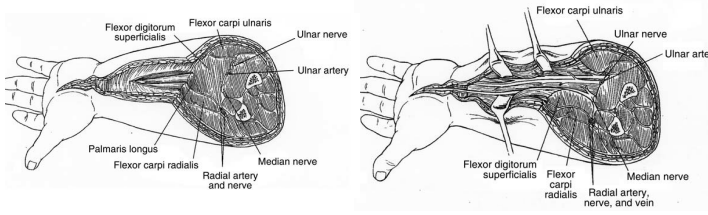
Ouellette EA: Compartment syndromes in obtunded patients. *Hand Clin* 1998;14.

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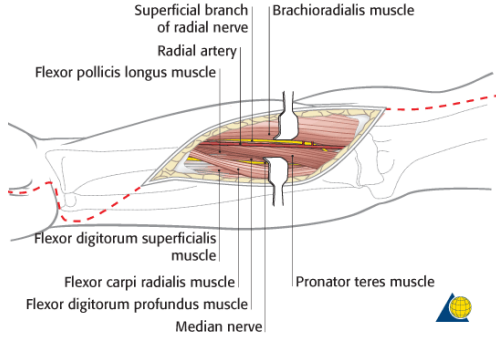
Ouellette EA: Compartment syndromes in obtunded patients. *Hand Clin* 1998;14.

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COMPARTMENT RELEASE FOREARM



Superficial branch of radial nerve
Radial artery
Brachioradialis muscle
Flexor pollicis longus muscle
Flexor digitorum superficialis muscle
Flexor carpi radialis muscle
Flexor digitorum profundus muscle
Median nerve
Pronator teres muscle
Ulnar nerve
Ulnar artery

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COMPARTMENT RELEASE FOREARM

- Thompson approach

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COMPARTMENT RELEASE UPPER ARM

- Lateral approach

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COMPARTMENT RELEASE UPPER ARM

- Anterior approach

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COMPARTMENT RELEASE UPPER ARM

- Posterior approach

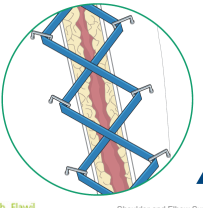
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WOUND CLOSURE


- Left open with sterile dressings
- 2nd look 48-72h
- Integra artificial dermis¹
- VAC²
- Retention sutures
- Closure after 2-7d
- Split thickness skin grafts



¹ Integra Life-Sciences, Plainsboro, NJ
² KCI, San Antonio, TX

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OUTCOME

- **Dependent on injury severity, duration of ischemia and comorbidities**
- **Delay beyond 6 to 24h¹ may result in:**
 - Volkmann's contracture
 - Neurologic deficit
 - Infection
 - Amputation
 - Death

¹ Prasarn ML, Ouellette EA. Acute Compartment Syndrome of the Upper Extremity. J Am Acad Orthop Surg 2011;19.

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