Musculoskeletal Infections

Improbability in Action….

6/26/2022 AAPA-AAOS
Musculoskeletal Guide to the Galaxy

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Disclaimer

- I have no personal financial issues to report.
- My research focuses on musculoskeletal infection
  - I have participated in research that was supported by industry in some way, but received no direct support

- I am not sure how intentional the " Guide to the Galaxy" reference is, but I have enjoyed Douglas Adams' work since the BBC radioplay in the 80s....
  - You might find a few "Easter Eggs" in this presentation if you know what to look for ……

DON'T PANIC

Musculoskeletal infections are fairly rare

- So, of course, they happen. (Improbability)

- Infection after Open Fracture: 12-14%
- Prosthetic joint infection (PJI): approx 1-2 (5?)%
- Infections due to dental seeding—very rare
  - PPX Abx not usually recommended, but keep in mind
- Musculoskeletal Tuberculosis --extremely rare
- Infections associated with IVDU
  - Much more probable than patients want to know…..
- SO, Always Carry a Towel... And think of Infection

- Fernandes Mde C, Peres LR, de Queiroz AC Jr, Lima JQ Jr, Turíbio FM, Matsumoto MH. Open fractures and the incidence of infection in the surgical debridement 6 hours after trauma. Acta Ortop Bras. 2015 Jan-Feb;23(1):38-42. doi: 10.1590/1413-78522015230100932. PMID: 26327794; PMCID: PMC4544519.

Musculoskeletal Infection- Overview
(Life, the Universe, and Everything)

- Basic and Clinical Science of Musculoskeletal Infection
  - Definition, Relevance, Pathology, Causative organisms
  - Classification, host and organism characteristics
  - Management issues
- Clinical cases in Musculoskeletal Infection
  - Hematogenous
  - Chronic, post traumatic with sequestrum
  - Native joint Septic Arthritis
  - Prosthetic Joint Infection
  - Soft tissue infections: Cellulitis, NSTIs, Abscesses
  - Wound / Ulcer related
- Research Update –Musculoskeletal Infection
  - Biofilm studies for greater understanding
  - Management strategies
  - Functional considerations

Basic Science-- What is infection?

Multiple types of relationships exist between microorganisms and host tissues.

- **Active infection:**
  - Active, functioning micro organisms, cause harm to host
  - **MSK Infection : of bone, tendon, muscle, fascia, joint, (skin)**
- **Synergistic relationship**:
  - Organisms and host interact, benefit both host and organism.
  - Example: GI flora of ruminants, humans (Harmless)
- **Latent infection:**
  - Live, inactive organisms in host tissues that are not growing and do not affect host in any way
  - May be in **biofilm**, can re-activate to cause active infection
- **Colonization:**
  - Active Organisms in a location and manner that do not directly harm or benefit host. "Contained" by host defenses.
  - Example: skin, oropharyngeal flora in humans (Mostly Harmless)
  - Breach in host defenses may allow conversion to active infection

Effects of MSK Infection--Why does it matter?

- Structural compromise:
  - Weakened bone from Osteolysis, decreased blood supply, sequestrum (nidus)
  - Soft tissue destruction: tendon, capsule, muscle injury
  - Residual nonfunctional scar
- Systemic Spread
- Hematogenous: endocarditis, epidural, UTI, other MSK
  - Contiguous or remote
  - General “malaise”, metabolic (catabolic) effects, poor appetite,
- Immune function and susceptibility
  - Microbial alteration of milieu improves environment for other pathogens
  - Example: decreased O_2 tension promotes facultative anaerobic organisms
- Societal burden
  - PJI alone: Costs exceed $390,800/ individual, 8% mortality
  - Agricultural costs from livestock loss, slowed growth
- Antibiotic stewardship effects
  - Poor understanding / disregard for pathophysiology, incorrect pathogen identification,
  - overuse of empiric, broad-spectrum antibiotics
  - promotes MDR organisms

Parisi et all, CORR 2017
McNamee, PT, Smyth, JA. Bacterial chondronecrosis with osteomyelitis ('femoral head necrosis') of broiler chickens: A review. *Avian Pathology*. 2000;29(5):477-795.

Musculoskeletal Infection--Microbiology

- Causative organisms
  - Fungi
    - Eukaryotes, hard to treat, toxicity of Abx is issue
    - Candida species, coccidiomycosis, aspergillus, others
  - Bacteria
    - Gram Positive: Staphylococci, Streptococci,—most common, others
    - Gram Negative bacilli,(Pseudomonas, Acinetobacter, others—often MDR)
    - Anaerobes
    - Mycobacterium TB and others—notable but not common
  - Sub cellular particles—viruses, prions, etc.?
    - REALLY? You have to think about it.....
    - Direct MSK effects rare/unknown
    - Affect host resistance to infection, may have role in systemic MSK disease, esp. autoimmune.

Musculoskeletal Infection--Microbiology

- Causative Organisms—Characteristics:
- Organism Strain/Subspecies: (DNA)
  - Affect function, pathology of active infection
    - Virulence factors: ability to produce toxins or proteolytic enzymes, evade host immune system, etc.
    - Antibiotic resistance genes
- Organism state:
- Planktonic (free floating) vs **Biofilm (matrix based)**
  - **Alters Antibiotic susceptibilities (50-10,000+ times)**
  - Antibiotics affect state
  - Changeable
- Relevant for bacteria, fungi, others?
  - The more we know, the more we know!

Biofilm Bacteria Antibiotic Tolerance

		Planktonic		Biofilm
		MIC	MBC	MBC
	Antibiotic (µg/mL)			
EMRSA	Vancomycin	2	4	>15000
S. epidermidis	Vancomycin	2	2	>15000
P. acnes	Vancomycin	1	2	>1024
P. aeruginosa PA01	Tobramycin	2	8	64
A. baumannii ATCC 19606	Tobramycin	16	16	128
K. pneumoniae ATCC 700831	Tobramycin	16	16	64

P. Stoodley, Personal communication

Basic Science- Pathophysiology

- Tissues involved: bone, tendon, muscle, capsule, fascia (skin)
- Exposure/ Pathogenesis
  - Hematogenous spread- typically 1 organism
    - Source often unknown—transient bacteremia?
    - May be from other known site
    - Often establishes in vulnerable potential space- trauma, hematoma, joint, bursa
  - Direct inoculation (Surgical, Traumatic, Injection)
    - from environment, 'normal flora', may be mono- or poly-microbial
    - Contamination of **potential space** is problematic
  - Contiguous spread- often polymicrobial
    - Hardware associated
    - Wound contamination
    - Role of joint fluid- great nutrition, spread, decreased antibiotic penetration
- Non-living or inert materials-- more prone to Biofilm attachment, provoke less immune response, protected from antibiotics
  - Implants, foreign bodies
- Duration
  - Acute
  - Chronic/ recurrent

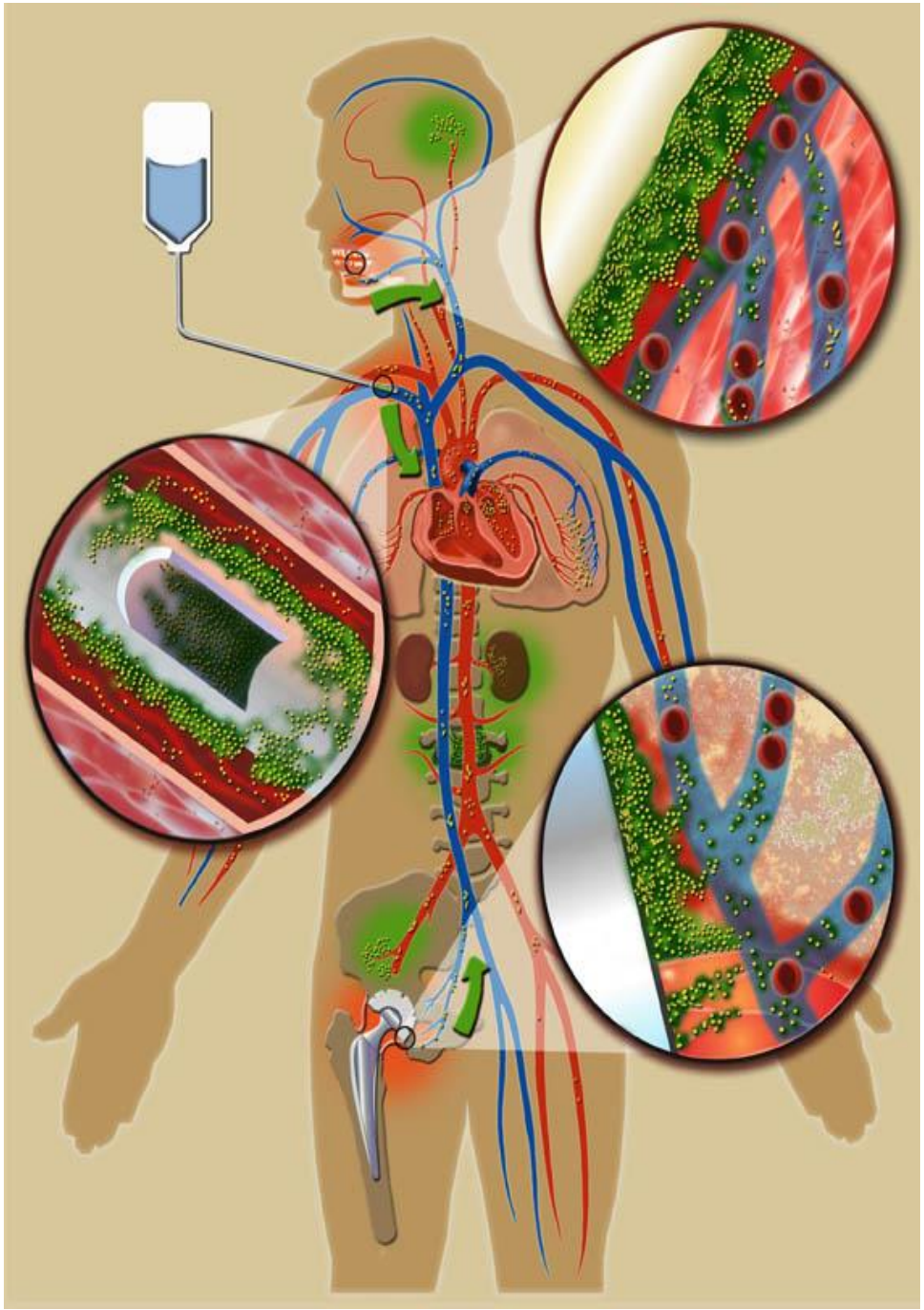
NIH : ~80% of chronic infections are biofilm related.

MEDICAL DEVICES

Orthopaedic Implants
IV Catheters
Urinary Catheters
Vascular Stents
Dental Implants
Sutures and Meshes

TISSUES

Dental Disease
Infectious Pneumonia
Ear Infection
Adenoiditis



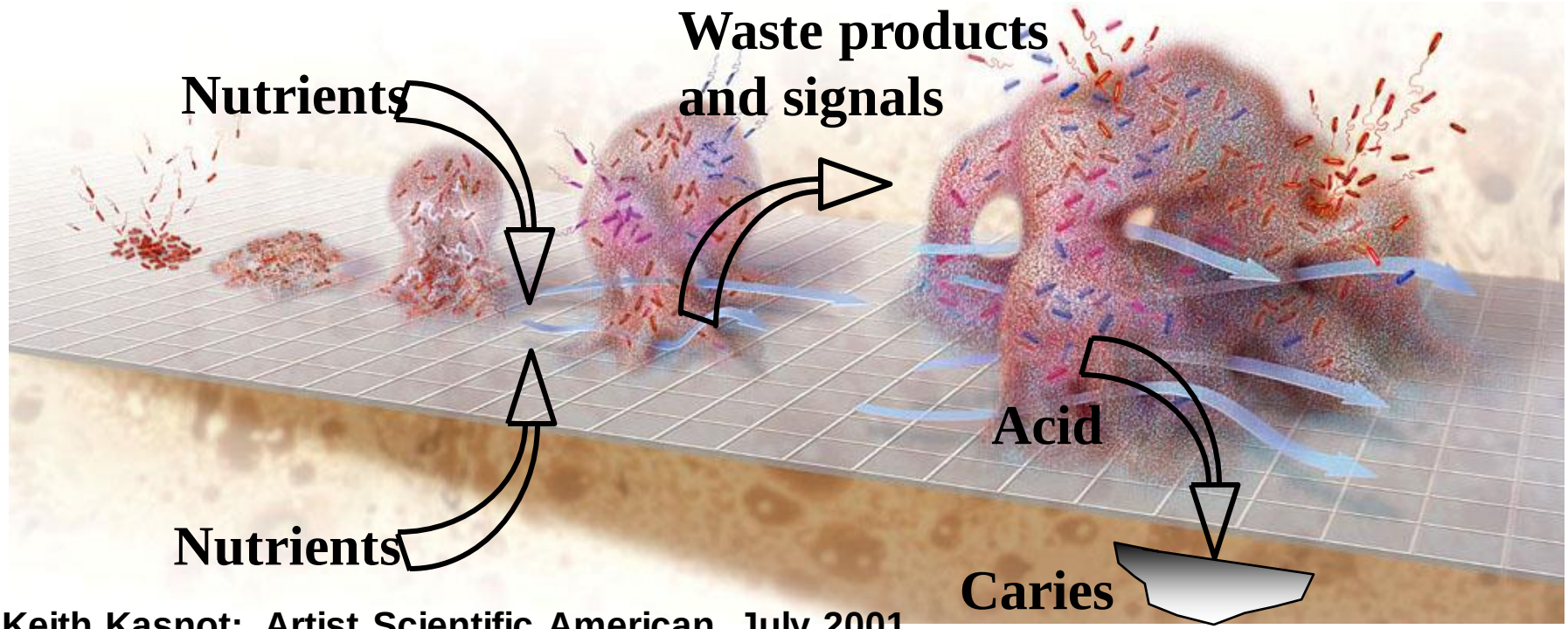
 National institutes of Health

Biofilm Development

Attachment

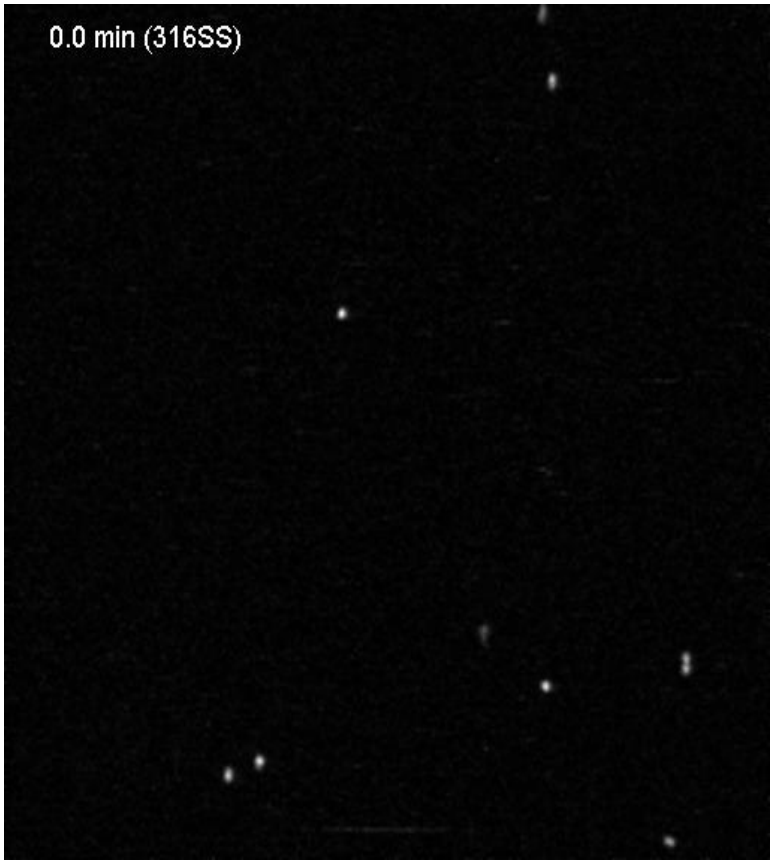
Growth and slime production

Detachment

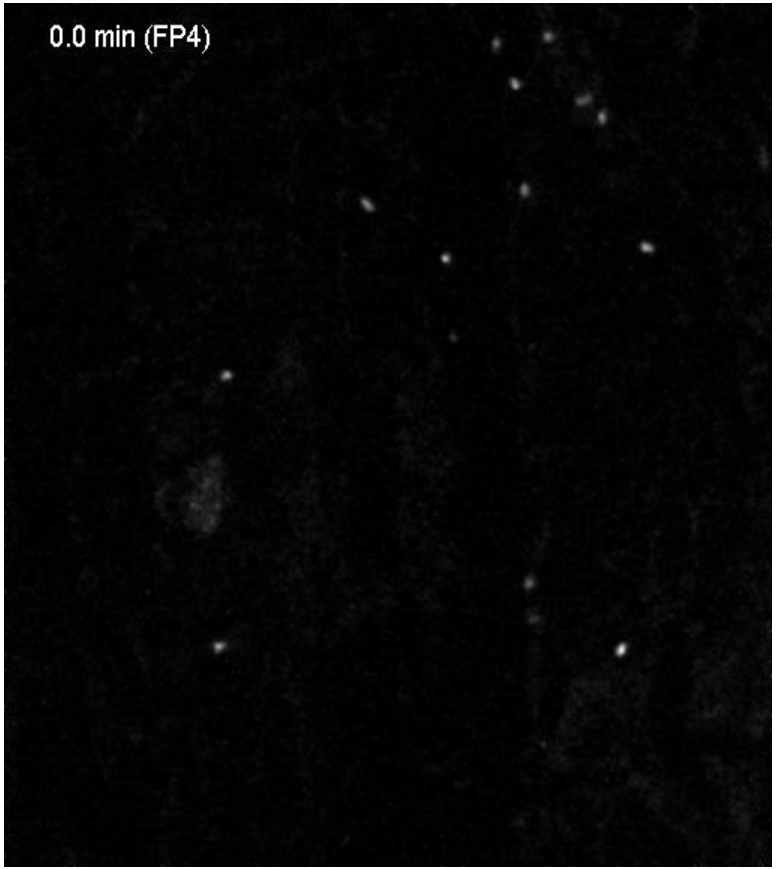


Keith Kasnot: Artist Scientific American, July 2001

BACTERIA READILY ATTACH TO ALL MATERIALS



316 Stainless Steel



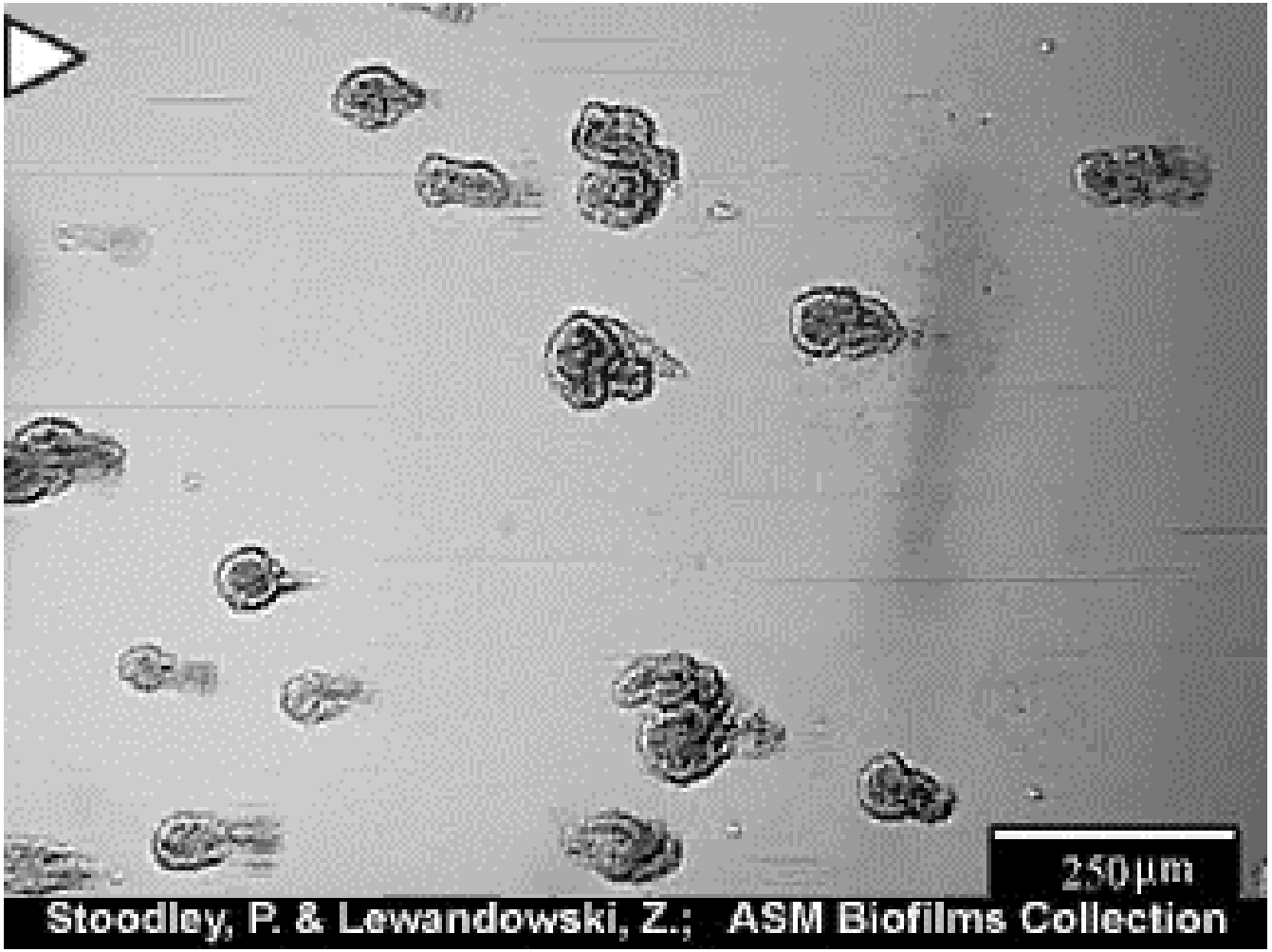
Fluropolymer

***P. aeruginosa* PAO1**

P. Stoodley, Personal communication

Growth and Detachment

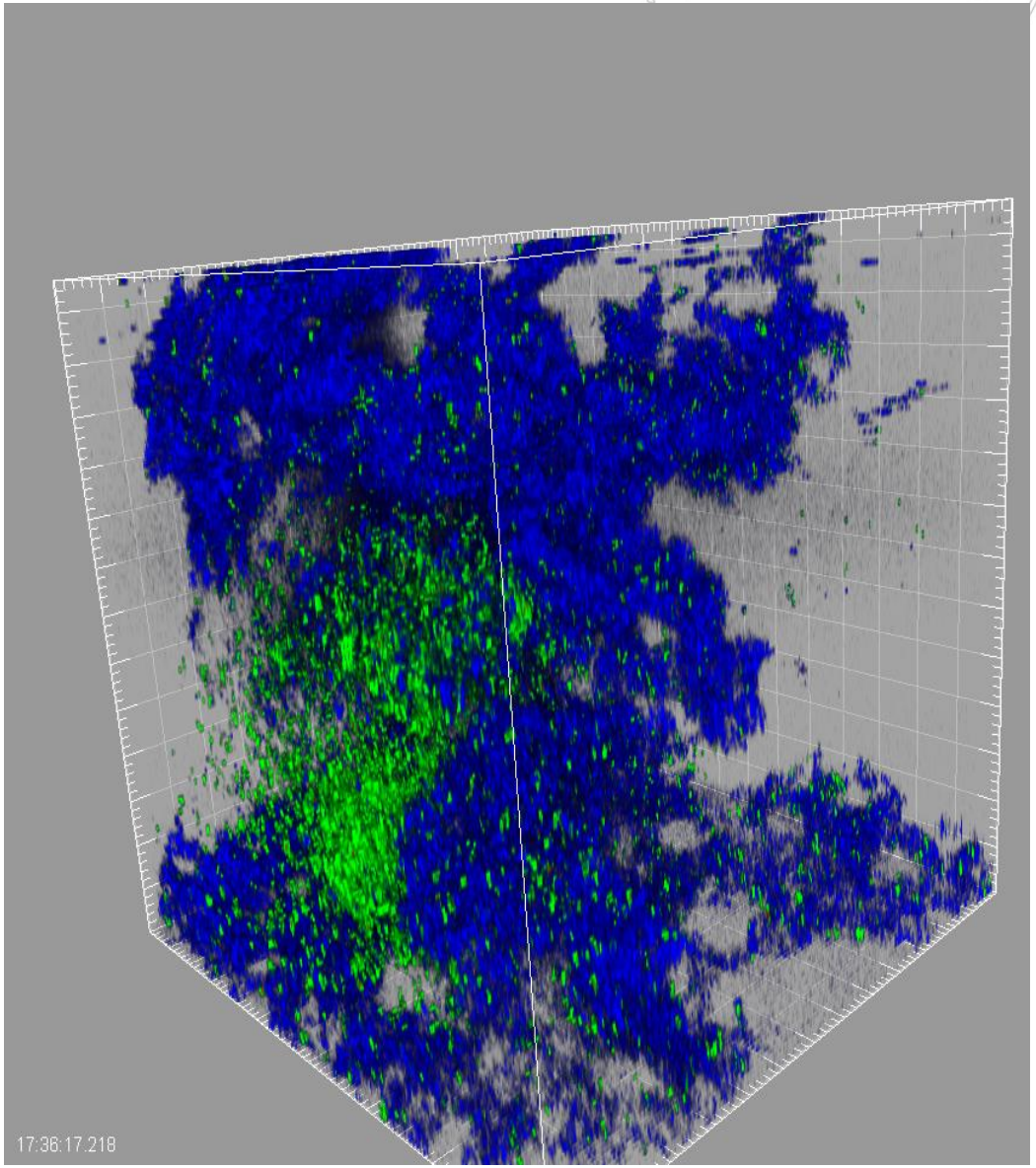
Time: Minutes – Weeks, Length: μm - mm



P. Stoodley, Personal communication

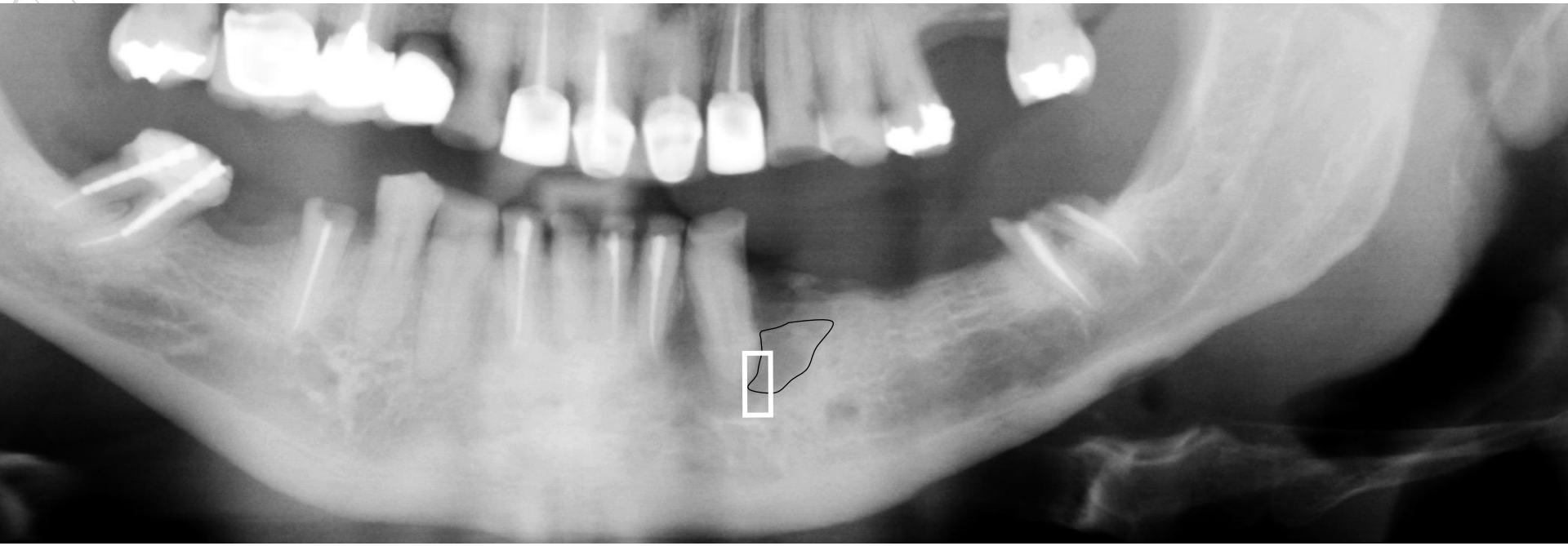
COMPOSITION OF BIOFILMS

- Live cells
- Dead cells
- Extracellular Slime
  - Carbohydrates
  - DNA
  - Protein
- Water



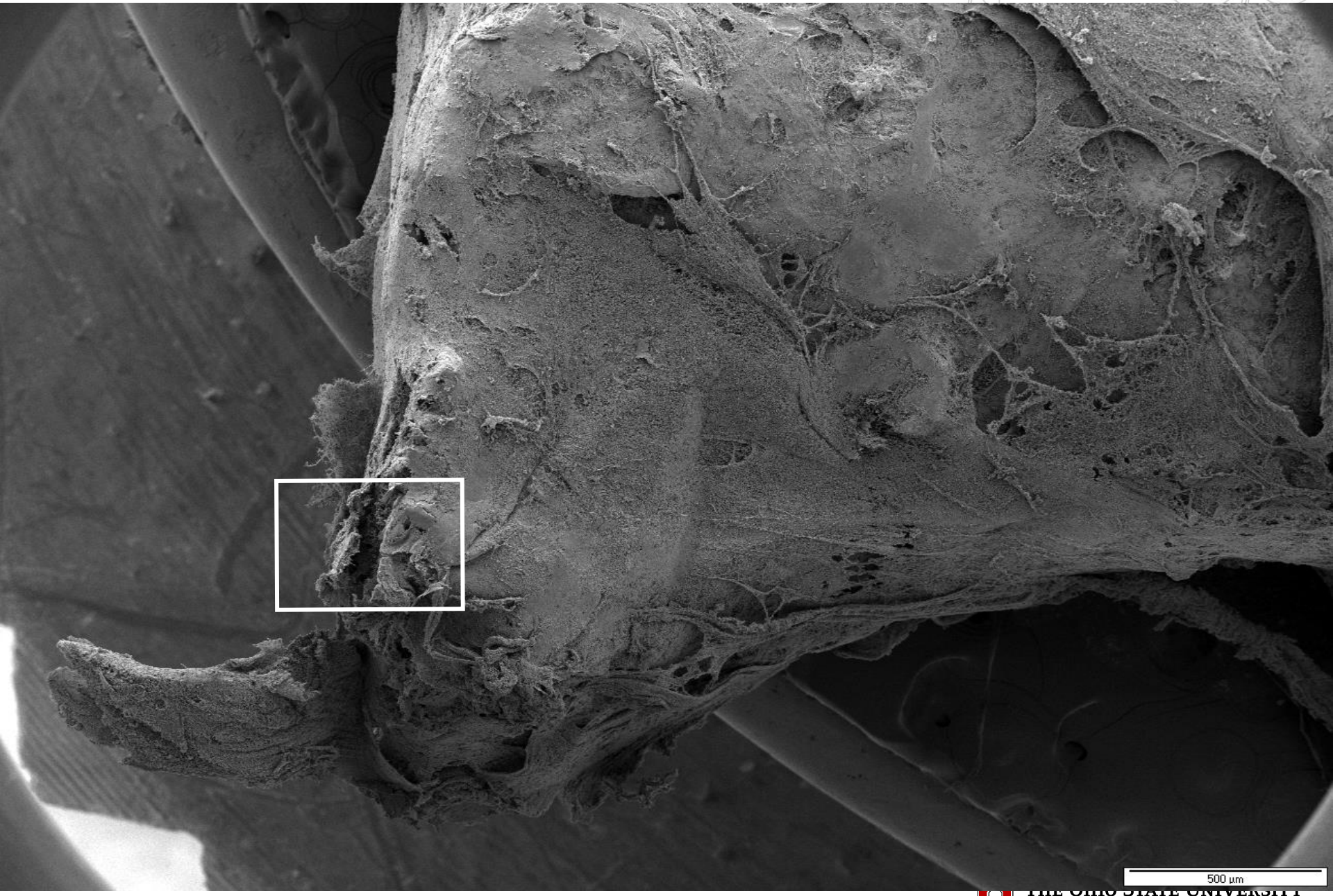
P. aeruginosa PittD,
P. Stoodley Personal communication

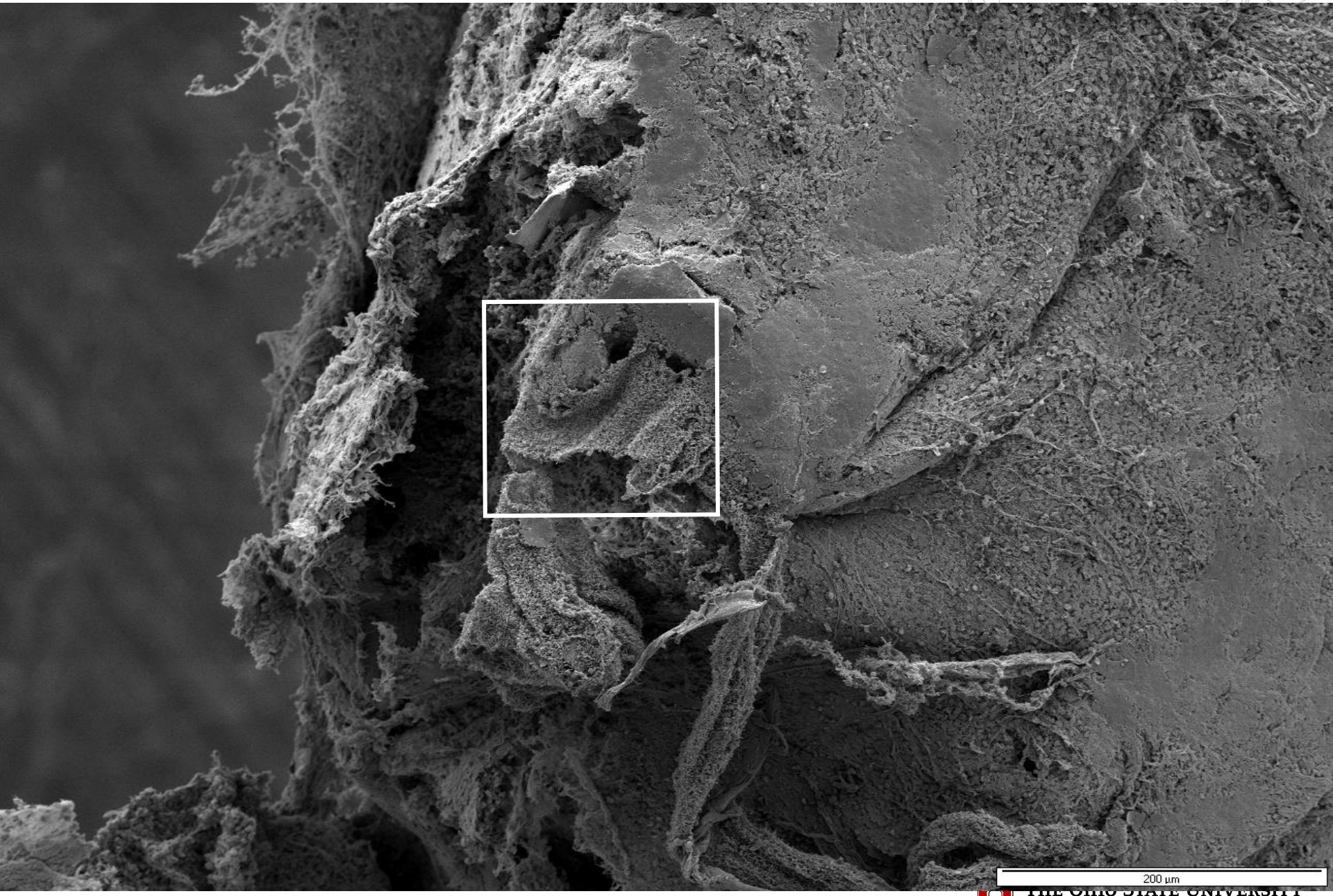
Case Example: Dental infection

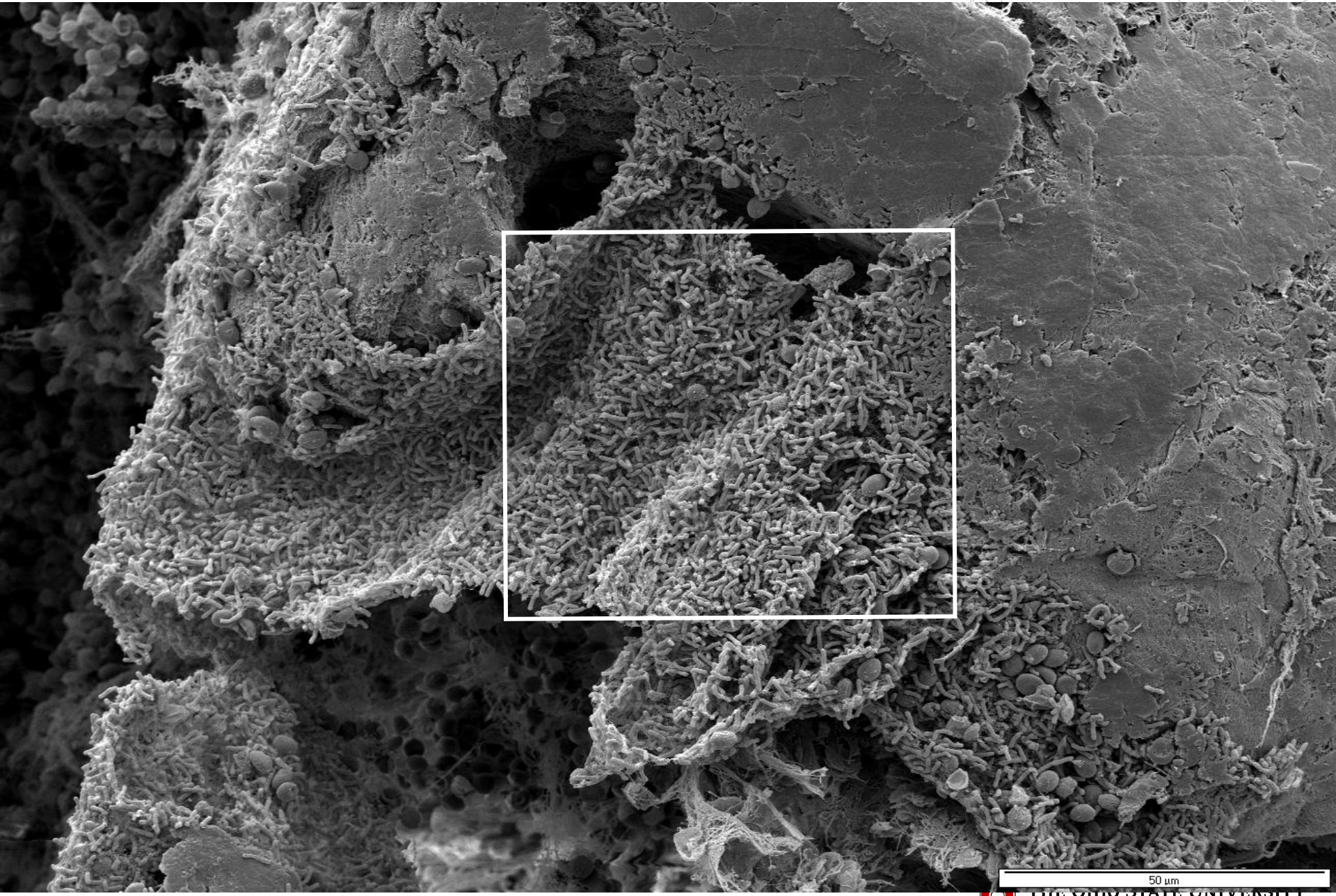


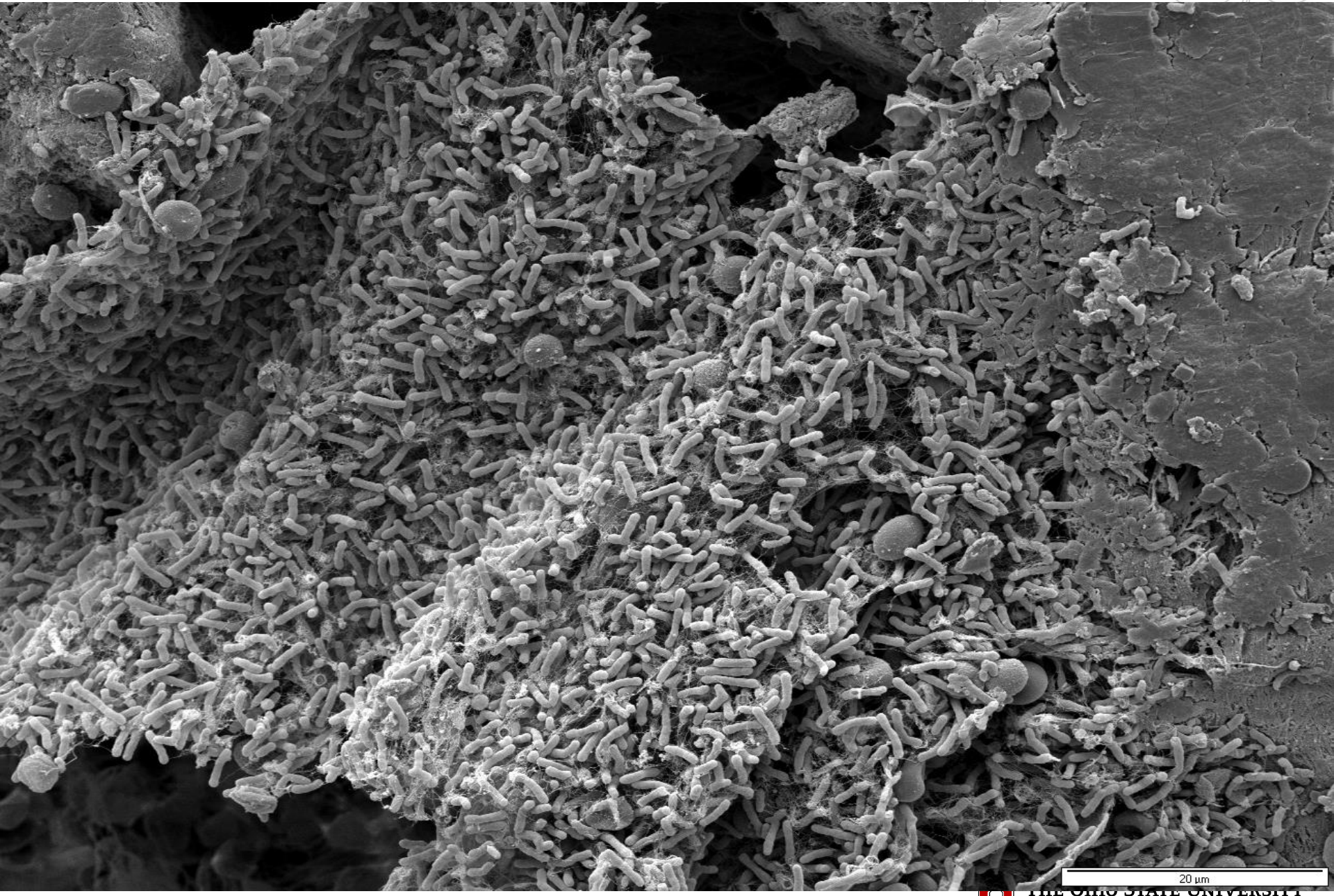
Patient had tooth extracted and socket was infected for 4.5 months despite antibiotic therapy. Infection resolved only when biofilm was completely surgically removed.

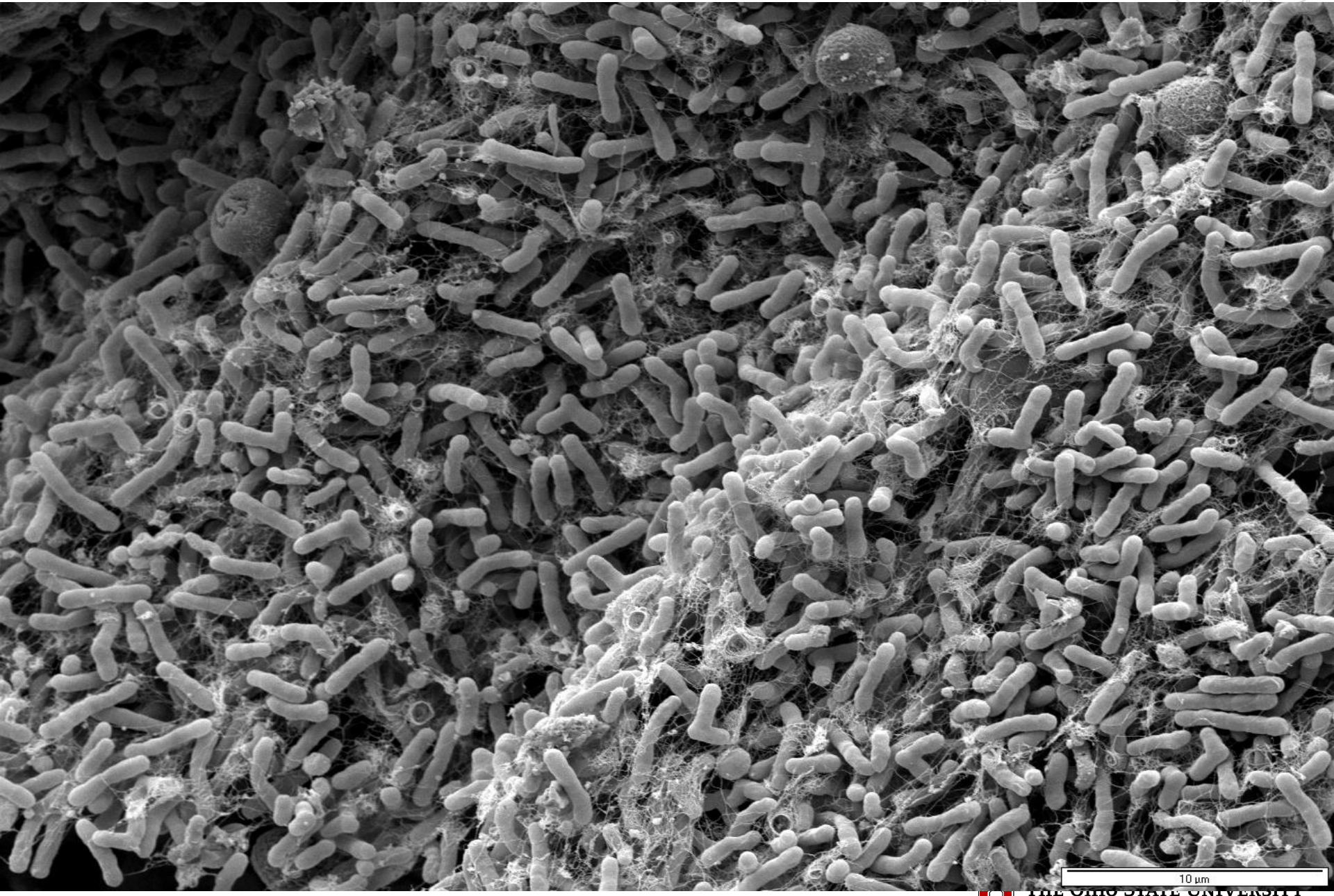
Parish Sedhizadeh and Bill Costerton (UCLA)
(P. Stoodley, personal communication)

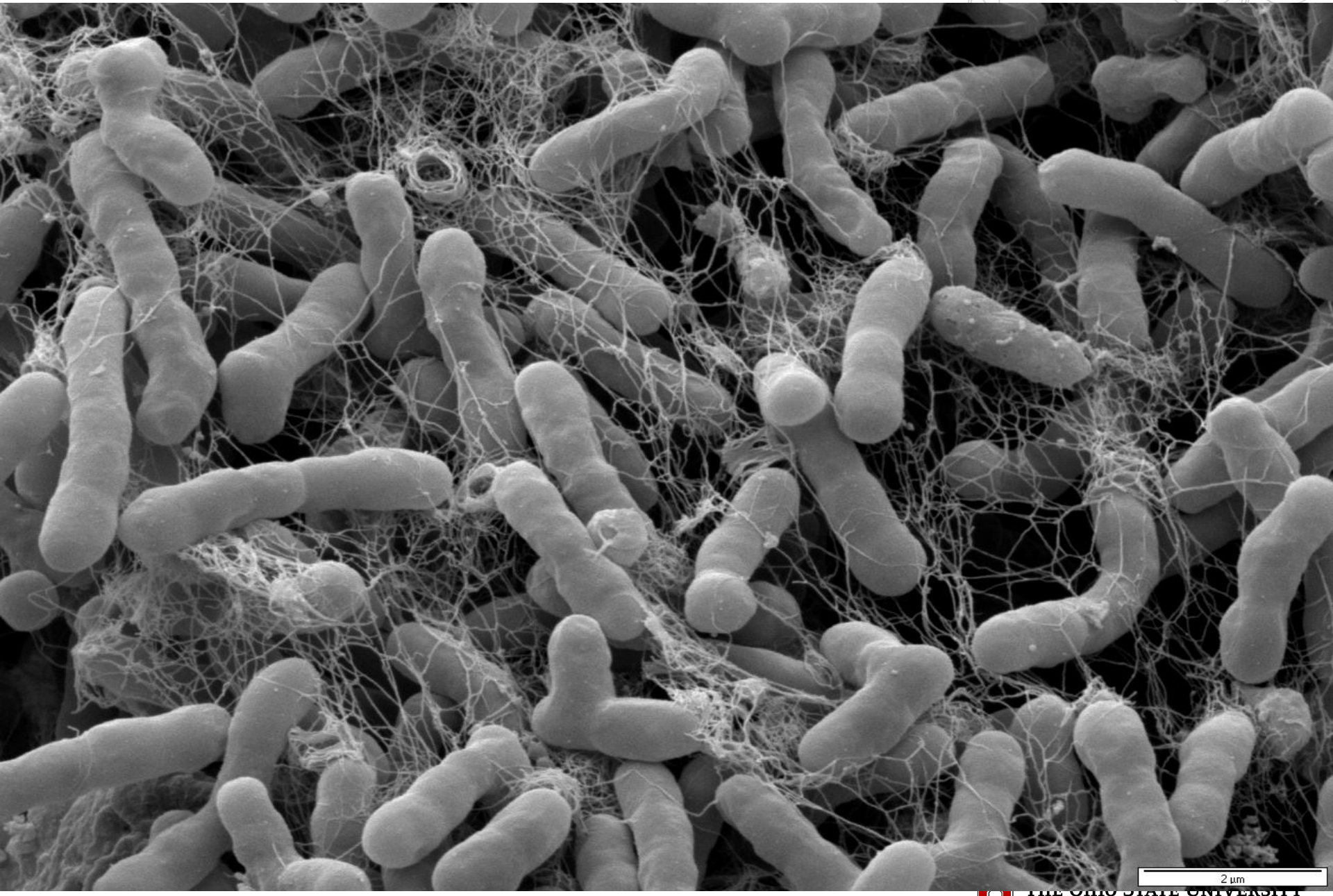

500 µm


200 µm


50 µm


20 µm


10 µm


2 µm

Case Example: Infection of Total Elbow Arthroplasty

THE JOURNAL OF BONE & JOINT SURGERY

JB&JS

This is an enhanced PDF from The Journal of Bone and Joint Surgery

The PDF of the article you requested follows this cover page.

Direct Demonstration of Viable Staphylococcus aureus Biofilms in an Infected Total Joint Arthroplasty. A Case Report

Paul Stoodley, Laura Nistico, Sandra Johnson, Leslie-Ann Lasko, Mark Baratz, Vikram Gahlot, Garth D. Ehrlich and Sandeep Kathju

J Bone Joint Surg Am. 2008;90:1751-1758. doi:10.2106/JBJS.G.00838

P. Stoodley, Personal communication)

Patient Time-Line

Elbow pins

Remove hardware
Gram / culture -ve
Low WBC
"Reactive tissue"
Void filled with tobramycin cement

Debridement
Gram / culture -ve

Remove TEA
Tob. cement spacer
Gram / culture -ve

Remove Spacer
Gram / culture -ve

Remove retained cement
MRSA + Biofilm

Flail Arm

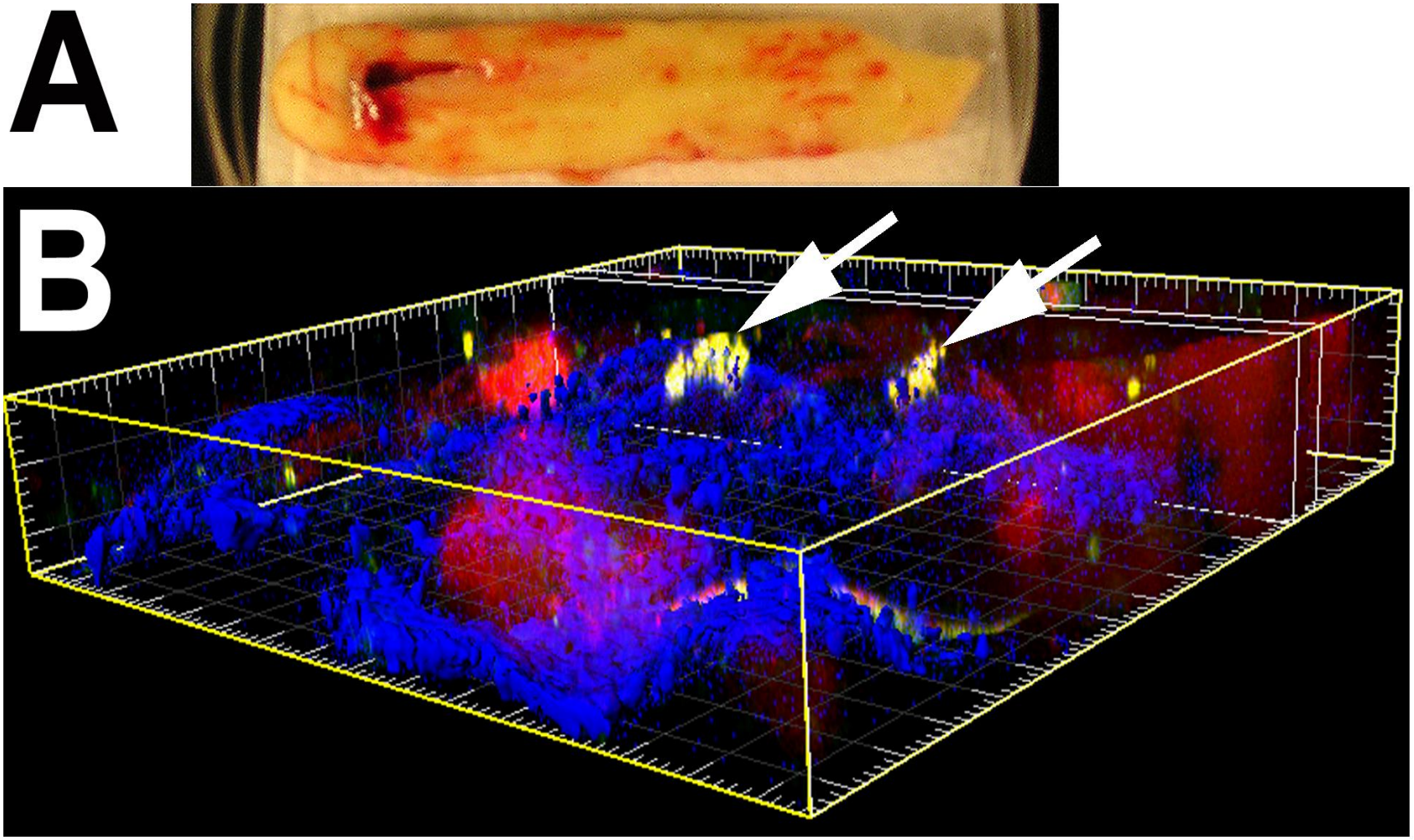
Click to add text

0 20 40 60 80 100

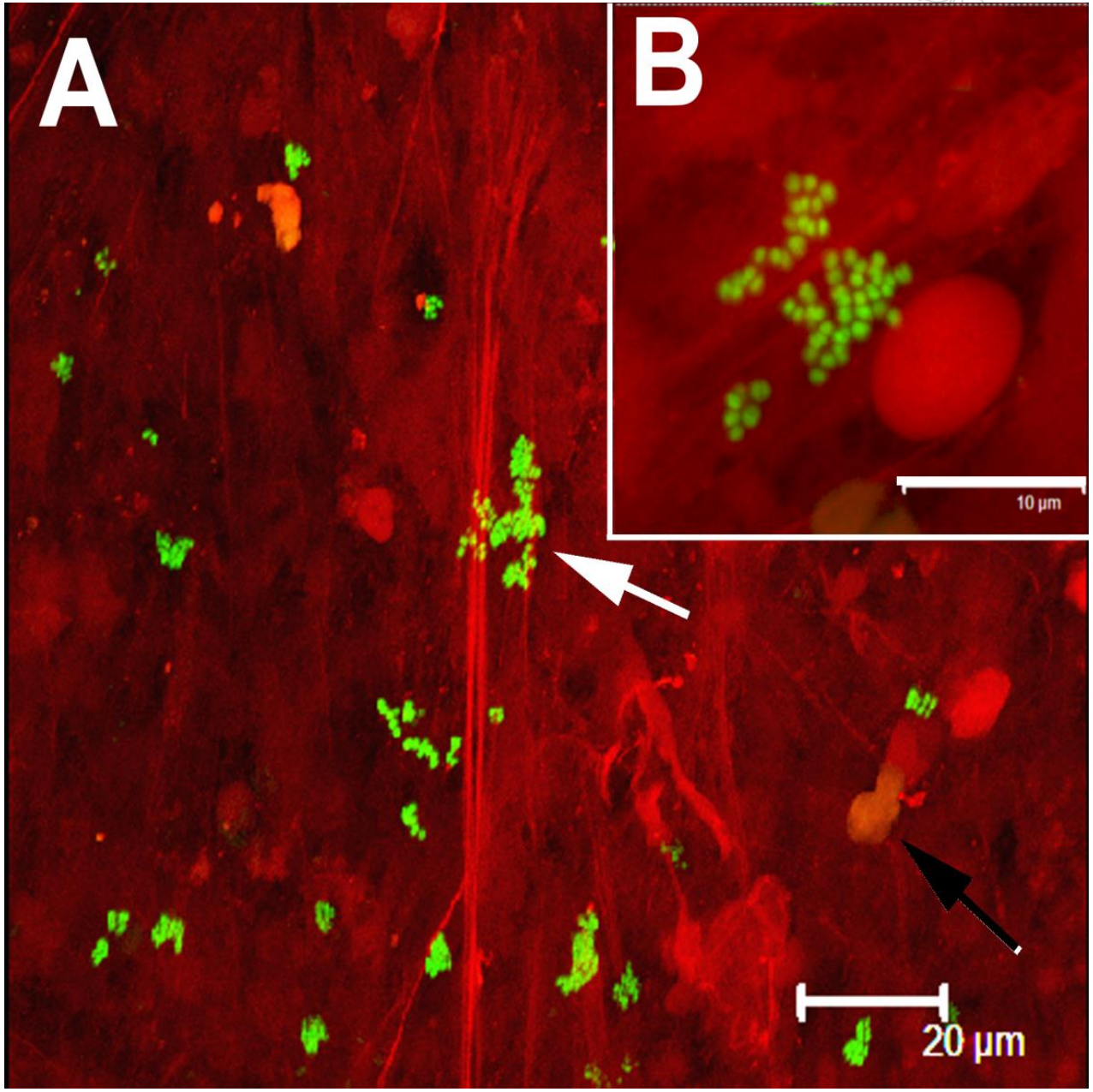
Time (Months)

(Paul Stoodley-personal communication)

Staph. aureus biofilm attached to cement loaded with tobramycin



P. Stoodley, Personal communication



P. Stoodley, Personal communication

Clinical Science: Classification

Waldvogel Classification

- Duration:
  - Acute
  - Chronic
- Source:
  - Hematogenous (from bacteremia)
  - Contiguous spread (from nearby tissue/ wound)
- Role of vascular insufficiency
- Limited- does not consider direct penetration
- Not applicable to clinical practice due to wide range of etiologies
  - But, conceptually useful

Calhoun JH, Manring MM, Shirtliff M. Osteomyelitis of the long bones. *Semin Plast Surg*. 2009;23(2):59-72.

Clinical Science: Classification

Cierny-Mader classification

- **Currently Dominant Classification**
  - Often used clinically to predict outcomes
    - Still not perfect,
    - ? Updates?
  - Employs anatomic, clinical and radiologic/ imaging features
- **Features:**
  - Anatomic stage: (location, imaging)
  - Host Types: (clinical)
    - Possible for host to improve through optimization

Calhoun JH, Manring MM, Shirtliff M. Osteomyelitis of the long bones. *Semin Plast Surg*. 2009;23(2):59-72.

Clinical Science: Classification

Cierny-Mader classification

- Anatomic stage: (location, imaging)
  - 1. Medullary: confined to medullary cavity of bone;
  - 2. Superficial: involves only cortex, often from direct inoculation or contiguous focus;
  - 3. Localized: involves both cortex and medullary bone, stable, does not involve entire diameter;
  - 4. Diffuse: involves entire thickness of bone, often with loss of stability, e.g. infected nonunion;

- Host Types: (clinical)
  - A: no compromising local or systemic factors
  - B: affected by one or more compromising factors
    - **May be Systemic (Bs) or Local (Bl)**
  - C: severely compromised host, cannot tolerate treatment
  - "Treatment is worse than the Disease"

Calhoun JH, Manring MM, Shirtliff M. Osteomyelitis of the long bones. *Semin Plast Surg*. 2009;23(2):59-72.

Host Factors-Cierny – Mader Classification

Understanding host factors is the real utility...

Systemic or local factors that affect immune surveillance, metabolism, and local vascularity

Systemic (Bs)	Local (Bl)
Malnutrition	Chronic lymphedema
Renal or hepatic failure	**Venous stasis**
Diabetes mellitus	**Major-vessel compromise**
Chronic hypoxia	Arteritis
Immune disease	Extensive scarring
Malignancy	Radiation fibrosis
Extremes of age	Small-vessel disease
Immunosuppression or neuropathy	Complete loss of sensation
Immune deficiency	**Tobacco abuse**

Calhoun, J. H., Manring, M. M., & Shirtliff, M. (2009). Osteomyelitis of the long bones. *Seminars in plastic surgery*, *23*(2), 59-72.

Clinical Science—Organism and Host Factors

Beyond Cierny & Mader, but same spirit....

- **Age of patient**:
  - Pediatric patients can resorb dead bone, removing surfaces susceptible to Biofilm, may not need OP debridement as often
- Time to diagnosis and treatment:
  - Bone vascularity is compromised early in course of infection, also at time of surgical debridement
  - Antibiotics "protect" compromised bone from bacteria, to a point, avoiding formation of sequestra, thus Biofilm formation
- Epidemiologic factors:
  - Recent Increase in **Multi-Drug Resistant Organisms (MDROs)**
    - Many originated overseas/ military
    - Some strains transfer between humans and animals
  - Population characteristics: **Increases in: *obesity, drug use, prevalence of chronic diseases (21st century problems!*)**
- ****NOTE: ***MODIFIABLE RISK FACTORS*****

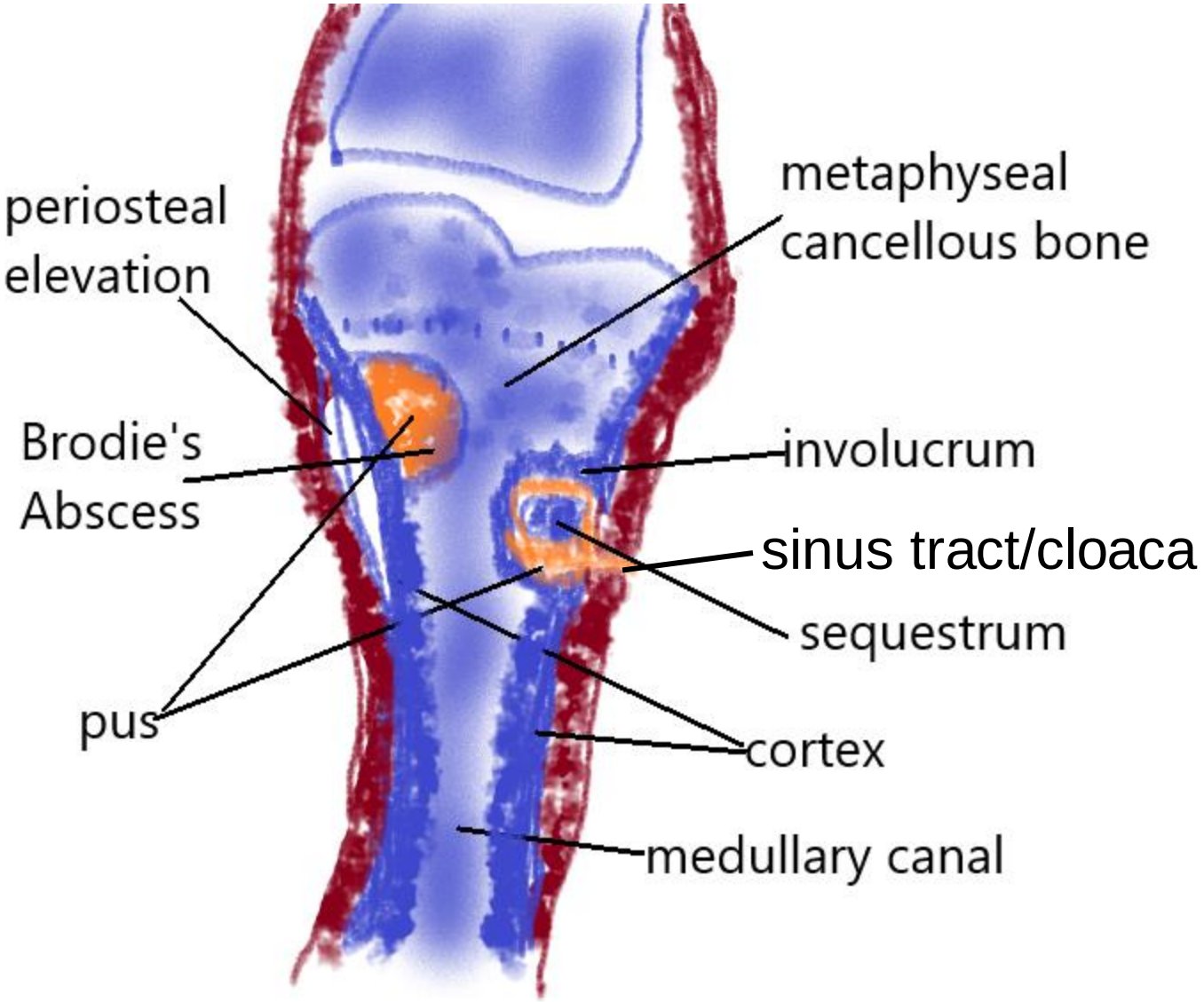
Calhoun JH, Manring MM, Shirtliff M. Osteomyelitis of the long bones. *Semin Plast Surg*. 2009;23(2):59-72.
Smith, TC, Livestock-Associated Staphylococcus aureus: The United States Experience. PLoS Pathogens.2015; 11(2) e1004564

TIME OUT—Consult the *Guide*

- **Brodie's abscess**
  - Localized abscess in cancellous bone, may be chronic, acute, or subacute, walled off from other bone
- **Sequestrum**
  - Dead bone, often surrounded by pus or granulation tissue in center of a bone abscess
- **Involucrum**
  - Sclerotic bone surrounding bone abscess and sequestrum
- **Cloaca**
  - Opening through cortex of bone communicating between Brodie's abscess and soft tissue
- **Sinus Tract**
  - Tunnel from any abscess communicating to outside environment through skin

Lee YJ, Sadigh S, Mankad K, Kapse N, Rajeswaran G. The imaging of osteomyelitis. Quant Imaging Med Surg. 2016 Apr;6(2):184-98. doi: 10.21037/qims.2016.04.01. PMID: 27190771; PMCID: PMC4858469.
Subacute Osteomyelitis (Brodie Abscess) Medscape, Updated: Jun 02, 2022
Author: Khalid I Khoshhal, MBBS, FRCS(Edin), ABOS; Chief Editor: Thomas M DeBerardino, MD

My Artwork:


periosteal elevation
metaphyseal cancellous bone
Brodie's Abscess
involucrum
sinus tract/cloaca
sequestrum
pus
cortex
medullary canal

Optimal Management of Musculoskeletal Infection

- **Presentation, recognition, evaluation:**
  - **H & P, Diagnosis**
- **Best Practice -- Guidelines**
  - **CPGs, stewardship**
- **Treatment / Available tools**
  - **Surgical**
  - **Medical**
  - **Other?**
- **Long term and outcome implications**
  - **Goals of Treatment**

****Beware of competing principles, such as sepsis prevention and management.
-Empiric Abx are often given.
-Note that patient safety is first priority.

******BUT, If patient is stable, Abx can wait!

Diagnosis Suspected MSK infection
H & P: History

- Chief Complaint
  - Involved Joint(s)/ bones/ structures, (PAIN) +/- mobility issue
  - Recent infection, injury, surgery, other contamination source?
  - Severity/Disability? (Why Now?)
    - Beware the Red Herring! __Dog bite, spider bite, etc.
  - Co-Presenting symptoms (fever, chills, drainage, etc.)
- History/ HPI
  - Timing: Onset/Acute/Chronic/Recurrence
  - H/O surgery or procedure? Injection in area? Pressure injury?
  - Co-morbidities? Substance use? Antibiotic use?
  - (? Old records if h/o procedure/surgery done elsewhere)

Diagnosis of possible MSK infection - H & P: Physical Exam:

- Constitutional –
  - Vitals—Fever, sepsis?
- Involved joint(s)/ region:
  - Pain, swelling, ROM? drainage? Incision/ scar? Stiffness?
  - Crepitus? Fluid wave? Ecchymosis? Erythema? Edema
  - Shiny swelling/cellulitis? Skin breakdown? Fistula? Bulla?
  - Distant involvement?
- Associated swelling? Concern for DVT?
  - Calf pain? Thigh pain? Lymphangitis?
- Other joint pain/swelling/stiffness?
  - Contralateral limb?
- Neuro involvement?
  - Numbness/ tingling/ paresthesia? radiation?
  - Response to neuro tension / compression signs/ SLR, tinel's

Principles of Management

- Host optimization
  - Sepsis management, co-morbid factor management
- Wound/ local environment optimization
  - Thorough debridement, stabilization
- Targeted antibiotics
  - Cultures first
  - Dosage, local concentration affect potency
  - Antibiotic stewardship
- Role of Musculoskeletal stability—Catch 22
  - Foreign body involvement—Biofilm?
  - Err to side of stability, first *when possible
    - (infected bones can often heal while treatment is in progress)
  - Wound management—address anatomic factors
  - Anatomic barriers? Coverage?

Principles of Management

Best Practice- Painful Prosthetic Joint (many similarities to native joints)

- **Clinical Practice Guideline (AAOS)**

- **BLOOD TESTS FOR PREOPERATIVE DIAGNOSIS**
- **A. Strong evidence supports the use of the following to aid in the preoperative diagnosis of**
- **prosthetic joint infection (PJI):**

- **• Serum erythrocyte sedimentation rate (ESR)**

- **• Serum C-reactive protein (CRP)**

- **• Serum interleukin-6**

- American Academy of Orthopaedic Surgeons. Diagnosis and Prevention of Periprosthetic Joint Infections Clinical Practice Guideline. https://www.aaos.org/pjiguideline. Published March 11, 2019.

Principles of Management

Best Practice- Painful Prosthetic Joint (many similarities to native joints)

- **Clinical Practice Guideline (AAOS)**

- **DIAGNOSIS OF INFECTED JOINT REPLACEMENTS**
- **SYNOVIAL FLUID TESTS**
- **A. Moderate strength evidence supports the use of the following**
- **to aid in the diagnosis of prosthetic joint infection (PJI):**

- **• Synovial fluid leukocyte count and neutrophil percentage**
- **• Synovial fluid aerobic and anaerobic bacterial cultures**
- **• Synovial fluid leukocyte esterase**
- **• Synovial fluid alpha-defensin (α-defensin)**
- **• Synovial fluid C-reactive protein (CRP)**
- **• Synovial fluid nucleic acid amplification testing**
- **[e.g., polymerase chain reaction (PCR)] for bacteria**
- Strength of Recommendation: Moderate
- *Description: Evidence from two or more "Moderate" quality studies with consistent findings, or evidence froma*
- *single "High" quality study for recommending for or against the intervention.*
- American Academy of Orthopaedic Surgeons. Diagnosis and Prevention of Periprosthetic Joint Infections Clinical Practice Guideline. https://www.aaos.org/pjiguideline. PublishedMarch 11, 2019.

Principles of Management

Best Practice- Painful Prosthetic Joint (many similarities to native joints)

- **Clinical Practice Guideline (AAOS)**

- A**VOIDING INITIATING ANTIMICROBIALS PRIOR TO OBTAINING INTRA-**
- **ARTICULAR CULTURE IN PATIENTS SUSPECTED OF HAVING PJI**
- *Update of 2009 CPG Recommendation*

- **Moderate evidence supports avoiding administration of antimicrobials in patients suspected of having a periprosthetic joint infection until cultures have been obtained and a diagnosis has been established.**

- Strength of Recommendation: Moderate
- *Description: Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.*

- American Academy of Orthopaedic Surgeons. Diagnosis and Prevention of Periprosthetic Joint Infections Clinical Practice Guideline. https://www.aaos.org/pjiguideline. PublishedMarch 11, 2019.

Why wait to give antibiotics?

- Antibiotics interfere with identification of organism and of *susceptibility to antibiotics*
  - PCR identifies organism but does not show susceptibility
- Culture directed antibiotics are more effective in targeting responsible organism.
- Infection may be polymicrobial, need to identify all organisms possible, even if one has been identified in past
- Aspiration itself may help to decrease bioburden, faster than antibiotics alone.
  - Not as thorough as surgical debridement,
  - Serial aspiration or drain placement can temporize if patient stability for surgery is an issue
  - Less invasive, but less effective at saving the joint.

Antibiotic stewardship

- What is Antibiotic stewardship?
- (responsible antibiotic use—includes) :
  - Use of correct (targeted) antibiotic to treat causative organism
  - Use of least broad spectrum antibiotic applicable to situation
  - Use of antibiotic for correct duration of treatment
  - Prevention of future MDR organism emergence
  - Med economics implications too! (SNF acceptance, $$)
- Competing considerations
  - Prevention of sepsis and effects
  - Accurate identification of and management of significant infection
  - Possibility of polymicrobial infection

Goals of Treatment

- Reduce pain/ discomfort
- Avoid further damage
  - Limit spread of infection*
    - *Eventual eradication of infection*--Probability?
  - Limit collateral damage, e.g side effects, joint damage, valve damge
  - Salvage or Re-establish integrity of joint/structure
  - Promote healing
  - Return patient to optimal function

  - * if infection is diagnosed

x

Diagnostic Studies Laboratory

- CBC/D & P, ESR, CRP,
- Chemistry, Tox Screen
- Assess for Sepsis
- Special tests for specific conditions
  - Cobalt, chrome (MOM bearings), D-Dimer, Lactate, etc.
- Joint Aspiration
  - Use imaging if needed
  - Cell count (consider WBC/Seg threshold in specific situations)
  - Culture (aerobic and anaerobic, Gram stain)
  - Synovasure if prosthetic joint is involved
  - Crystals (not eliminated if prosthetic joint, and do not r/o infection)
- **It is CRITICAL to get joint aspiration PRIOR to ANY antibiotic administration**
- AAOS: CPG for PJI: http://www.orthoguidelines.org/topic?id=1028

Galactic Tour of MSK Infection Cases

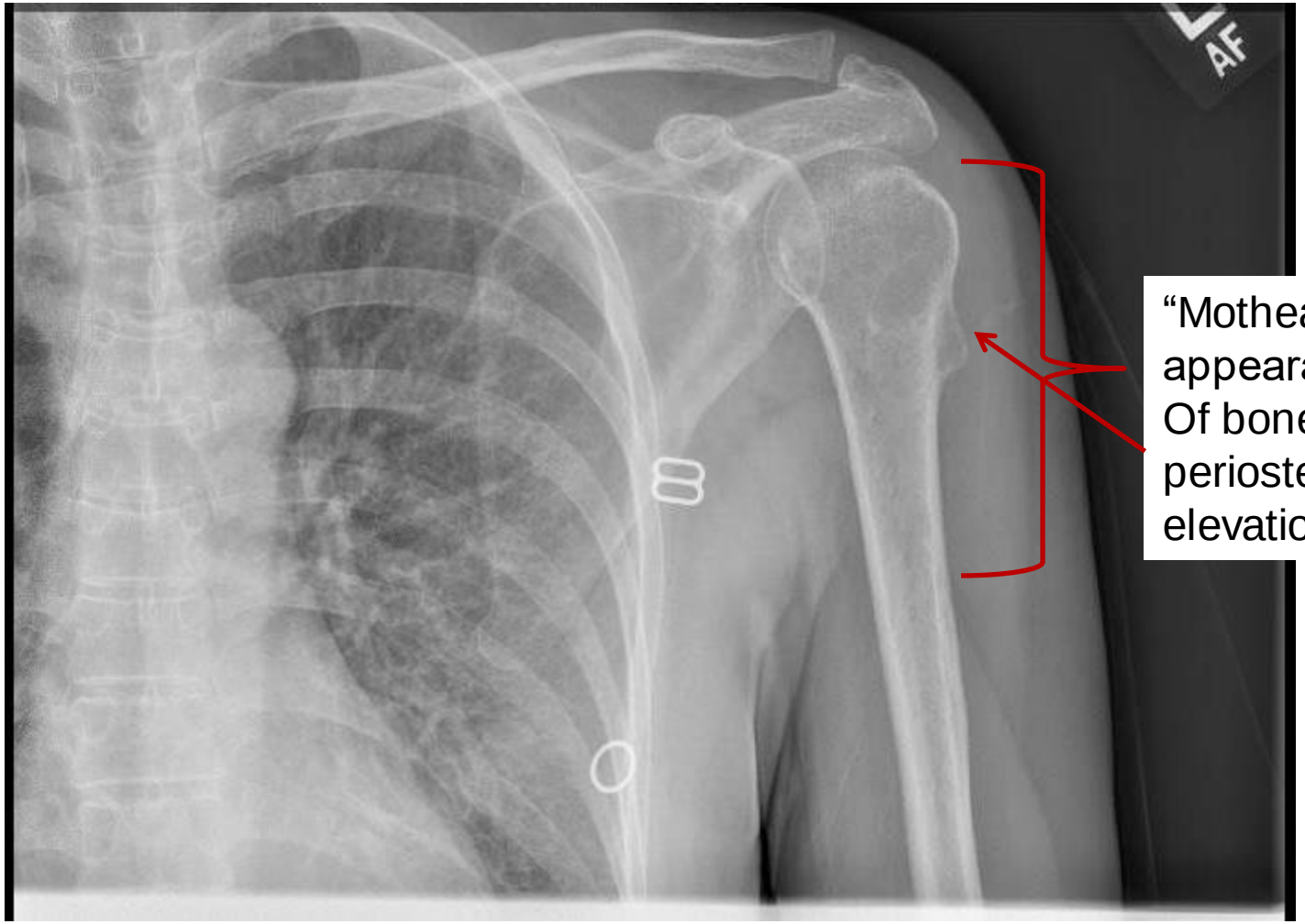
Grab your towel and hang on…

- Hematogenous Osteomyelitis without hardware
- Post Traumatic Osteomyelitis
- Native joint arthritis (hematogenous)
- Prosthetic joint infection 2(+) stage exchange
- Wound related/ abscess
- Hardware related infection
- Decubitus ulcers
- Diabetic foot ulcers
- Other implant (suture, metal) related infection
- ***All Biofilm associated in some way***

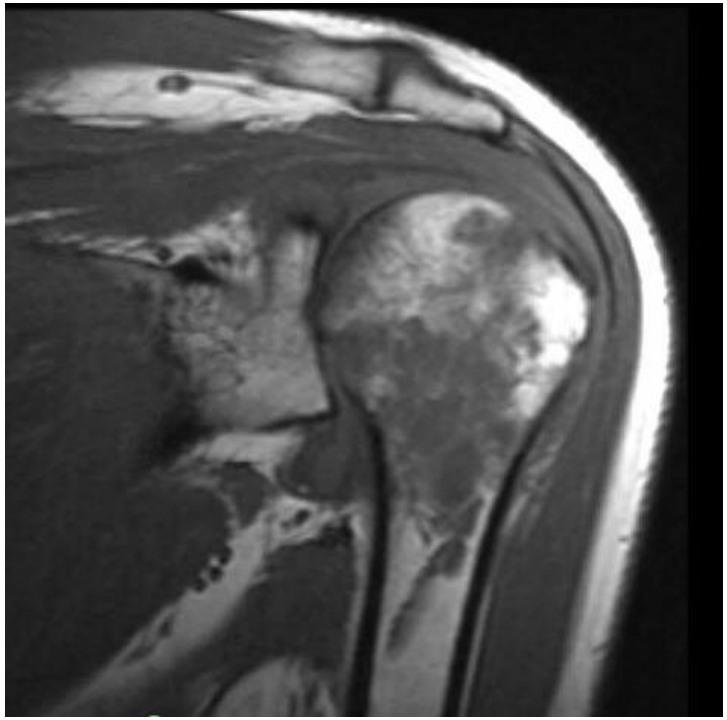
Case: Hematogenous Osteomyelitis

- 51 y.o female, c/o left shoulder pain, no known injury
- HX:
  - Remote h/o Rotator cuff tendonitis
  - Recent h/o “vasculitis”
  - 6 mos. Prior: had I & D of deep neck/ peripharyngeal abscess by ENT (Streptococcus pyogenes)
  - ? Dental origin
  - h/o multi (PO, IV) drug use, tobacco, psych issues
- X-ray, MRI left shoulder showed mass lesion
- Referred to Ortho Oncology for biopsy
  - CT guided biopsy done
  - Pathology: osteomyelitis, **no culture growth**
  - **(“Culture your biopsies, Biopsy your cultures”--**
  - **Like Carrying a Towel—always a good idea)**
- **Referred to me for infection management**

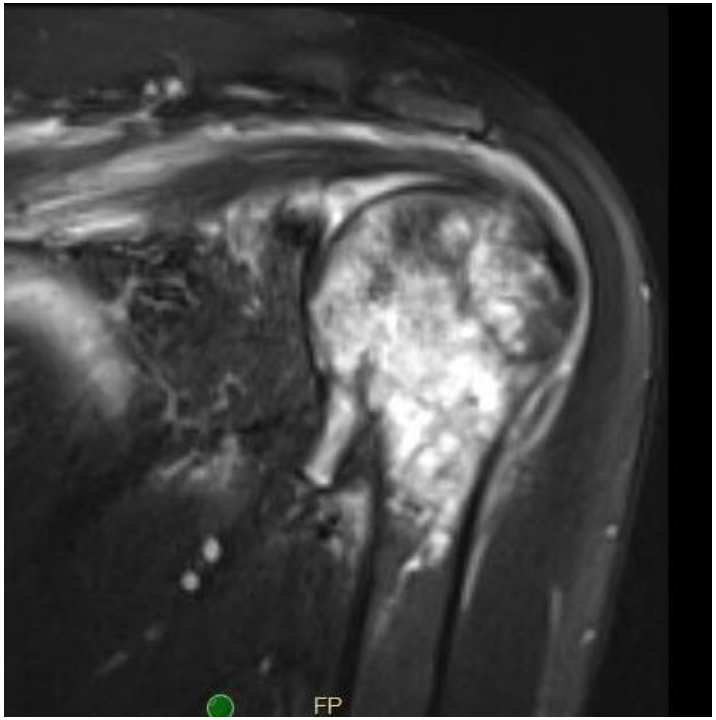
Left shoulder at presentation-
concern for malignancy



MRI Left shoulder (Initial)

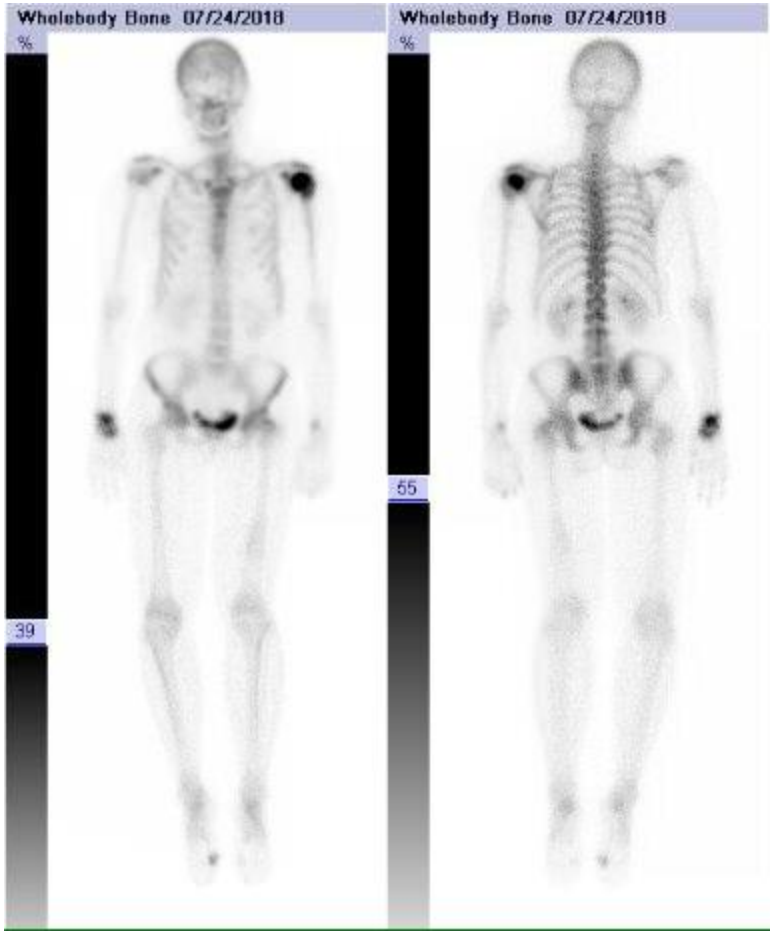


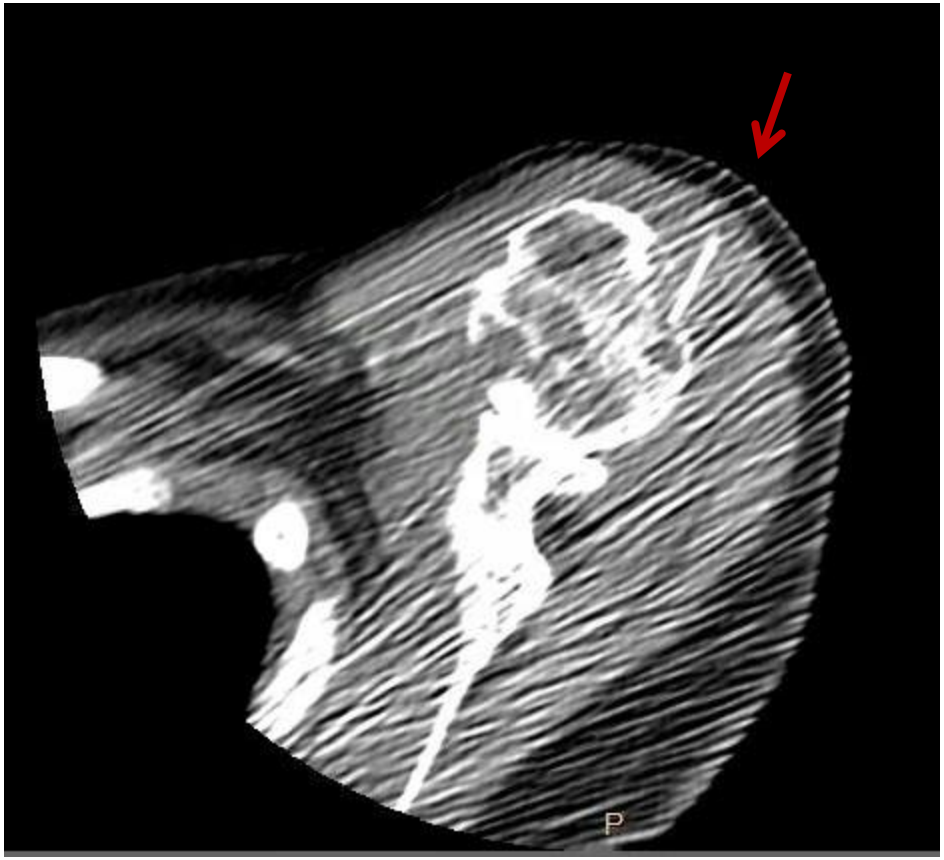
T1 TSE



T2 TSE FS

Radiolabeled WBC scan; CT guided Biopsy





Right Wrist films

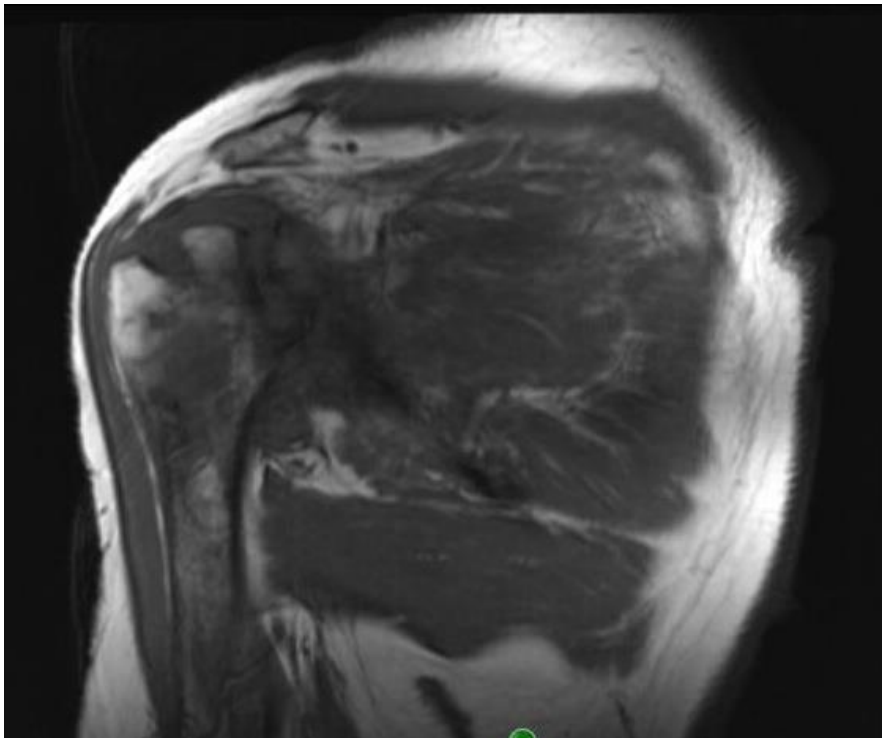
Initial Right Wrist

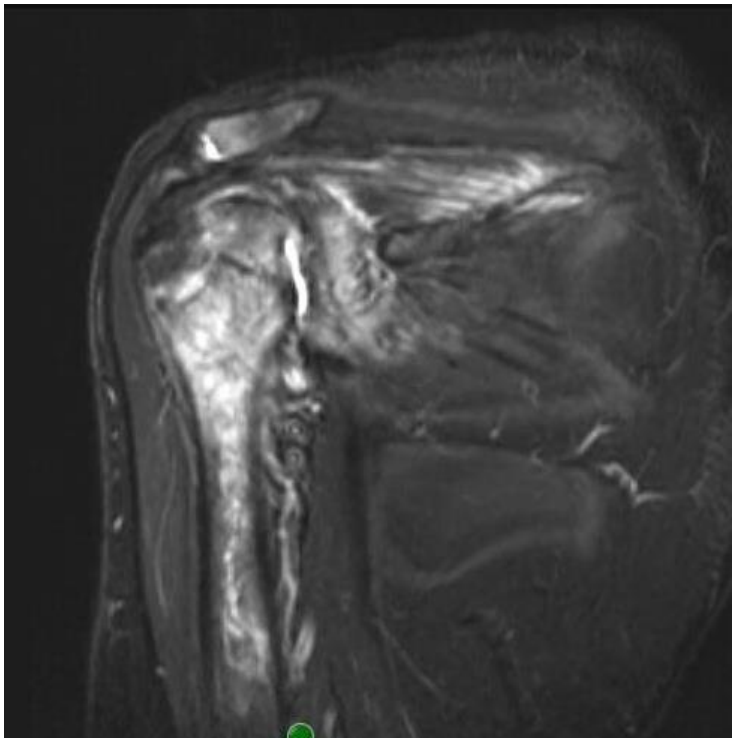
Follow up (+3 mos) Right Wrist

"Chronic Multifocal Osteomylelitis"

- C-M Type 4 –Diffuse
- Multiple sites—disseminated
- Type C Host
  - Tobacco (+), vasculitis, malnutrition, Psych, Social issues
- IV ABX recommended, PICC placed
- Initial SNF stay
- Lost to Follow up, readmitted, no-show f/u appt
- Surgery considered, essentially contraindicated due to diffuse disease, patient unreliability
- Outcome TBD

F/U MRI 3 mos later





Clinical Science: Classification

Cierny-Mader classification

- Anatomic stage: (location, imaging)
  - 1. Medullary: confined to medullary cavity of bone;
  - 2. Superficial: involves only cortex, often from direct inoculation or contiguous focus;
  - 3. Localized: involves both cortex and medullary bone, stable, does not involve entire diameter;
  - 4. Diffuse: involves entire thickness of bone, often with loss of stability, e.g. infected nonunion;

Left Shoulder 3 mos later

Outcome TBD

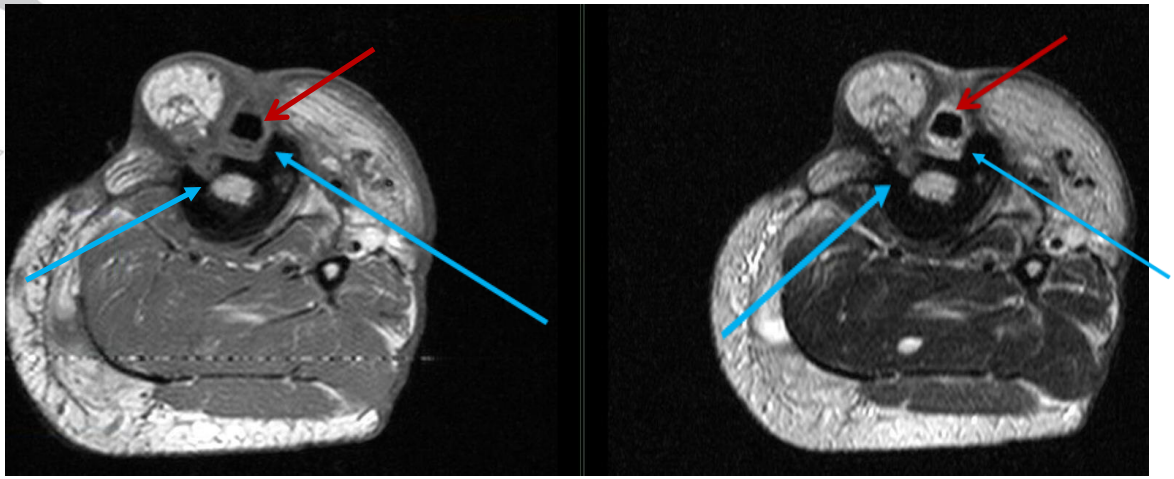
Case : Post traumatic Osteomyelitis with Sequestrum

- 56 Y.O. male [Host Type?]
- c/o chronic draining wound left anterior shin, w/odor
  - No pain, no instability, no comorbidities
  - Ambulatory, mild foot drop, active, educated, employed
  - Neg tobacco, neg substance use, neg ROS
- HX:
  - Ped. vs. MVA 30+ years prior (1981)
  - Gr IIIB Open Tibia fracture Initial Rx with IMN, Latissimus flap coverage,
  - Infection, nail removal
  - Ultimately healed in cast; slight varus
  - Rx with intermittent abx in past, persistent pinpoint drainage with odor, patient covered "wound" daily
- Had sought care in multiple other systems

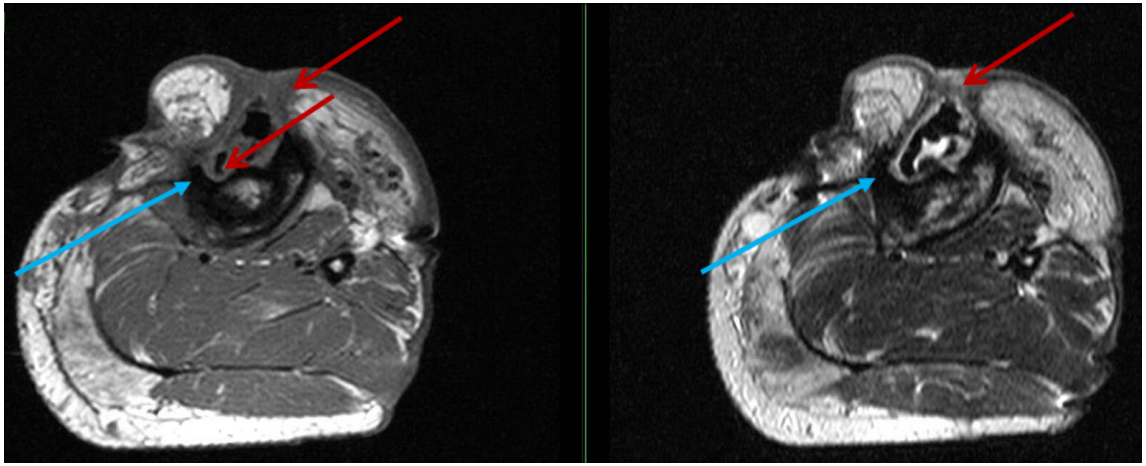
X-ray Left tibia on presentation

MRI Left Tibia on presentation

[Anatomic type?]

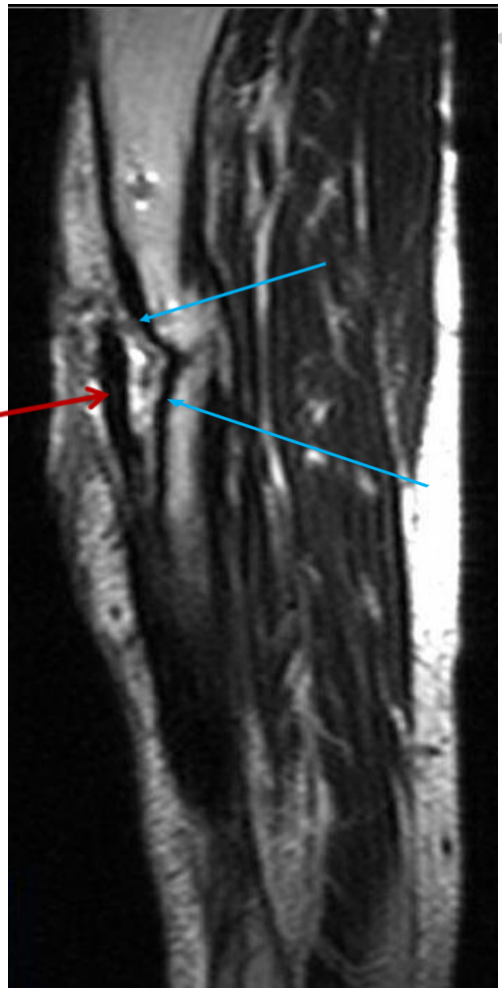


Involucrum, sequestrum



T1 Axial

T2 Axial



T2 Sagittal

Surgery

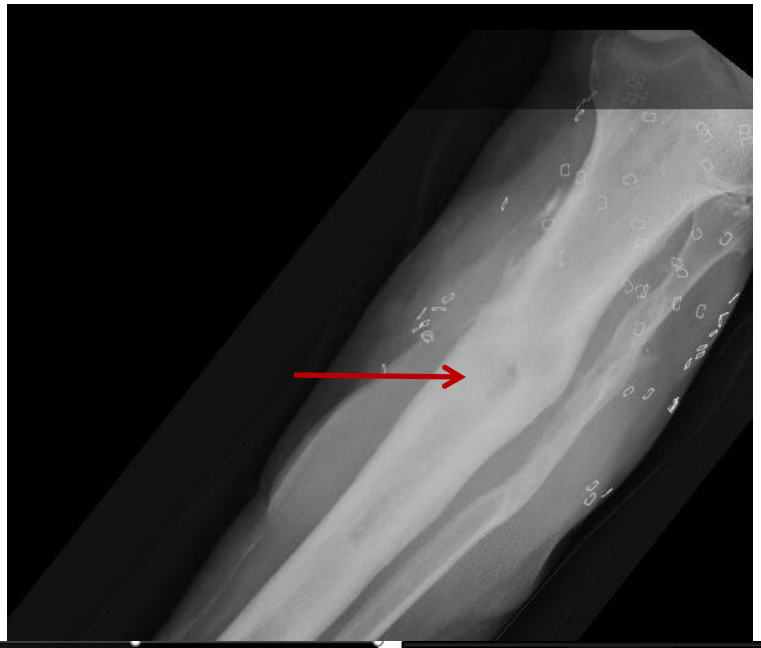
- Flap opened by Plastic Surgeon
- Dissection to bone with limited stripping
- Local debridement
- Loose fragment (sequestrum) of bone identified
- Burr used to remove excess callus and free loose fragment
- "Pan Galactic Gargle Blaster": Calcium Sulfate + Vancomycin and Tobramycin Beads formed and applied
- Flap closed by Plastic Surgery

Follow up Photo

- 3 year Follow up
- No recurrent drainage

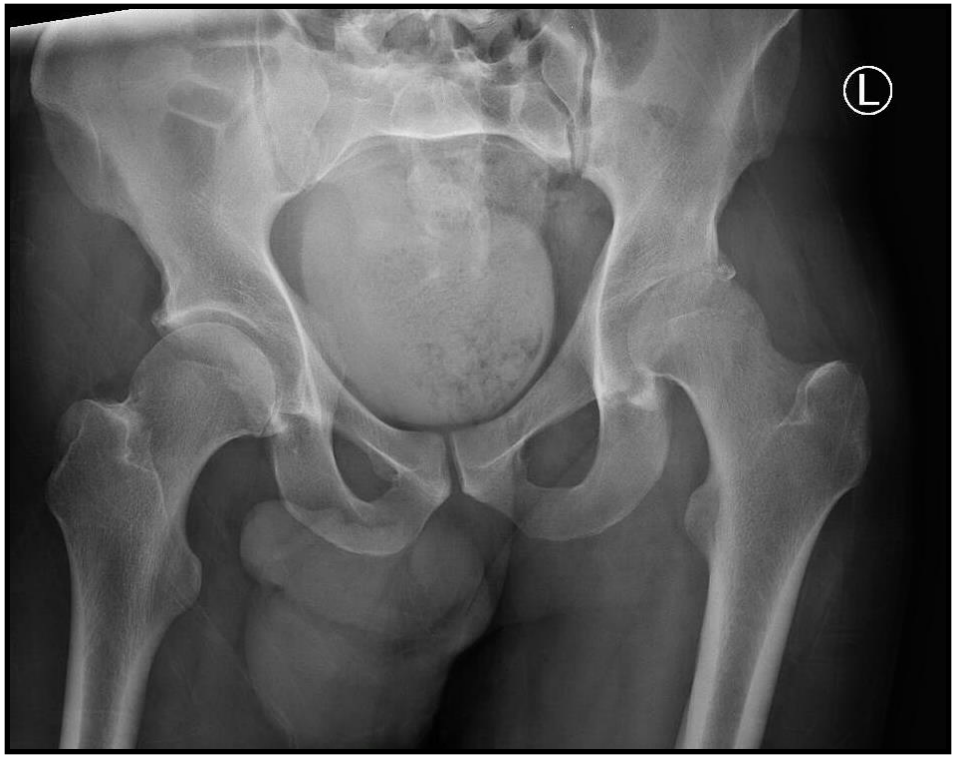
- Arrow Shows site of prior drainage

3 Year Follow up X-ray Left Tibia



Case: Native Joint Infection (Septic Arthritis)

- 33. y.o. male, several weeks worsening Left Hip pain (2016)
- Now unable to bear weight --Worsened after twisting injury
- Hx: poly substance abuse, + tobacco, + EtOH
- No prior h/o hip or ambulatory problems
- BP:136/75, p: 104, T: 101.6 ° F , RR:16, , SpO2 96 %.
- CRP- 194, ESR- 98



Pelvis film:
progressive arthritis

Clinical Science: Classification

Cierny-Mader classification

- Anatomic stage: (location, imaging)
  - 1. Medullary: confined to medullary cavity of bone;
  - 2. Superficial: involves only cortex, often from direct inoculation or contiguous focus;
  - 3. Localized: involves both cortex and medullary bone, stable, does not involve entire diameter;
  - 4. Diffuse: involves entire thickness of bone, often with loss of stability, e.g. infected nonunion;

Review: Goals of Treatment

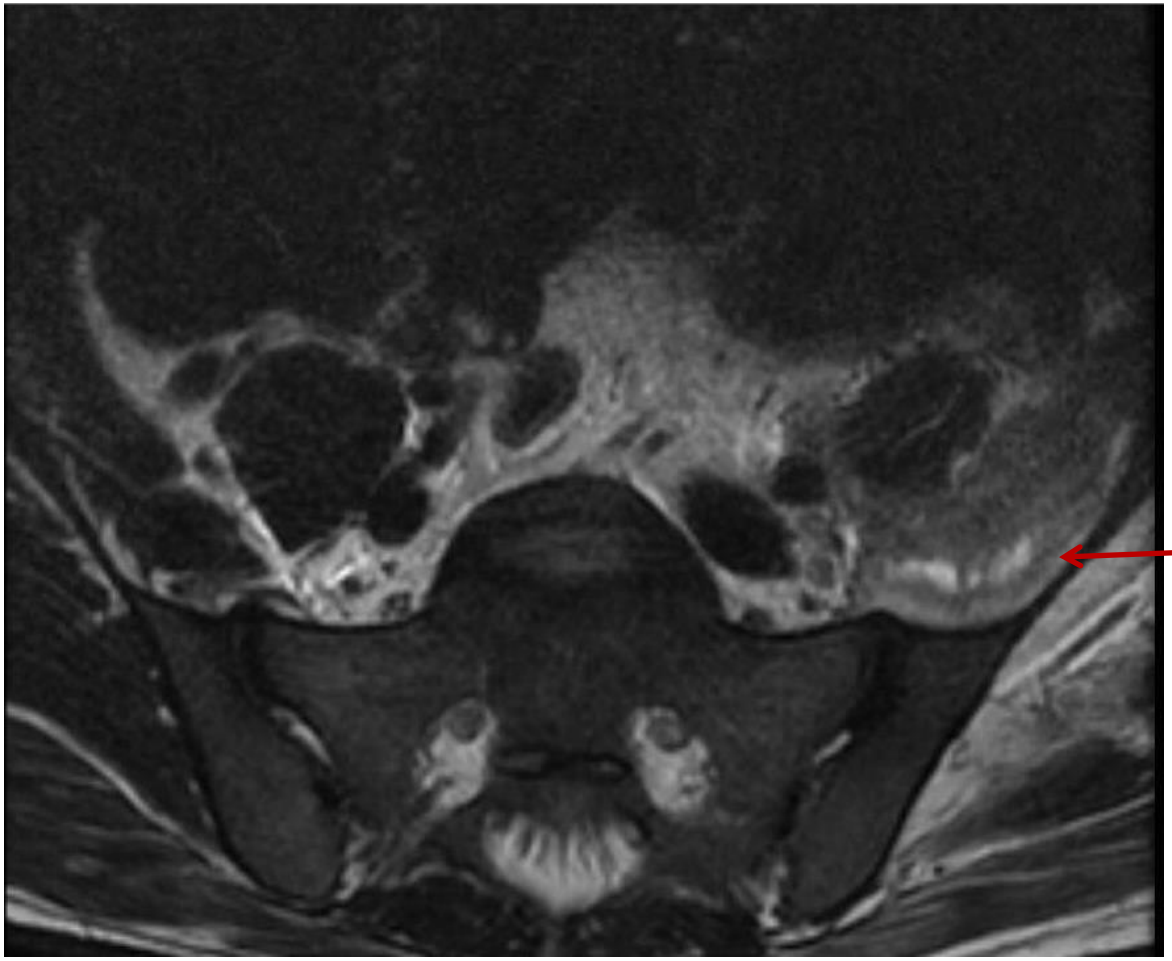
- Reduce pain/ discomfort
- Avoid further damage
  - Limit spread of infection*
    - *Eventual eradication of infection*--(IM)Probability?
  - Limit collateral damage, e.g side effects
  - Salvage or Re-establish integrity of joint/structure
  - Promote healing
  - Return patient to optimal function

  - * if infection is diagnosed

Treatment plan

- Urgent surgical arthrotomy, I & D left hip
- Intraop cx: PCN -R MSSA
- Infectious Disease consult,
- Blood Cultures, Echocardiogram for endocarditis surveillance, (all Neg.)
- Post op. Spine MRI: Iliacus Muscle abscess
- Rx Vancomycin (dosing convenience) x 6 wks per ID
- Plan: surgery to drain iliacus abscess
  - (Improbability –better to stay away most of the time, like Vogon poetry. Never Happy.)

MRI Spine with iliacus abscess



Post op films

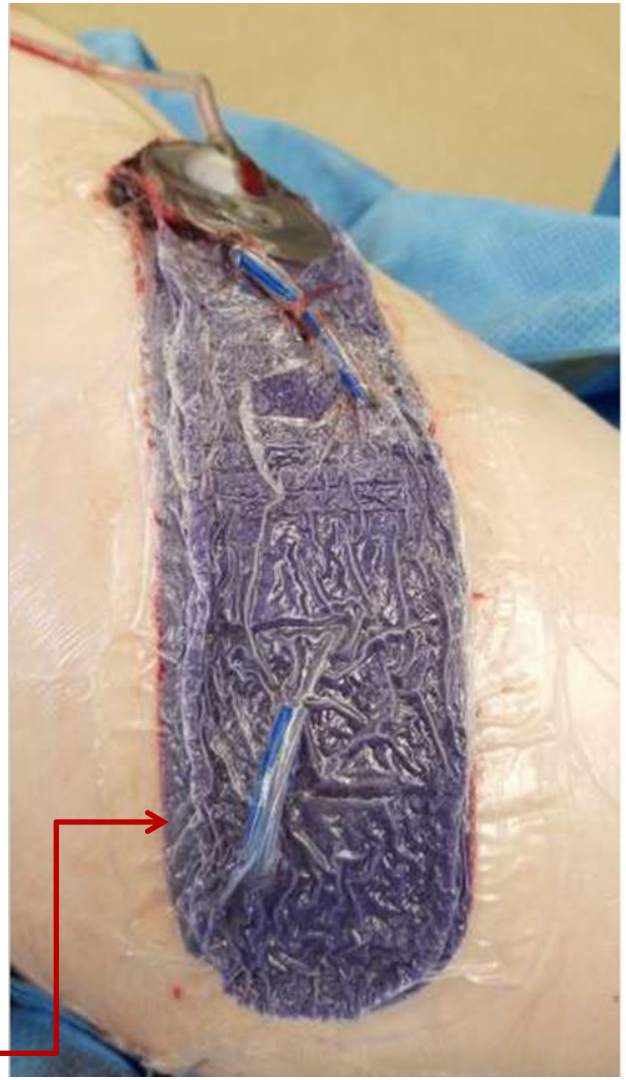
Continued course

- Surgery 4 days Postop: I & D pelvis, drain placed
- Noted to have poor dentition
- Patient discharged with IV Abx per Home Health, (Mother's house)
- Sketchy ID f/u—says he took all doses of vanco
- Continued pain, stiffness, amb with 2 crutches
- 1 mo f/u pelvis xray: progressive joint deterioration
- CRP decreased to 16 (10) , ESR to 51 (30)
- Patient became incarcerated, lost to follow up

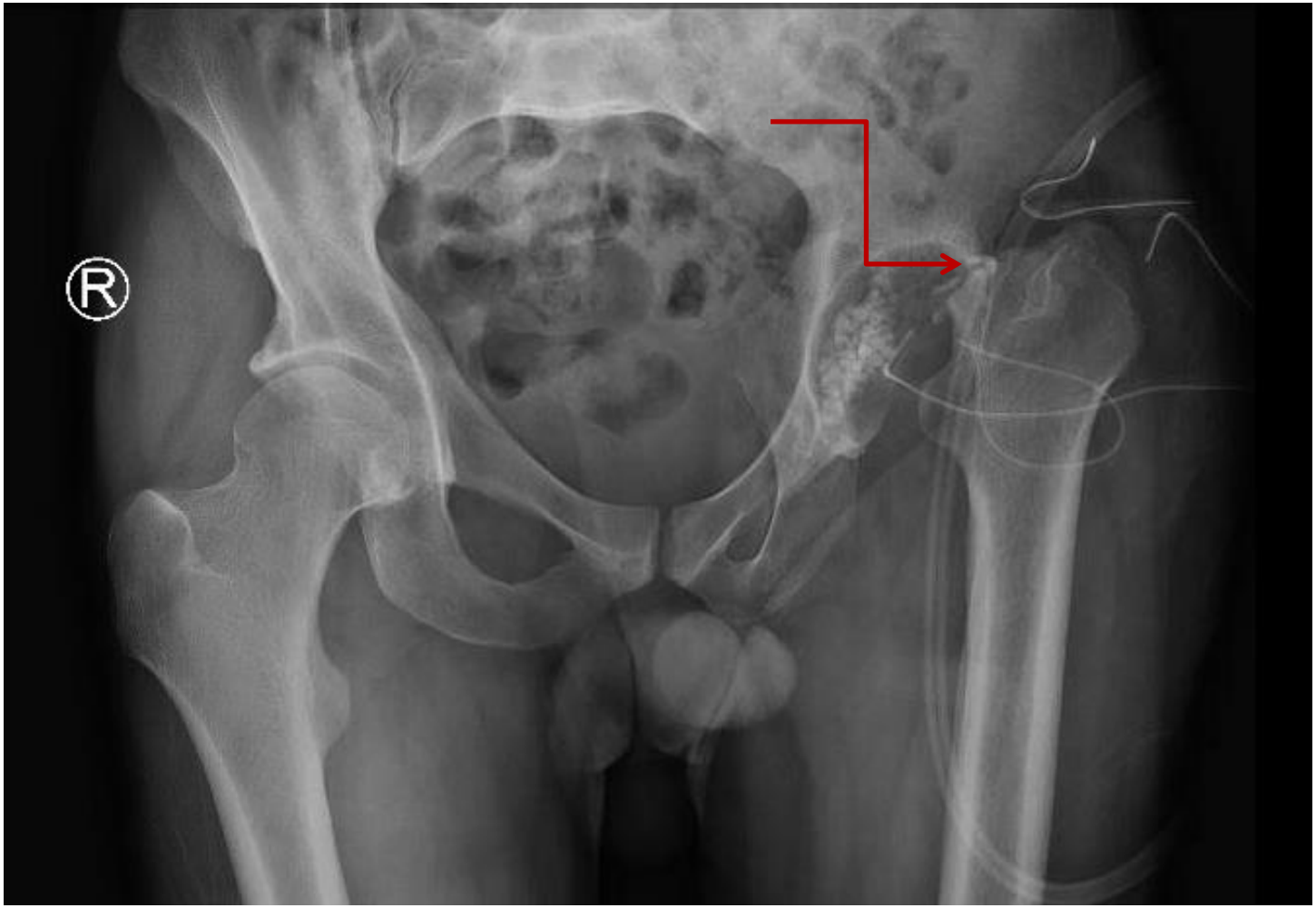
Back Again....

Surgical Rx: staged Girdlestone Procedure

- Stage 1: fem head resection , I & D, cultures
  - left open with Negative pressure wound therapy (NPWT) fluid instillation
    - intermittent irrigation) 4 days
  - IV antibiotics
- Stage 2: return to OR for repeat I & D,
  - Absorbable antibiotic beads (Calcium sulfate with Vancomycin, tobramycin)
  - Closure, with incisional NPWT and Drains
- Plan: Continue IV ABX per ID service recommendations
  - NWB, Progress WB slowly after 1 month
  - Discharge with Home Health for IV Daptomycin
  - Incisional NPWT to be removed @ 3 weeks



s/p Girdlestone femoral head resection



Ongoing course..

- Returned 1 weeks post discharge with “seizure”
- Appeared intoxicated, had withdrawal-like episode
- Found to have amphetamines, marijuana and oxycodone on drug screen
- Confusion, pulled out PICC
- Recovered mental status, multiple problems.
- Required drain placement due to fluid collection

Typical problems for Girdlestone patients

- **Patients Hate** Girdlestone status
- Difficulty with pain control, spasms, drainage from wound, poor ambulation, leg length difference
- Required drain placement due to fluid collection
- 3+ week stay—Patient was difficult to place
- Patient became motivated to improve –for his child
- Decided to offer articulating PMMA antibiotic spacer for improved function (I'm probably crazy)
- Eventual Conversion to THA possible, if patient meets criteria
  - clean, & sober, no tobacco, stable living situation
  - Remains to be seen…..limited f/u

“Prostalac” PMMA + endoskeleton spacer

Case: Prosthetic joint infection

- 62 y.o Female c/o near-syncope, Rt. Knee pain after fall
  - Hx: bilat TKA 2 years prior at another institution
    - No problems until fall on stairs 1 month ago, again 2 days ago
    - No complaints about left knee
  - HX past IV Cocaine use, no smoking
  - Afebrile, hypotensive on presentation
    - Stabilzed, labs, ESR, CRP, WBC elevated
  - Rt knee aspirated, synovial fluid WBC > 1000000 (nl 1000)
    - Cultures grew Gp G Beta hemolytic Strep
  - Explant and Spacer Planned
    - Extensive debridement done, antibiotic loaded PMMA

Diagnosis of infected joint

- Clinical picture
  - hot, red, swollen joint, etc.
  - Malaise +/- fever, pain "micromotion"
- Laboratory
  - Serum inflammatory markers
    - ESR, CRP, CBC with differential and platelets
  - Synovial fluid aspiration, analysis and culture
    - WBC count with differential
      - WBC different for native and prosthetic joints.
    - Microbial identification -*all*
    - Antibiotic susceptibility
    - Synovial fluid biomarkers
      - Alpha defensin, IL-2,CRP, etc

Diagnosis (Painful prosthetic joint) Differential diagnosis

- Infection
  - Acute: Postop(contamination)/hematogenous
  - Chronic: Recurrent/Persistent
- Loosening/ wear (aseptic)/particle disease
- Fracture/ Dislocation/catastrophic failure
- Hematoma/DVT/Inflammatory arthropathy/ Arthrofibrosis
- Other instability—ligamentous failure, component malposition/ mismatch

Presenting X-Rays

"Mobile" PMMA + ABX spacer placed after explant of first TKA

Interim course

- Hospital course benign,
  - Patient improved
  - IV abx
  - Blood Cx pos then cleared, TEE : possible vegetations
  - PICC placed for IV Unasyn
- Patient discharged to SNF for rehab and IV antibiotics
- Office f/u consistent, drainage at first, then resolved.
  - Difficulty with pain, WB restrictions
  - Saw dentist, ID, had Joint aspiration with Cx neg and low WBCs, markers downtrending reports quitting drugs, screen OK.
- Replant scheduled

Rt TKA revision, 8 mos after explant

- Preop aspiration negative
- Some Suspicious material seen intraop
- All intraoperative cultures negative
- Preop screen for SA pos (MSSA)..

Re-presented, 2 yrs 3 mos after initial explant, (1 yr, 8 mos after initial replant)

- Presented to ED with multiple c/os
- Wrist abscess “Spider bite”
  - Put on oral ABX
- Large effusion rt knee, flexion contracture noted
- Drug screed pos. for opioids and oxycodone
  - ? Heroin use
- Office F.u: delayed aspiration planned due to ABX
- In ED 2 weeks later with intolerable pain, effusion
  - WBC 12.1 ESR >130 CRP 42.1
  - Aspiration done, WBC: 8>8000, then > 1200
  - Cultures pos Candida Paraspilosus
- Repeat Explant planned

Interim course

- Cultures pos Candida paraspilosus
  - Susceptible to fluconazole (oral)
  - ID Recc: 4 month course and 6 mos after replant
- Explant and placement of Non mobile spacer with brace
- Patient discharged to SNF for rehab

3 mos after 2nd explant: “non mobile” spacer

Interim course after 2nd explant

- Fluconazole to continue
- Spacer not designed for motion, put patient moves it, bony erosion noted on xrays
  - needs brace to stabilize, patient not wearing
- Pain control issues
- Preop workup neg cx, ESR 76 (30), CRP 6 (10)
- Synovasure neg (off label)
- Pain med use issues, otherwise neg (?)
- Replant planned
- “Tumor prosthesis” with hinge needed due to extensive bone loss

Rt.TKA revision 2.5 years after initial explant

Rt.TKA 2nd Revision

Last Follow up

- Last Ortho F/u
- 1 year s/p replant
- Amb with walker Full WB, still has knee…..
- Limited ROM
- Pain control ….ok
- Opioid use issues, pain procedures done
- Brace recommended, patient avoids
- Dealing with other medical issues
- Continued f/u ortho schedule ---TBD

Management of Chronic wounds

—with or without exposed bone

- principles same
- Optimize host
  - NUTRITION, NICOTINE CESSATION
- Debridement of wounds
- Coverage, (Flap) stop drainage and nutrient loss
- Local and systemic abx.
- Protection of tissues during healing time (Offloading)
- Only the healthiest seem to be able to heal wounds with bone exposed—Optimization matters!

Case: 52 y.o male, h/o remote achilles tendon repair, c/o swelling and drainage

Note: Sutures protruding from draining sinuses

Case: Soft tissue infection associated with permanent sutures

Plan: Surgical debridement and coverage

Multiple permanent sutures found, meticulously removed. Tendon was split longitudinally to follow Kessler suture pattern and preserve strength.

Negative pressure dressing with Na Hypochlorite instillation

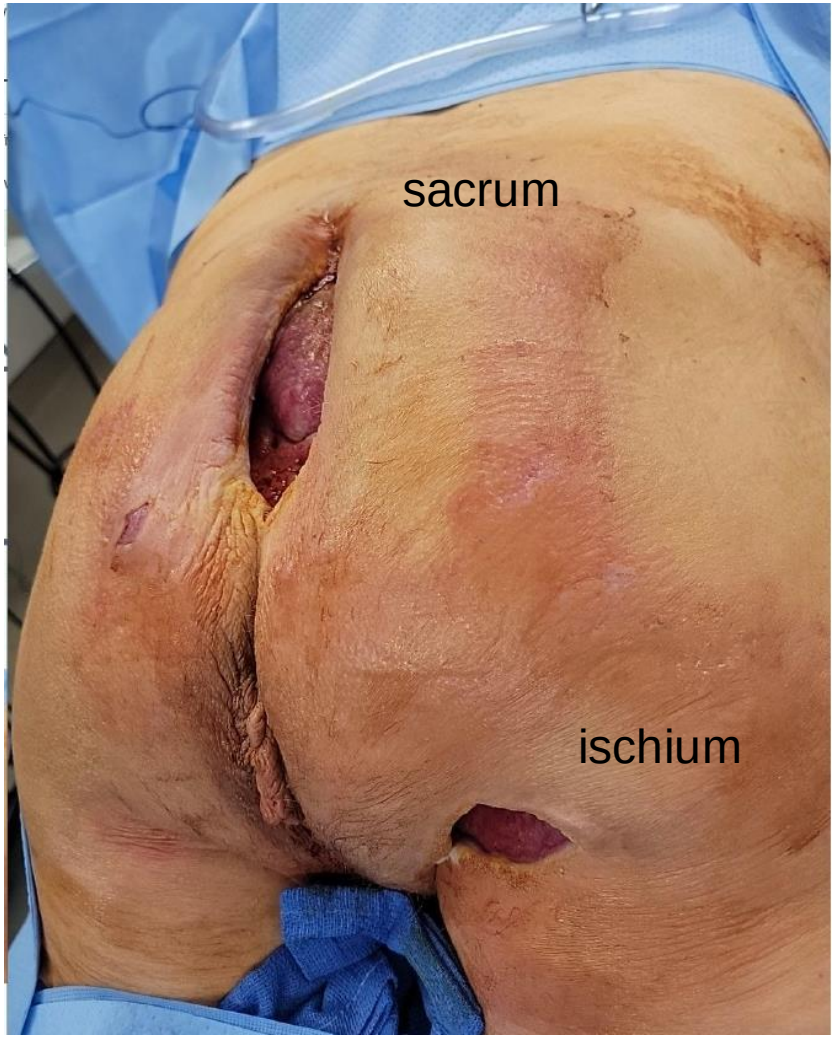
Coverage in process

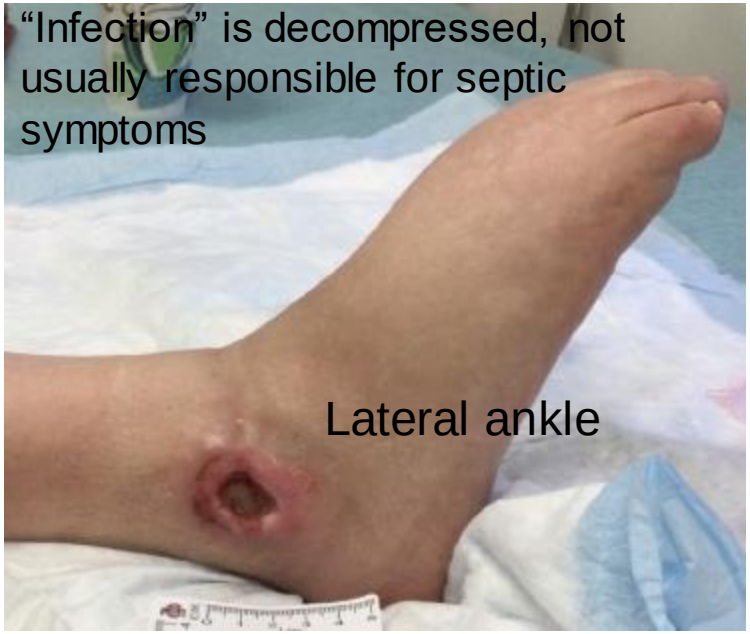
Decubitus Ulcer (2 cases)

reflect inability of tissue to regenerate after injury

- If stage IV, bone is involved, osteomyelitis by definition -- contact with environment
- Risk factors:
- Sensory loss or immobility
- Malnutrition/ Anemia/ Vitamin deficiencies,
- Smoking
- Vascular compromise, ischemia
- Poorly fitting equipment, padding or bracing
- Atrophic conditions e.g. poorly controlled DM
- Cierny –Mader factors contributing to host compromise

Decubitus ulcer wounds--Photos





General Approach: medical optimization, nutrition, debridment, Flap coverage to eliminate contamination.
Often post op antibiotics

Sacrum 4 weeks s/p debridement and coverage

Surgical procedure and protocol

Orthopaedic surgery: debride ulcer surface including bone; Send cultures from deep bone

Plastic surgery: v-y gluteal flap

Absorbable antibiotic beads placed under flap

Follow up antibioitics based on intraop cultures

Bedrest until flap is healed ~6 wks

Lateral ankle 5 days post excision and coverage

Surgical procedure and protocol

Orthopaedic surgery: debride ulcer surface including bone;
Send cultures from deep bone

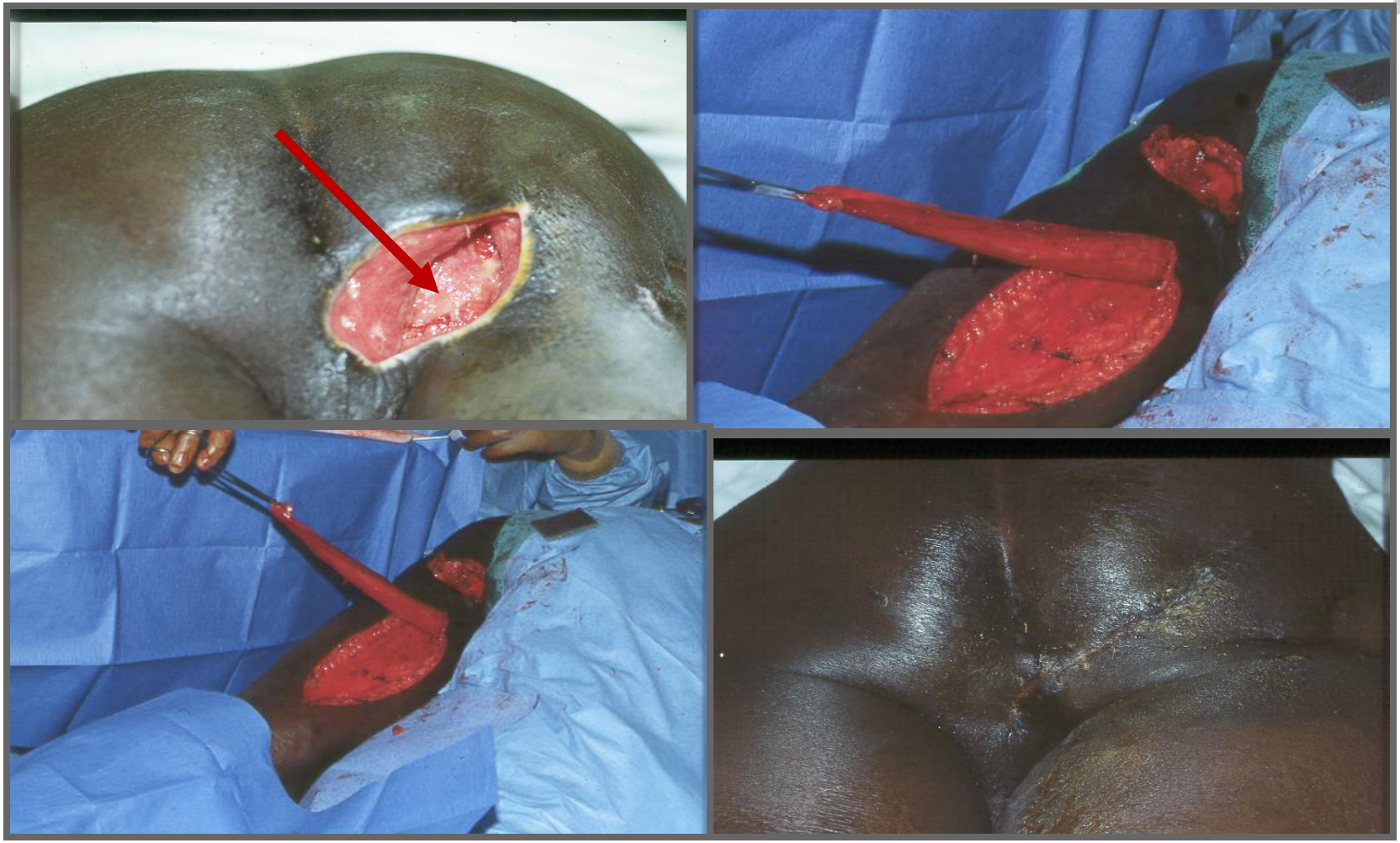
Plastic surgery: rotation flap and skin graft

Absorbable antibiotic beads placed under flap

Follow up antibiotics based on intraop cultures

Protect, elevate until flap is healed ~6 wks

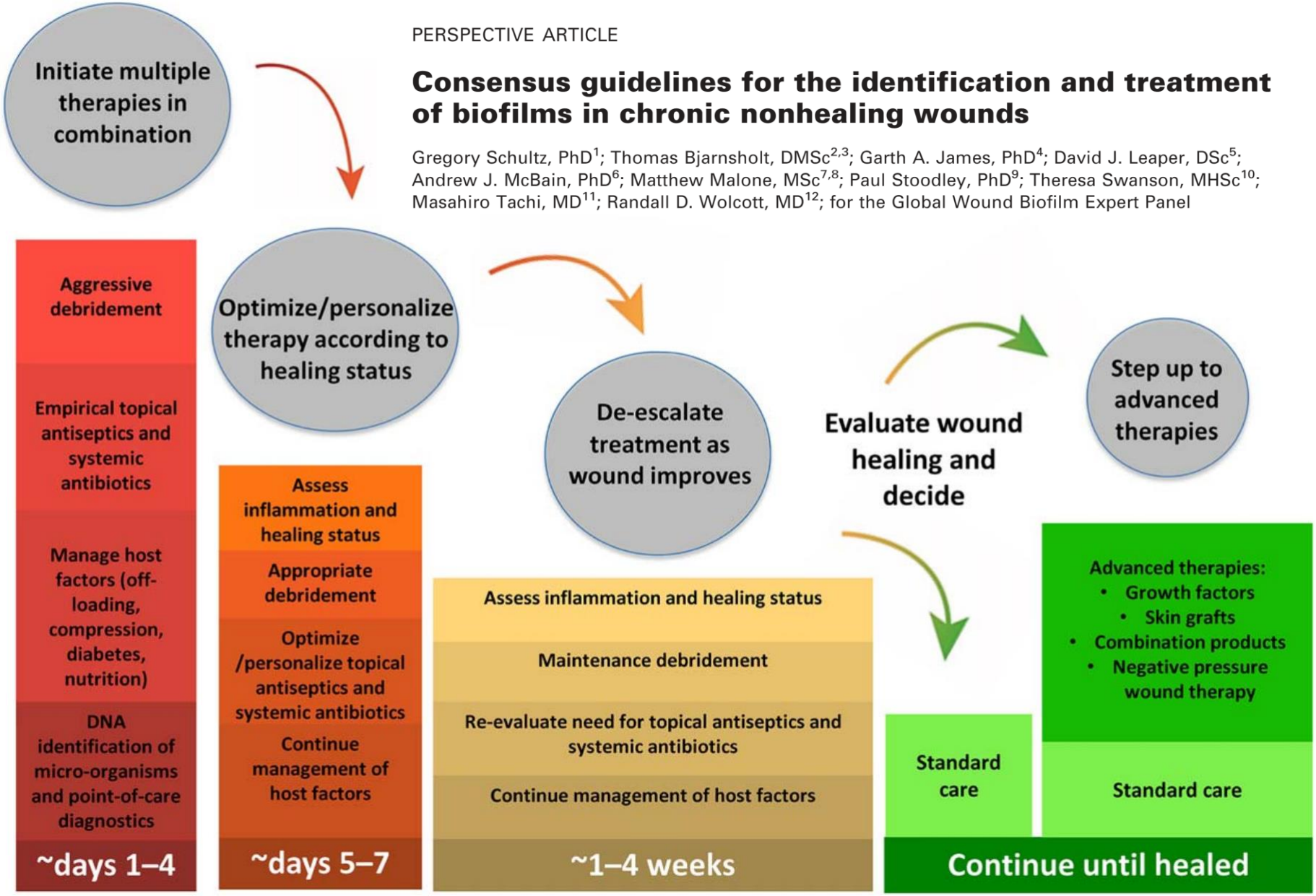
Case: stage IV ischial ulcer—Bone exposed



PERSPECTIVE ARTICLE

Consensus guidelines for the identification and treatment of biofilms in chronic nonhealing wounds

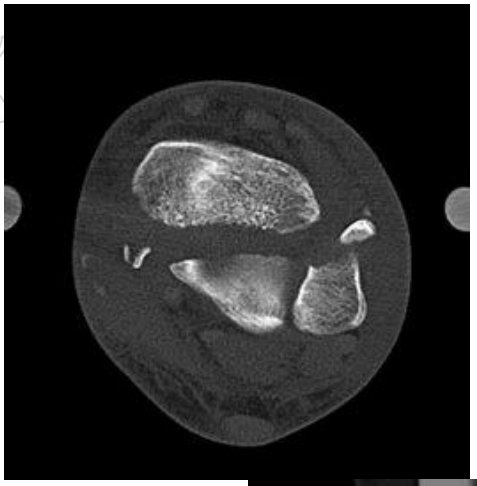
Gregory Schultz, PhD[1]; Thomas Bjarnsholt, DMSc[2,3]; Garth A. James, PhD[4]; David J. Leaper, DSc[5]; Andrew J. McBain, PhD[6]; Matthew Malone, MSc[7,8]; Paul Stoodley, PhD[9]; Theresa Swanson, MHSc[10]; Masahiro Tachi, MD[11]; Randall D. Wolcott, MD[12]; for the Global Wound Biofilm Expert Panel

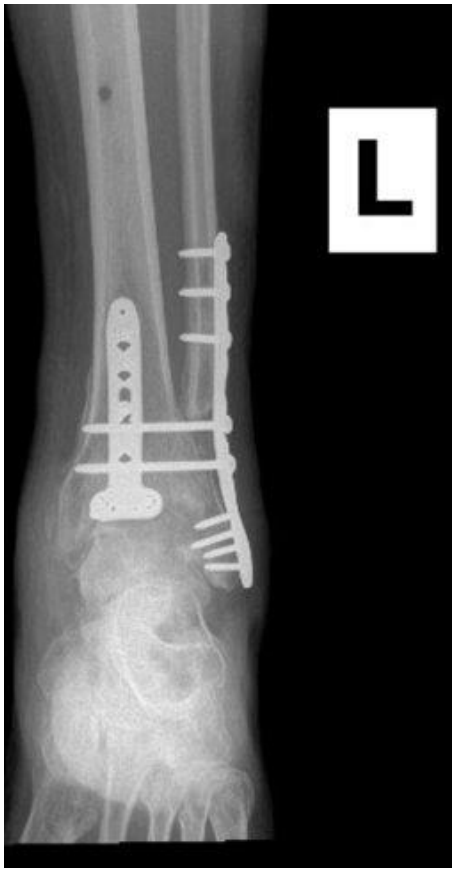


Case: 41 y.o. male s/p Altercation, c/o Left ankle injury

EX FIX applied;
--maintain length
-- allow early soft tissue healing

CT scan followed by definitive fixation, note progressive joint space loss (4 mos)





Intermittent drainage reported- MSSA osteomyelitis

Plan: Hardware removal, debridement, ABX bead placement, IV ABX

Future direction: ....Fusion?

Diabetic Foot Wound Management

- Local wound care is used as long as possible
- Host optimization, local wound optimization
  - Often managed in a wound center or by podiatrists/ specialists
  - Multiple modalities:
    - Advanced dressings, Skin substitutes
    - Offloading, Total contact cast, CROW boot, Specialty shoes
- Surgery is last resort, often for amputation vs. limb salvage
- Critical points:
  - Team approach
  - Patient optimization, engagement and cooperation
  - Expert surgical technique
- The following cases are shown with permission of Rajiv Chandawarkar MBBS

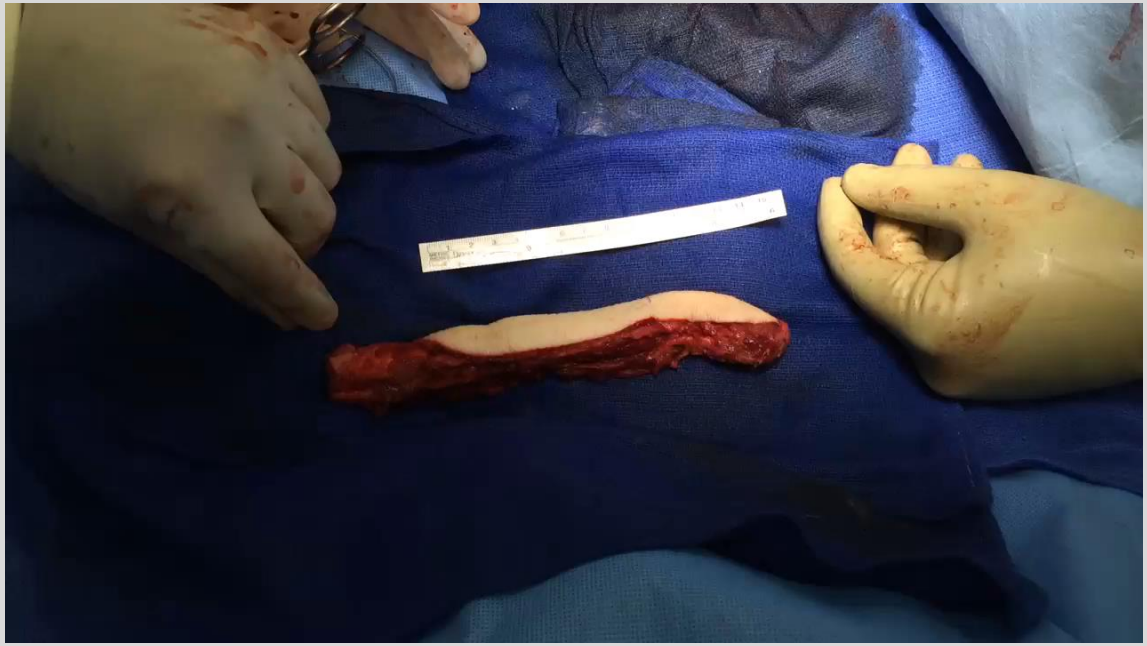
Calcaneal reconstruction with microvascular double/single barrel fibula osteocutaneus flap

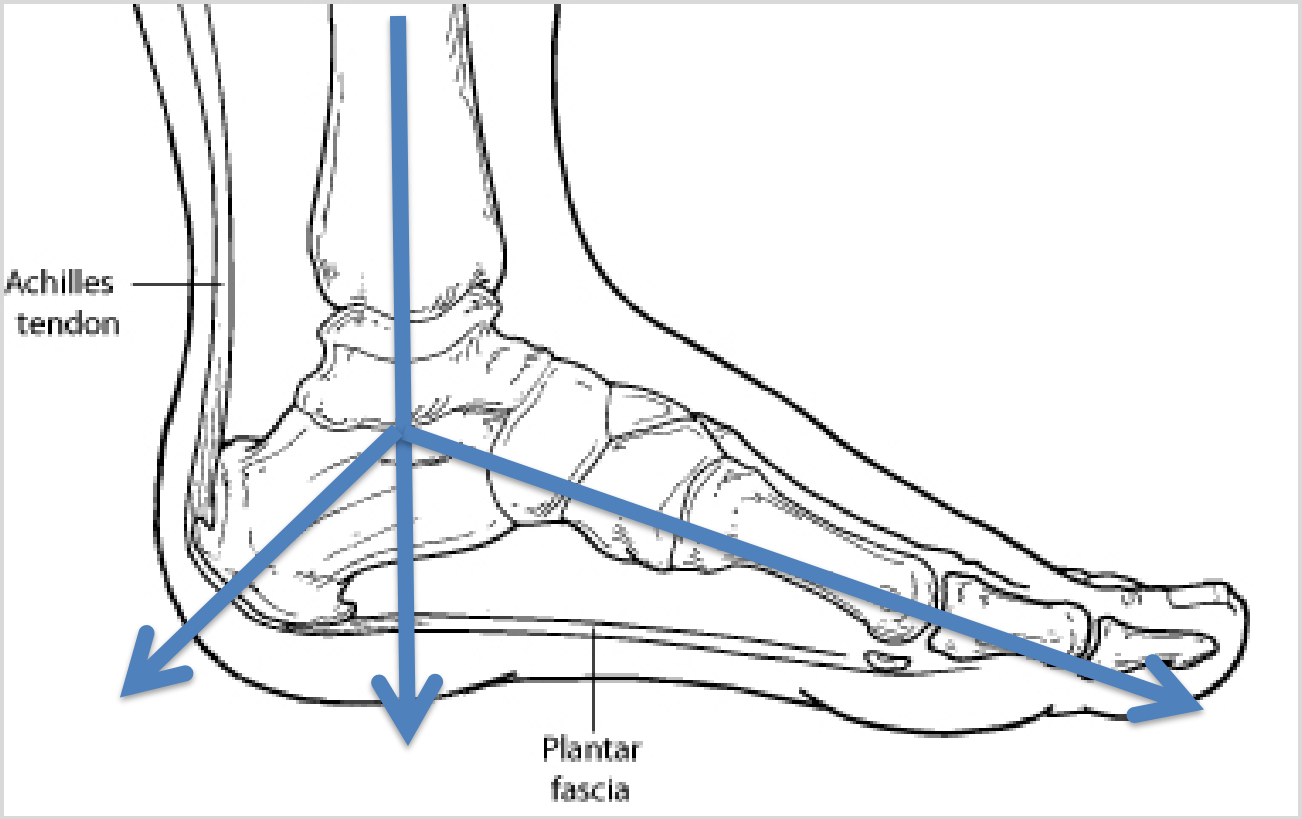
Background

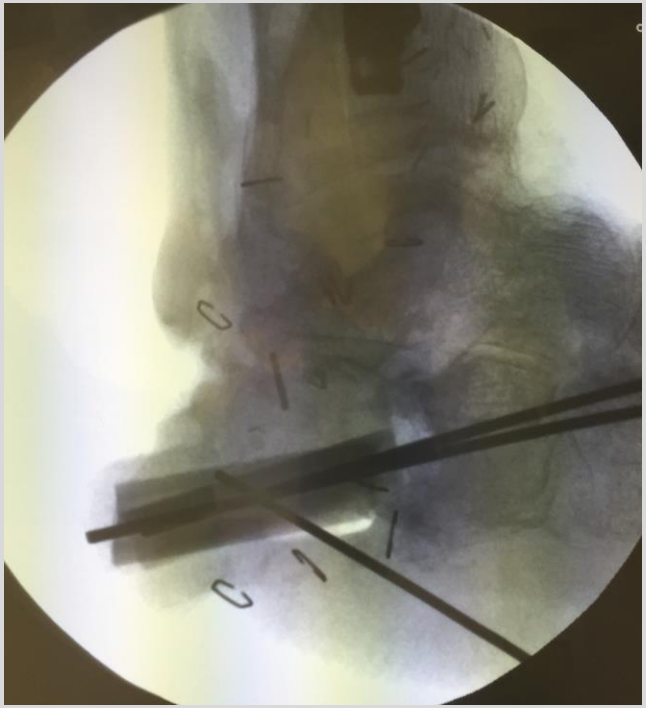
Calcaneal destruction commonly occurs in diabetics - usually necessitates a below-knee amputation since the central weight-bearing mechanism is lost and reconstructive choices are limited.

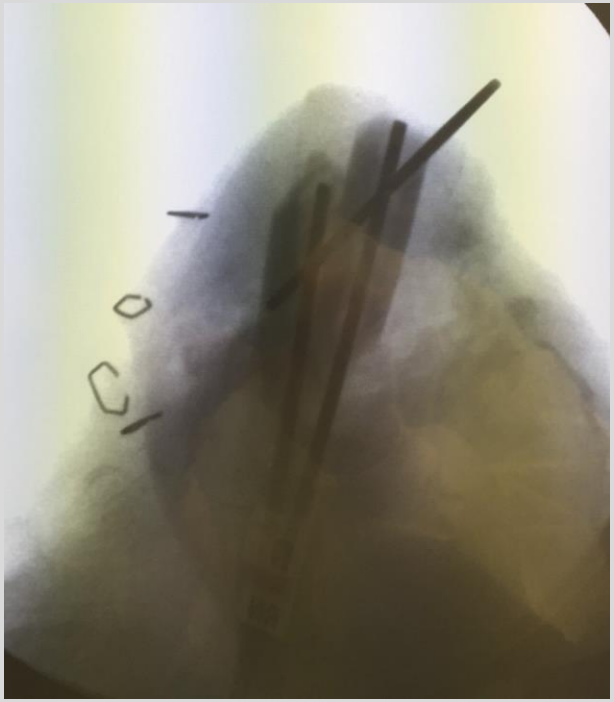
Here we present two cases of calcaneal reconstruction, using double/single-barreled fibular osteocutaneous free flaps.

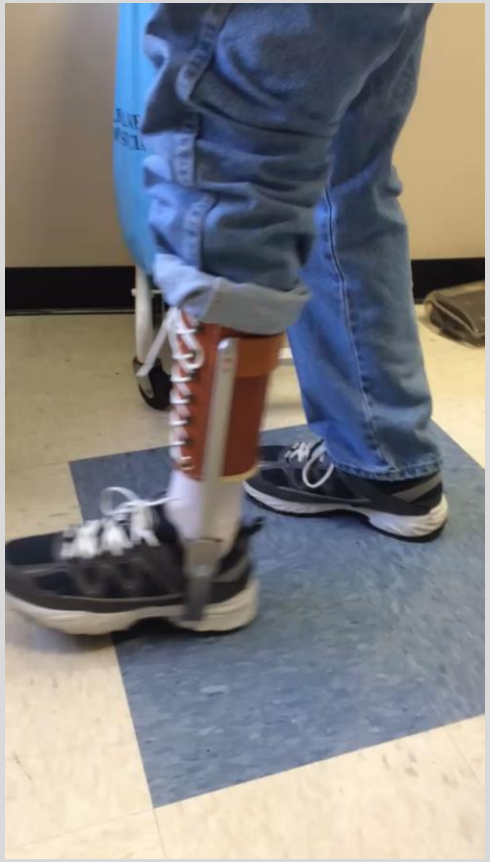

PORT




Achilles
tendon
Plantar
fascia







Currently, this patient walks without support and has resumed his job as a supervisor in a tree-cutting agency





Currently, this patient walks without support and has resumed his job as a short-distance truck driver.
He even takes his Harley out, once in a while!

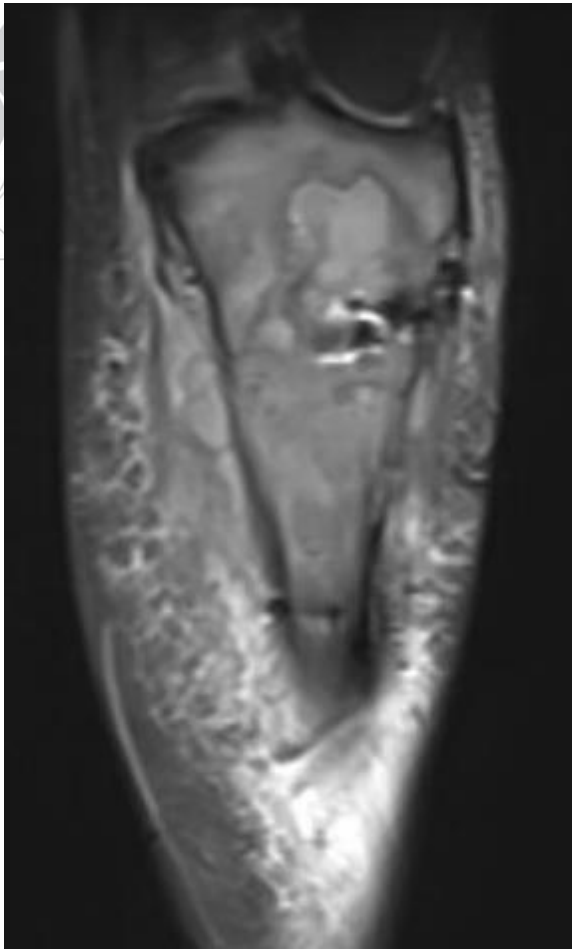
Case: multi abscesses/ soft tissue infection, due to septic emboli, pressure, IVDU

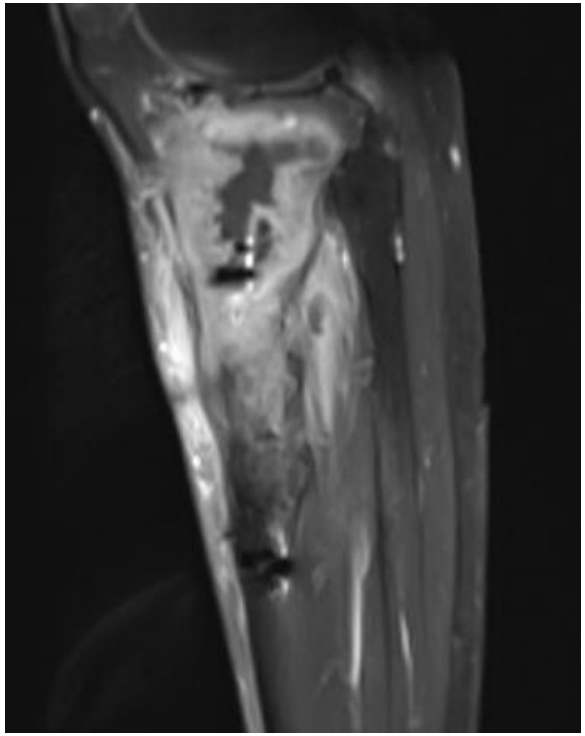
- 22 Y.O. female, IVDU, endocardits.

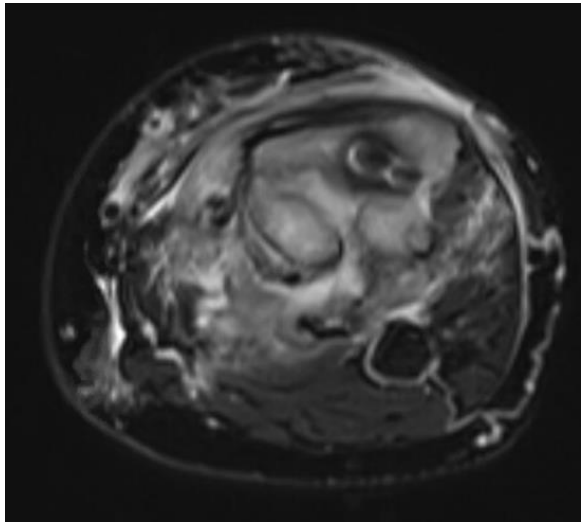
Necrosis skin of elbow due to septic emboli and pressure--tendon and bone exposed

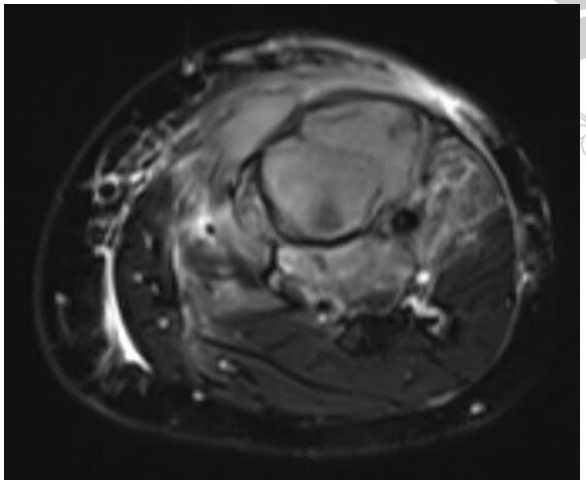
Case –68 y.o female, h/o remote (30+) MCC, left leg injuries,-- recent redness, swelling, pain

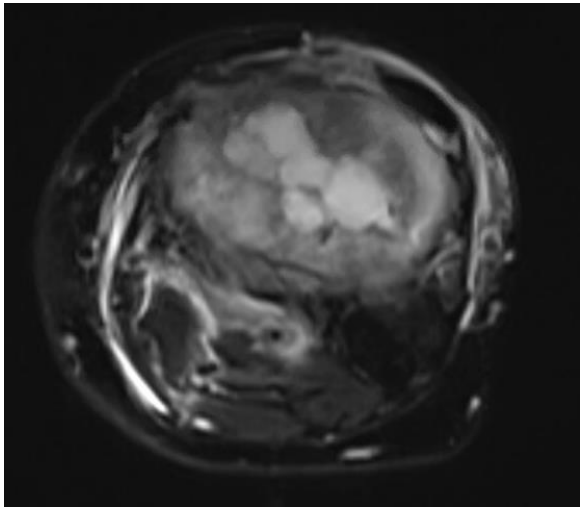
Case –Intra- + extra osseous abscess











Sequestrum? Involucrum?
Retained foreign material?Brodie's abscess?
Cloaca?
Cierny Mader type?

Case –Intra- + extra osseous abscess

Plan: Call team obtained open biopsy/ Cx, limited drainage.

x

Infection team later performed thorough I & D, started Neg. Pressure with instillation of Na Hypochlorite.

Ongoing plan for ABX spacer/ induced membrane - based bone grafting of abscess cavity

Musculoskeletal Infection Research Update

- Understanding Biofilms
  - Persistors, resistant organisms
- Advances in Diagnostics
  - PCR / molecular based ID
  - These Don't yield antibiotic susceptibilities, …yet….
  - Biomarkers: alpha-defensin, Leukocyte esterase, others
- Advances in management
  - Antibiotics…..development pipeline, understanding current capabilities
  - Materials—
    - antimicrobial suture, implants? Resorbable (small) functional implants?
    - Depot antibiotics—Ca So4
- Negative pressure wound therapy, irrigation therapies. evolving
    - Stabilizes tissue, protects, manages fluids
    - Irrigation of tissues to remove bioburden
    - Biofilm efficacy unknown, improves host

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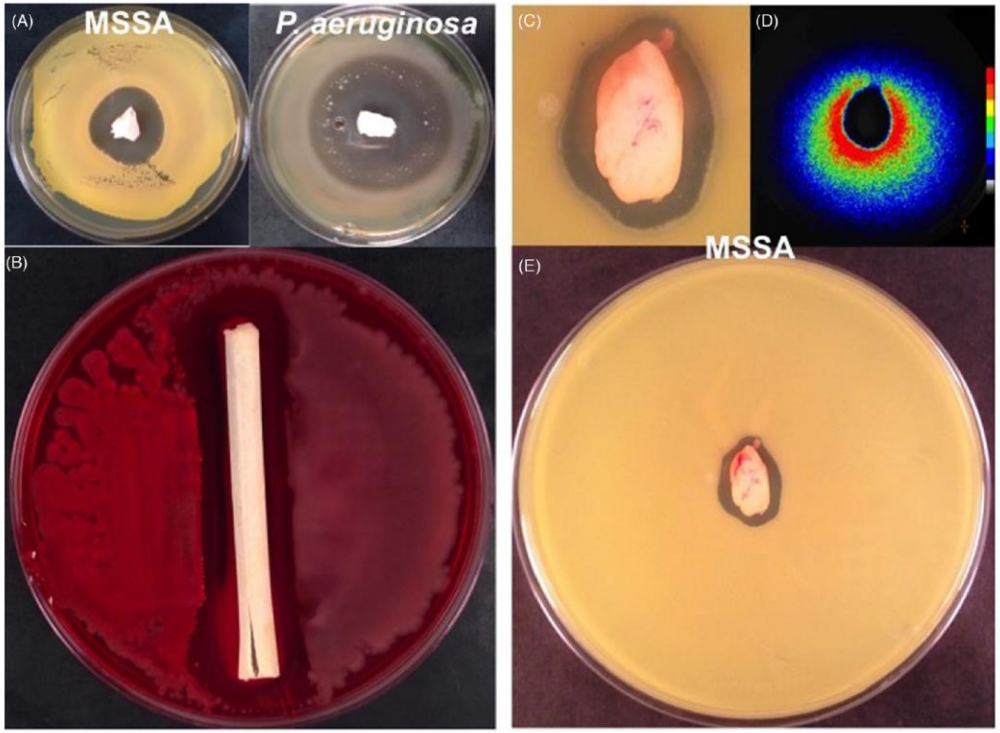
Advance Access Publication Date: 1 November 2015
Short Communication

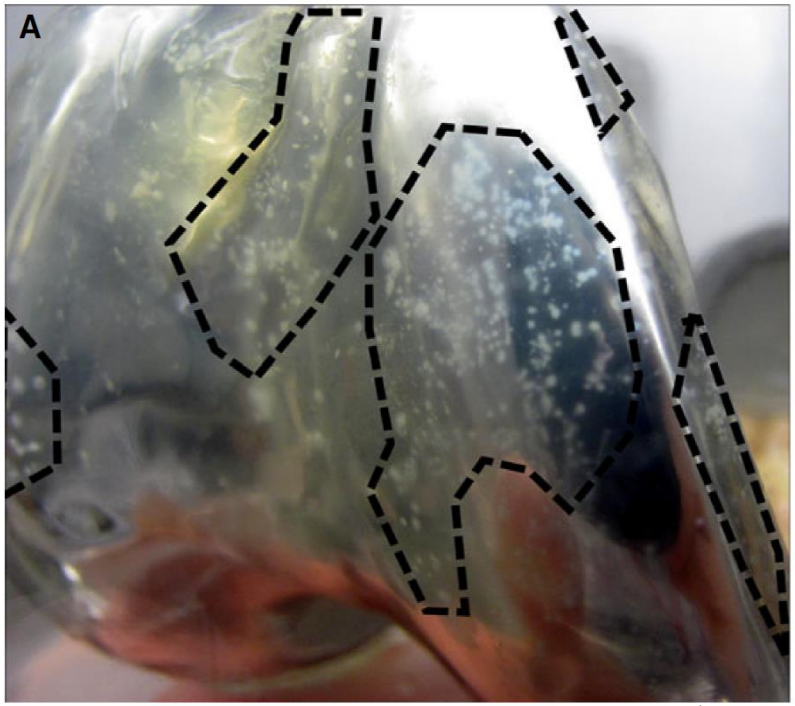
SHORT COMMUNICATION

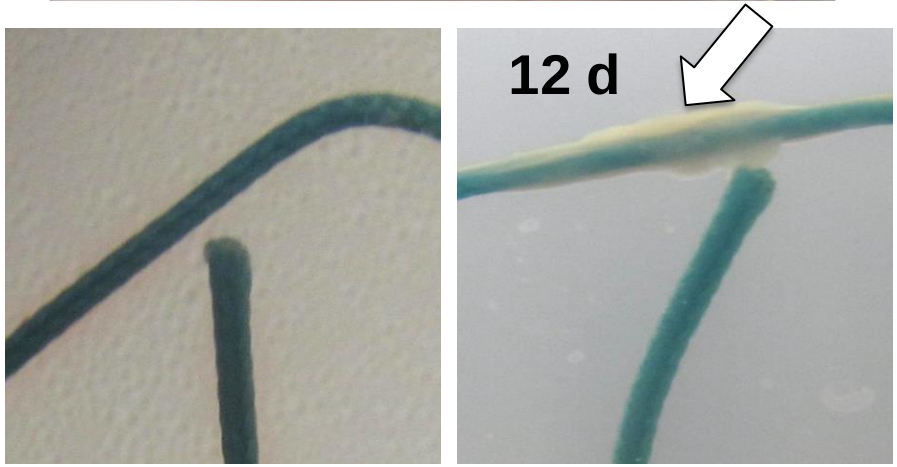
Elution of antibiotics from poly(methyl methacrylate) bone cement after extended implantation does not necessarily clear the infection despite susceptibility of the clinical isolates

Matthew C. Swearingen[1], Jeffrey F. Granger[2], Anne Sullivan[2] and Paul Stoodley[1,2,*]



Revealing biofilms by the “candle dip” method

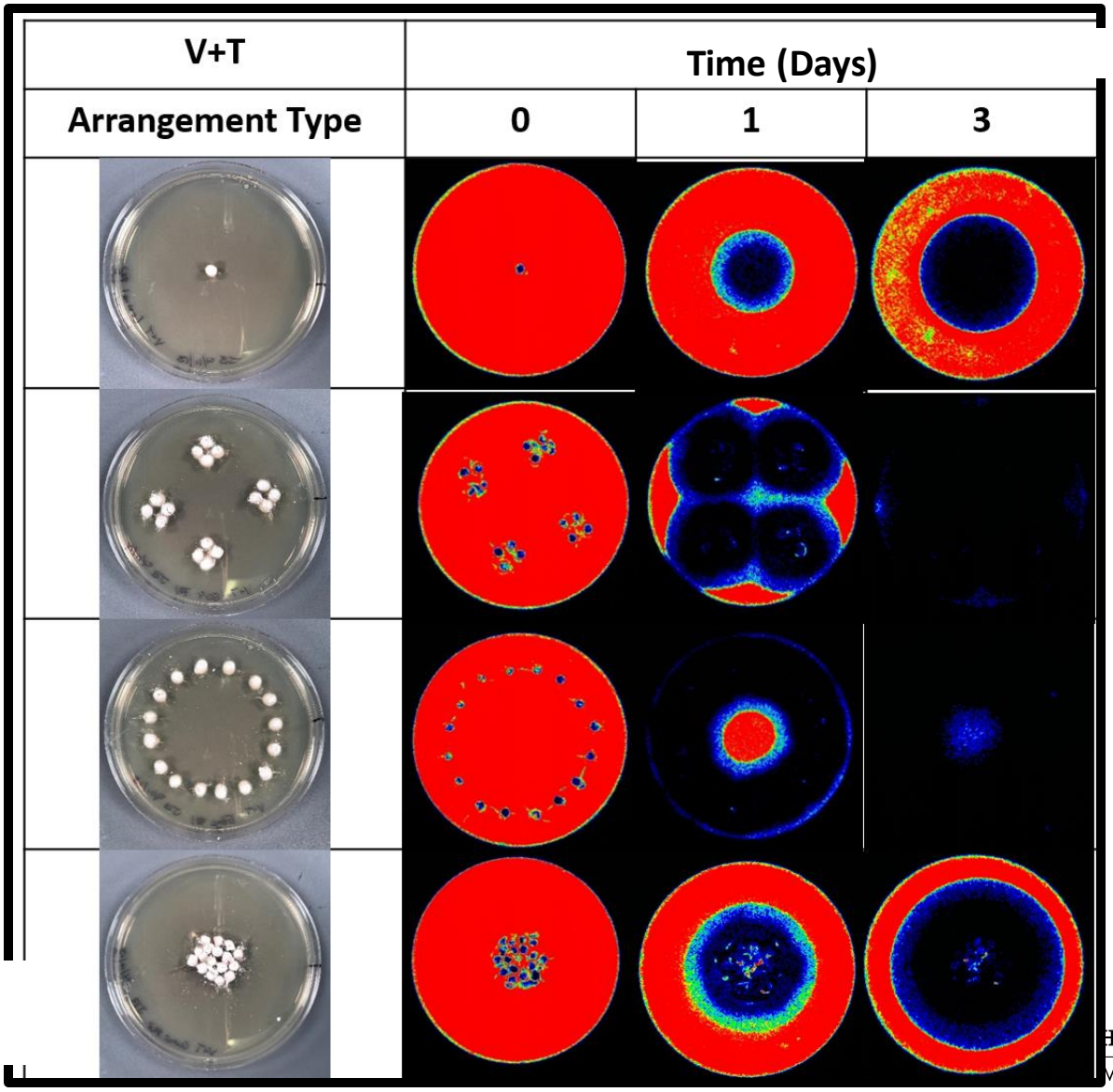




Use of resorbable materials to increase ABX delivery

Slide provided by Dr. E. McPherson,
Director, LA Orthopedic Institute,
Used by permission of P. Stoodley,

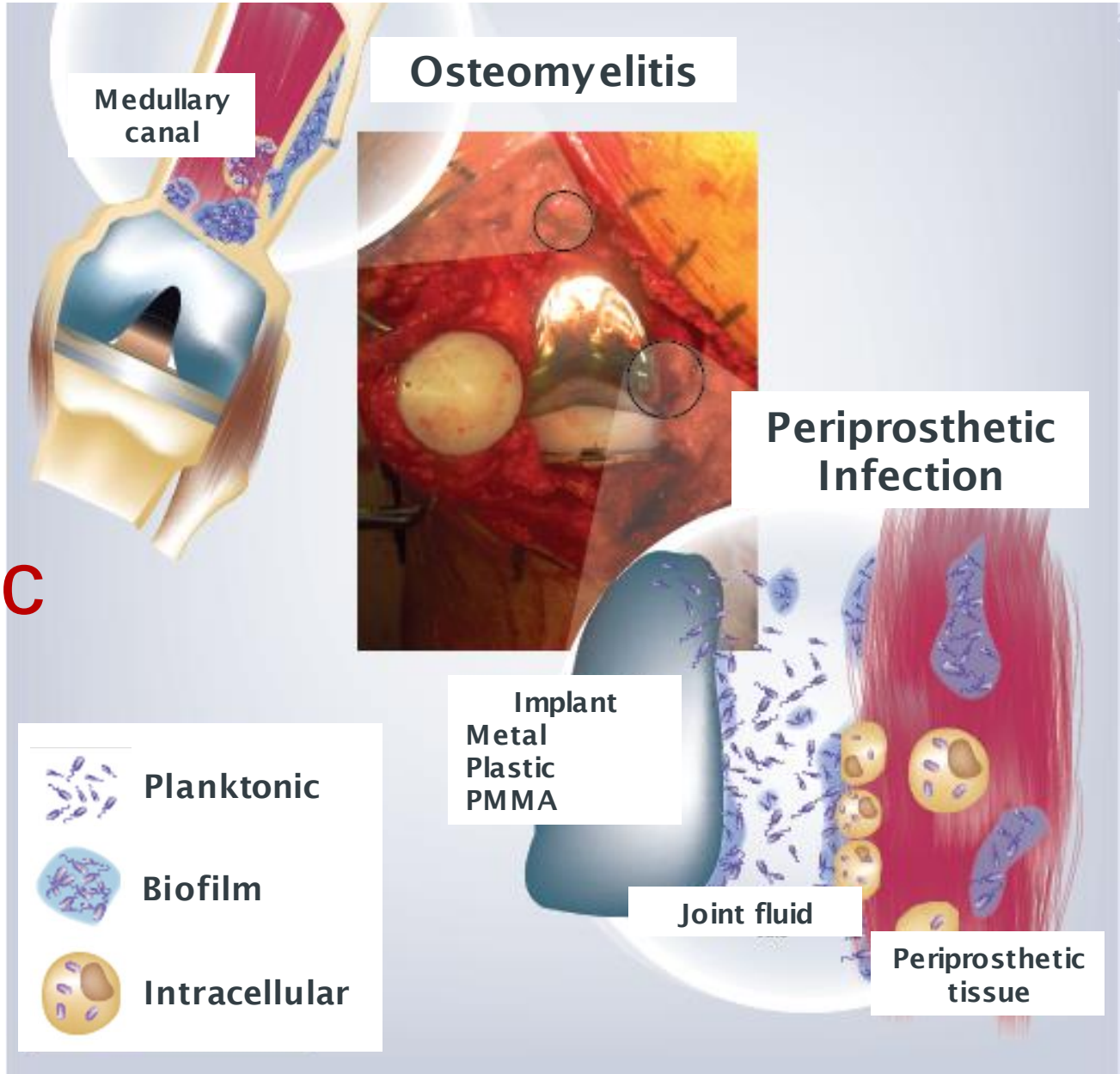
Bead Density AND Pattern Important – In Diffusion Dominated Areas



P. aeruginosa

McConoughey, S.J., Howlin, R.P., Granger, J.F., Manring, M.M. Calhoun, J.H., Shirtliff, M., Kathju, S., Stoodley, P. 2014. Biofilms in periprosthetic orthopaedic infections. Future Microbiol. 9(8):987-1007.

Emerging Picture of Periprosthetic Infection



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Questions?

(42)

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