



European
Knee
Society



TWO STAGE REVISION

F. Benazzo

018 International Consensus Meeting on Periprosthetic Joint Infections

- Gold Standard in the Prevention, Diagnosis, and Treatment of PJI
- EBM approach
- Minimum standards for prevention, diagnosis, and treatment were established.

Proceedings of the International Consensus Meeting on Periprosthetic Joint Infection

Chairmen:

Thorsten Gehrke MD

Javad Parvizi MD, FRCS



Treatment algorithm

Current treatments for biofilm-associated periprosthetic joint infection and new potential strategies

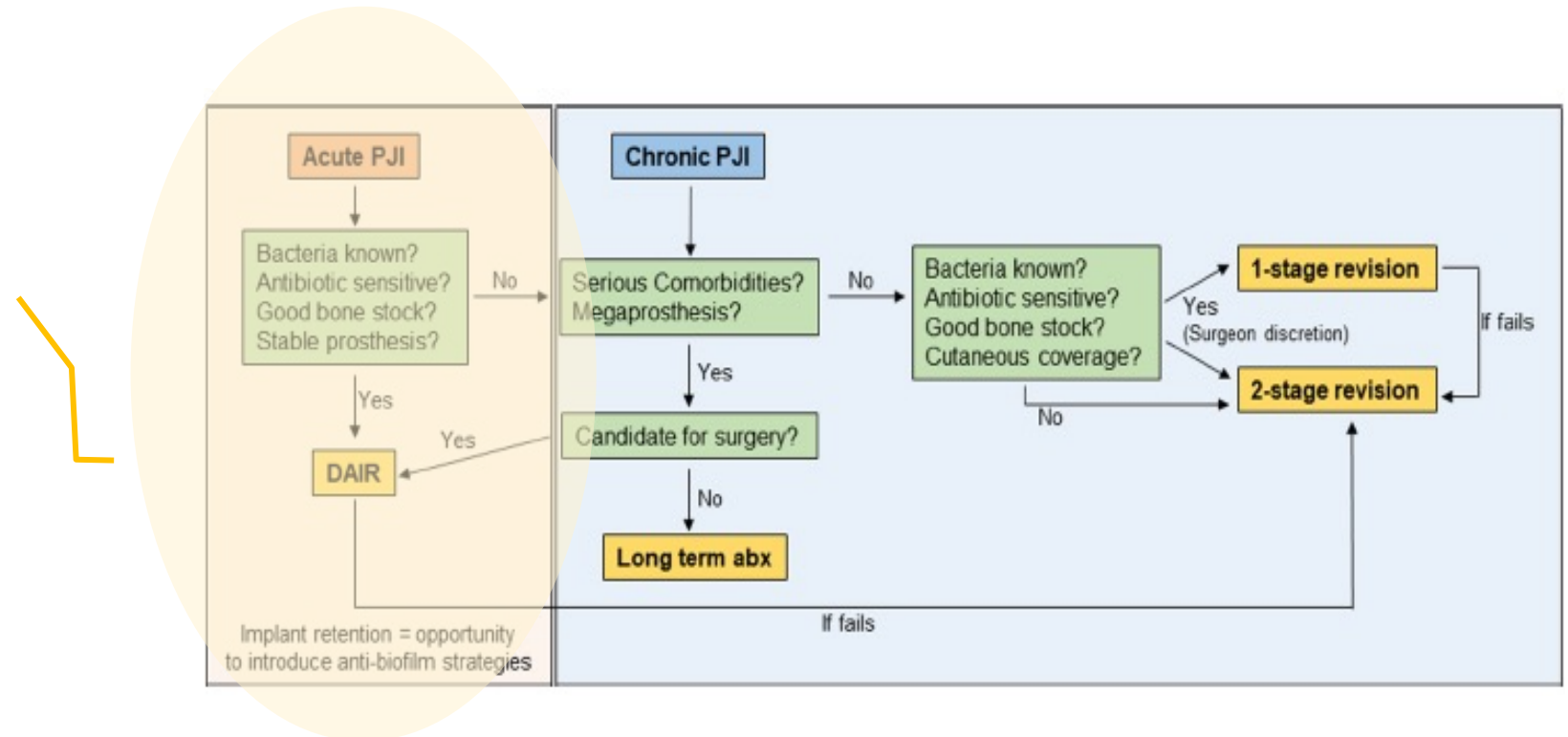
Anabelle Visperas¹ | Daniel Santana^{1,2} | Alison K. Klika¹ |
Carlos A. Higuera-Rueda³ | Nicolas S. Piuze¹

J Orthop Res., 2022

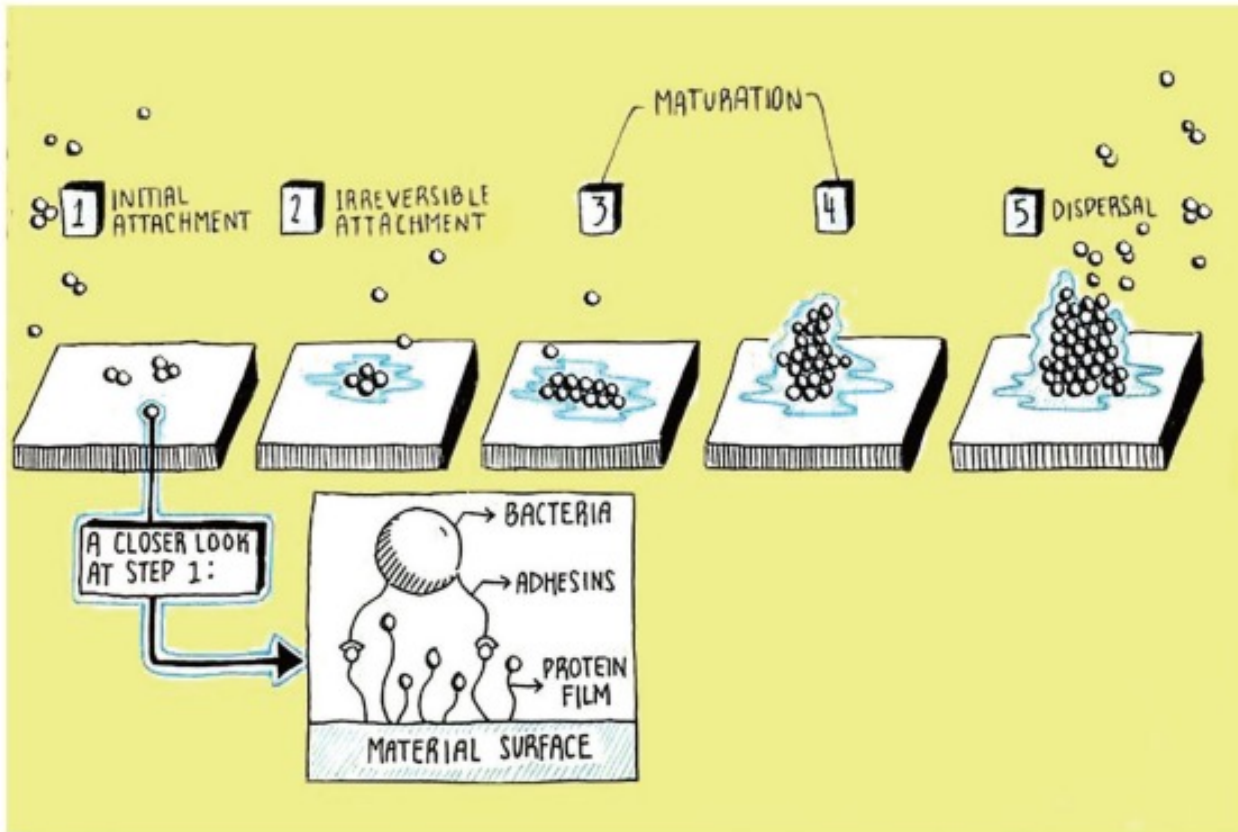
Historically the treatment algorithm is
time dependent

Acute within the first 4 weeks:

- Before the formation of the BIOFILM
- It is possible to save the implant



WHY TIME DEPENDENT?



The formation of the BIOFILM requires 4 phases:

1. Initial bacterial aggregation
2. Aggregation and production of EPS for binding
3. Modification of the microenvironment (PH, nutrient concentration, production of signal molecules) and biofilm maturation
4. Cell dispersion and bacterial propagation from native biofilm

Biofilm formation in periprosthetic joint infections

Amelia Staats^{1,2,#}, Daniel Li^{3,#}, Anne C. Sullivan³, Paul Stoodley^{1,3,4}

¹Department of Microbial Infection and Immunity, The Ohio State University, Columbus, Ohio, USA;

PROSTHETIC JOINT INFECTIONS

Treatment options



(DAIR - Debridement And Implant Retention)

Acute

One-stage revision

Two-stage revision

Chronic

One-stage revision

The one-stage approach raises several concerns

1. Pre-op diagnosis
2. OR set-up
3. Debridement
4. Implant
5. Intraop cultures
6. Recurrence

+1: Good outcomes reported in the literature are center-specific



Two-stage revision



- treat infection (current success rate: range 74.5-100%)
- high-dose local antibiotic delivery
- maintain joint space
- reduce scarring
- reduce bone loss

Two-stage revision

FROM 2018

**Published more than 2000 works
on PJI**

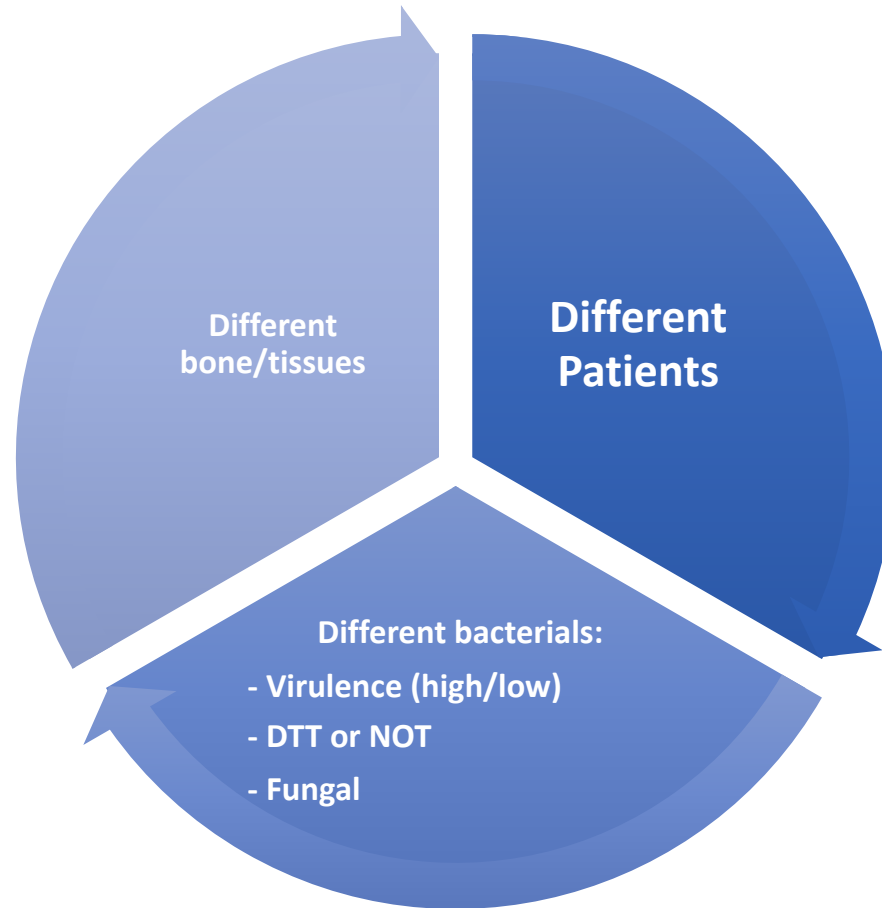


Since the last consensus

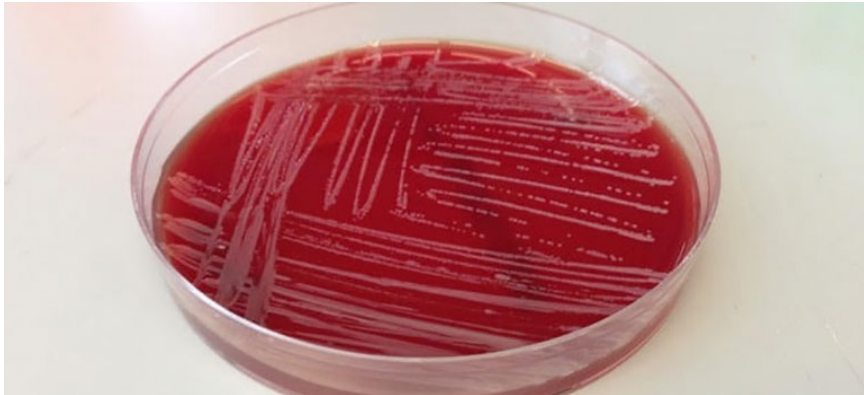
WHAT IS CHANGING?

**CUSTOMIZATION OF
PJI MANAGEMENT**

CUSTOMIZATION OF PJI MANAGEMENT



DIFFICULT-TO-TREAT BACTERIA



Article

Superinfection with Difficult-to-Treat Pathogens Significantly Reduces the Outcome of Periprosthetic Joint Infections

Ali Darwich ^{1,*}, Franz-Joseph Dally ¹, Khaled Abu Olba ¹, Elisabeth Mohs ¹, Sascha Gravius ¹, Svetlana Hetjens ², Elio Assaf ^{1,†} and Mohamad Bdeir ^{1,†}

«Infections supported by bacteria against
which there are no available antibiotics
active against BIOFILM»

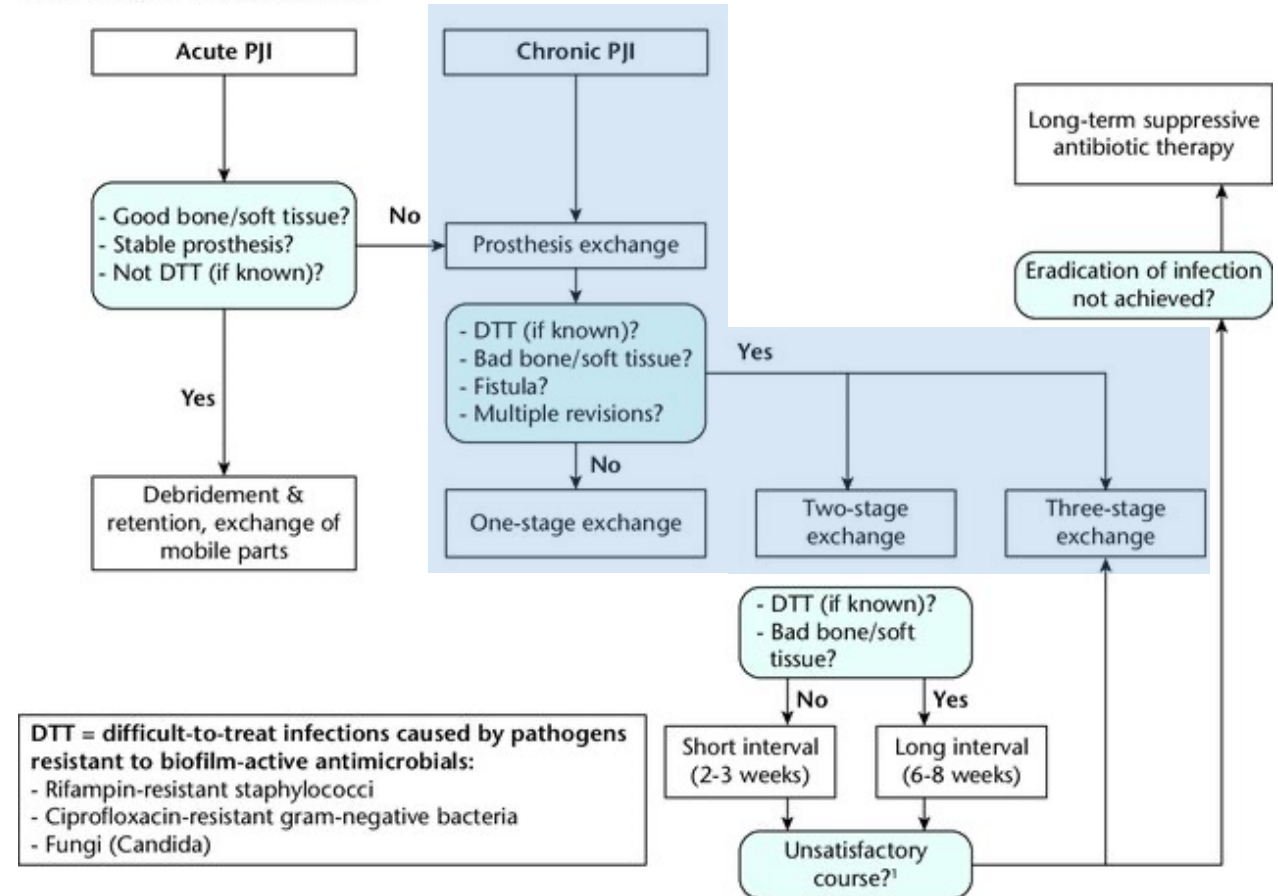
Modern treatment protocols:

- Maintained the cornerstone of PJI's time determination
- Growing importance of **bacterium-specific factors**
 - **DTT or NOT-DTT bacteria**

Periprosthetic joint infection: current concepts and outlook

Petra Izakovicova¹
Olivier Borens²
Andrej Trampuz³

TREATMENT ALGORITHM



¹ Clinical signs of infection, elevated CRP, intra-operative pus, compromised tissue

> [Int Orthop](#). 2023 Nov;47(11):2727-2735. doi: 10.1007/s00264-023-05895-7. Epub 2023 Aug 5.

The fate of fungal periprosthetic joint infection after total knee arthroplasty

Hong Yeol Yang ¹, Hyun Ho Shin ¹, Ji Won Kim ¹, Jong Keun Seon ²

Affiliations + expand

PMID: 37542541 DOI: [10.1007/s00264-023-05895-7](#)

> [J Arthroplasty](#). 2023 Nov;38(11):2464-2471.e1. doi: 10.1016/j.arth.2023.05.003.
Epub 2023 May 10.

Treatment and Outcomes of Fungal Prosthetic Joint Infections: A Systematic Review of 225 Cases

Marcos R Gonzalez ¹, Angad D S Bedi ¹, Daniel Karczewski ¹, Santiago A Lozano-Calderon ¹

Affiliations + expand

PMID: 37172795 DOI: [10.1016/j.arth.2023.05.003](#)

•Outcomes:

- **Infection Eradication Rates:** success rate in eradicating fungal infections 70%: high rate of treatment failure
- **Mortality and Morbidity:** significant morbidity

•Risk Factors for Poor Outcomes:

- immunosuppression
- presence of multiple comorbidities
- delayed initiation of appropriate antifungal therapy

Antibiotic spacers

Review > Arch Bone Jt Surg. 2020 Jan;8(1):11-20. doi: 10.22038/abjs.2019.42018.2141.

The Use of Antibiotic Impregnated Cement Spacers in the Treatment of Infected Total Joint Replacement: Challenges and Achievements

Omid Shahpari ¹, Alireza Mousavian ¹, Nafise Elahpour ¹, Michael-Alexander Malahias ²,
Mohammad H Ebrahimzadeh ¹, Ali Moradi ^{1 3}

- Antibiotics can cause renal failure
- Local administration of antibiotics may have many advantages

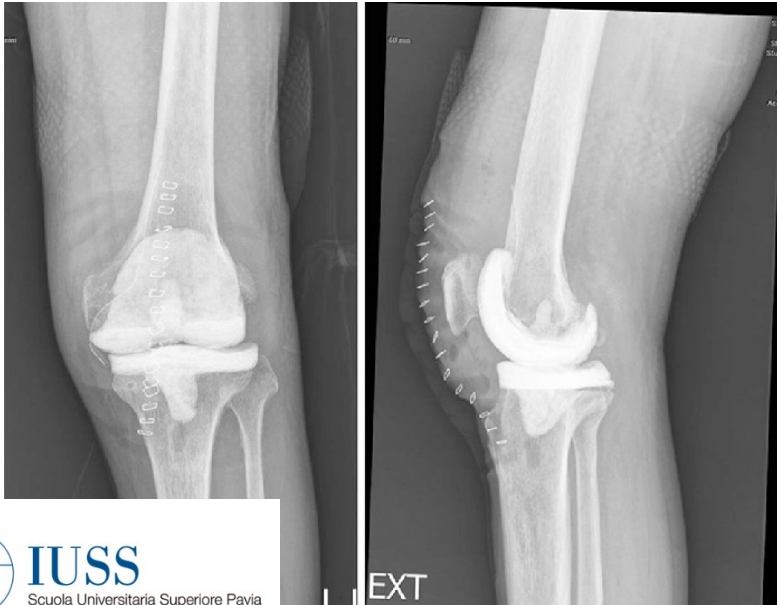


Table 2. Cement/antibiotic formulations with their corresponding complications

Study	No. of Patient	Cement/Antibiotic Formulation	Complications
Jung et al.	82 (hip spacers)	0.5 g gentamicin and 2 g vancomycin / 40 g cement	5 cases of acute renal failure (80).
Hsieh et al.	42 (hip spacers)	480 mg liquid gentamicin + 3 g vancomycin / 40 g of cement	0.5 mg/DL increase in serum creatinine (81).
Springer et al.	36 knees 34 patients	10.5g vancomycin + 12.5 g gentamicin / 40 g cement	no complications reported (13).
Dovas et al.	a 61-year-old patient	high-dose gentamicin-vancomycin impregnated cement	acute renal failure (82).
Evans et al.	44 (total 54 periprosthetic infections)	4 g vancomycin + 4.6 g tobramycin / 40 cement	no complications reported (29).

Calcium sulphate beads (CSB)



BJR



■ BIOMATERIALS

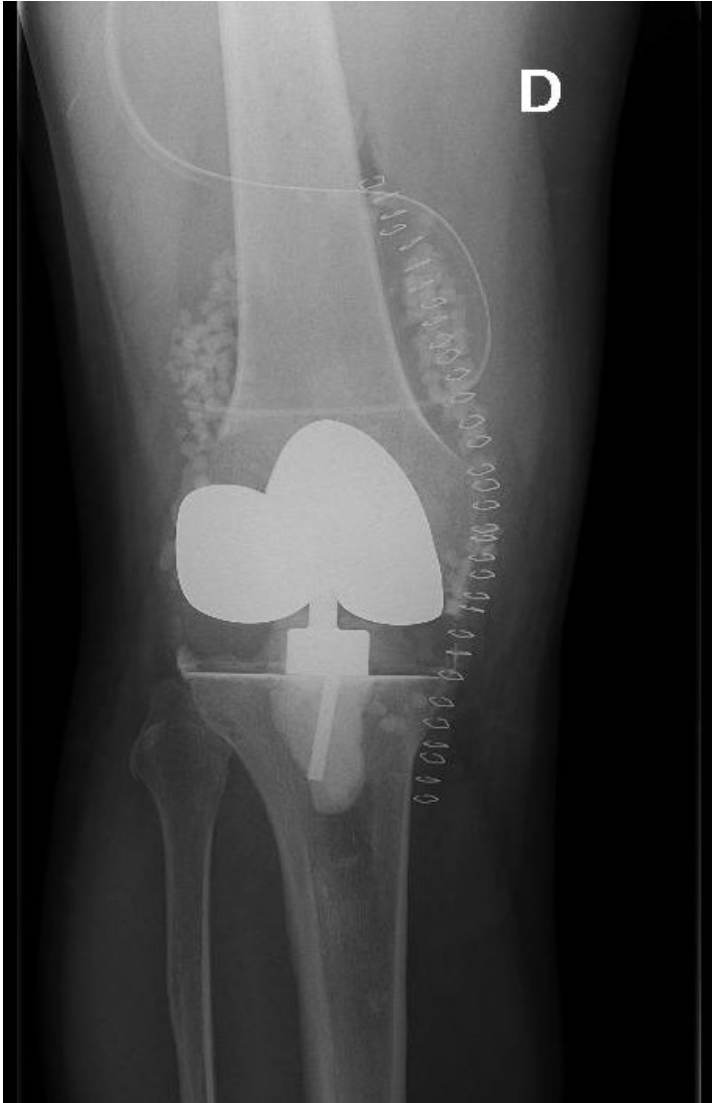
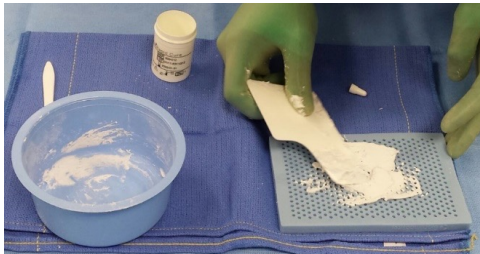
Use of Stimulan absorbable calcium sulphate beads in revision lower limb arthroplasty

SAFETY PROFILE AND COMPLICATION RATES

BENEFITS:

- Dissolves in 3 weeks with no need for removal
- Constant and predictable release of antibiotic
- Can be used for heat sensitive antibiotics

Antibiotic Added Beads



Different Patients

> [J Orthop Surg Res](#). 2023 Oct 27;18(1):804. doi: 10.1186/s13018-023-04293-4.

Concomitant malnutrition and frailty are significant risk factors for poor outcome following two-stage revision for chronic periprosthetic joint infection

Tengbin Shi ^{# 1}, Zhi Chen ^{# 1}, Dingxiang Hu ^{# 2}, Dingwei Wu ¹, Zhenyu Wang ¹, Wenge Liu ³

Affiliations [+ expand](#)

PMID: 37891602 PMCID: [PMC10612160](#) DOI: [10.1186/s13018-023-04293-4](#)

malnourished and frail group:

- **Functional Outcomes:** significantly lower scores on physical and mental health assessments, including the SF12-PCS, SF12-MCS, Harris Hip Score (HHS), and Knee Society Score (KSS)
- **Reinfection Rates:** The incidence of reinfection was higher
- **Complications:** higher rates of postoperative complications, including increased need for transfusions (OR 2.92), readmissions within 60 days (OR 4.91), and extended hospital stays post-operation (OR 5.78).

Different Patients

Articulated or mobile spacer?

Review > Arthroplasty. 2025 Jan 9;7(1):4. doi: 10.1186/s42836-024-00288-6.

Prosthetic articulating spacers as a preferred option for two-stage revision arthroplasty in chronic periprosthetic joint infection

Jiamin Lin ¹, Hongyan Li ¹, Yang Chen ¹, Haiqi Ding ¹, Qijin Wang ², Jianhua Lv ², Wenbo Li ¹, Wenming Zhang ¹, Xinyu Fang ³

Affiliations + expand

PMID: 39780262 PMCID: [PMC11714949](#) DOI: [10.1186/s42836-024-00288-6](#)

Advantages of Prosthetic Articulating Spacers

• Functional Benefits:

- Preserve range of motion.
- Reduce soft tissue contractures.
- Enhance patient mobility during the interim period.

• Clinical Outcomes:

- High rates of infection eradication.
- Improved patient satisfaction.
- Potential for better postoperative joint function compared to static spacers.

Articulated or mobile spacer?

- Contraindications to mobile?

> [Knee Surg Sports Traumatol Arthrosc.](#) 2024 Jul;32(7):1766-1774. doi: 10.1002/ksa.12187.
Epub 2024 Apr 21.

Static spacers play a crucial role in the treatment of complex periprosthetic joint infections of the knee

Andre Lunz ¹, Georg W Omlor ^{1 2}, Moritz N Voss ¹, Andreas Geisbüsch ¹, Tobias Renkawitz ¹, Burkhard Lehner ¹

Affiliations + expand

PMID: 38643391 DOI: [10.1002/ksa.12187](#)

The choice is influenced by various patient-specific factors:

Indications for Using Static Spacers:

- Severe Bone Loss
- Extensive Soft Tissue Damage
- Ligamentous Instability
- Persistent Infection Concerns

Customized intraoperatively molded articulating cement spacers for two-stage revisions TKA with major bone defects

European Journal of Orthopaedic Surgery & Traumatology 2021

Stefano Marco Paolo Rossi¹  · Marta Medetti² · Loris Perticarini¹ · Matteo Ghiara² · Francesco Benazzo^{1,3}



Customized intraoperatively molded articulating cement spacers for two-stage revisions TKA with major bone defects

European Journal of Orthopaedic Surgery & Traumatology 2021

Stefano Marco Paolo Rossi¹  · Marta Medetti² · Loris Perticarini¹ · Matteo Ghiara² · Francesco Benazzo^{1,3}

<i>Organism</i>		Outcomes	SS	MAS	CMAS	HS
<i>Staphylococcus</i> species	70%	<i>OKS</i>				
<i>Streptococcus</i> species	20%	Pre-op	12.3 (3)	12.5 (2)	12.3 (3)	12.3 (3)
Methicillin-/vancomycin-resistant	35%	With spacer	13.3 (2)	22.3 (2)	23.3 (2)	28.3 (2)
Methicillin-resistant <i>Staphylococcus aureus</i>	65%	Final f-u	29.1 (4)	34.1 (4)	33.4 (4)	35.1 (4)
Other organisms	10%		(<i>P</i> < 0000.1)	(<i>P</i> < 0000.1)	(<i>P</i> < 0000.1)	(<i>P</i> < 0000.1)
		<i>EQ 5D</i>				
		Pre-op	0.22 (0.7)	0.22 (0.6)	0.21 (0.7)	0.23 (0.7)
		With spacer	0.30 (0.5)	0.50 (0.5)	0.50 (0.4)	0.62 (0.5)
		Final f-u	0.69 (0.5)	0.77 (0.5)	0.76 (0.5)	0.77 (0.5)
			(<i>P</i> < 0000.1)	(<i>P</i> < 0000.1)	(<i>P</i> < 0000.1)	(<i>P</i> < 0000.1)
		<i>EQ VAS</i>				
		Pre-op	25.2 (3)	24.2 (3)	24.7 (2)	24.5 (3)
		With spacer	40 (3)	45 (5)	45 (4)	60 (4)
		Final f-u	73.1 (3)	78.1 (3)	77.1 (3)	79.1 (3)
			(<i>P</i> < 0000.1)	(<i>P</i> < 0000.1)	(<i>P</i> < 0000.1)	(<i>P</i> < 0000.1)

- Static spacer (SS)
- Molded articulating spacer (MAS)
- Customized molded articulating spacer (CMAS)
- Hofmann Spacer (HS)

Optimal reimplantation timing

> J Orthop Traumatol. 2024 Mar 25;25(1):15. doi: 10.1186/s10195-024-00745-7.

Evaluation of time to reimplantation as a risk factor in two-stage revision with static spacers for periprosthetic knee joint infection

Jan Puetzler ¹, Marc Hofschneider ², Georg Gosheger ², Christoph Theil ², Martin Schulze ², Jan Schwarze ², Raphael Koch ^{# 3}, Burkhard Moellenbeck ^{# 2}

Affiliations + expand

PMID: 38528169 PMCID: [PMC10963354](#) DOI: [10.1186/s10195-024-00745-7](#)

• Time to Reimplantation:

Delays in reimplantation are associated with higher rates of complications

Optimal Timing: Reimplantation within 8–12 weeks

•Extended Delays:

- Increased risk of joint stiffness.
- Greater difficulty in reimplantation due to scar tissue formation.
- Higher infection recurrence rates.

Optimal reimplantation timing

> J Orthop Traumatol. 2024 Mar 25;25(1):15. doi: 10.1186/s10195-024-00745-7.

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PMID: 38528169 PMCID: [PMC10963354](#) DOI: [10.1186/s10195-024-00745-7](#)

1. Serological Markers

•C-Reactive Protein (CRP):

- Optimal level: **<10 mg/L**.
- A significant decrease from pre-debridement levels indicates improvement.

2. Synovial Markers

•Synovial fluid leukocyte count:

- **<3,000 cells/μL** for knee prostheses.
- **<1,500 cells/μL** for hip prostheses.

•Neutrophil percentage:

- **<80%** neutrophils in synovial fluid.

•Alpha-Defensin:

- A highly sensitive and specific test for persistent infection, which must be negative before reimplantation.

Optimal reimplantation timing

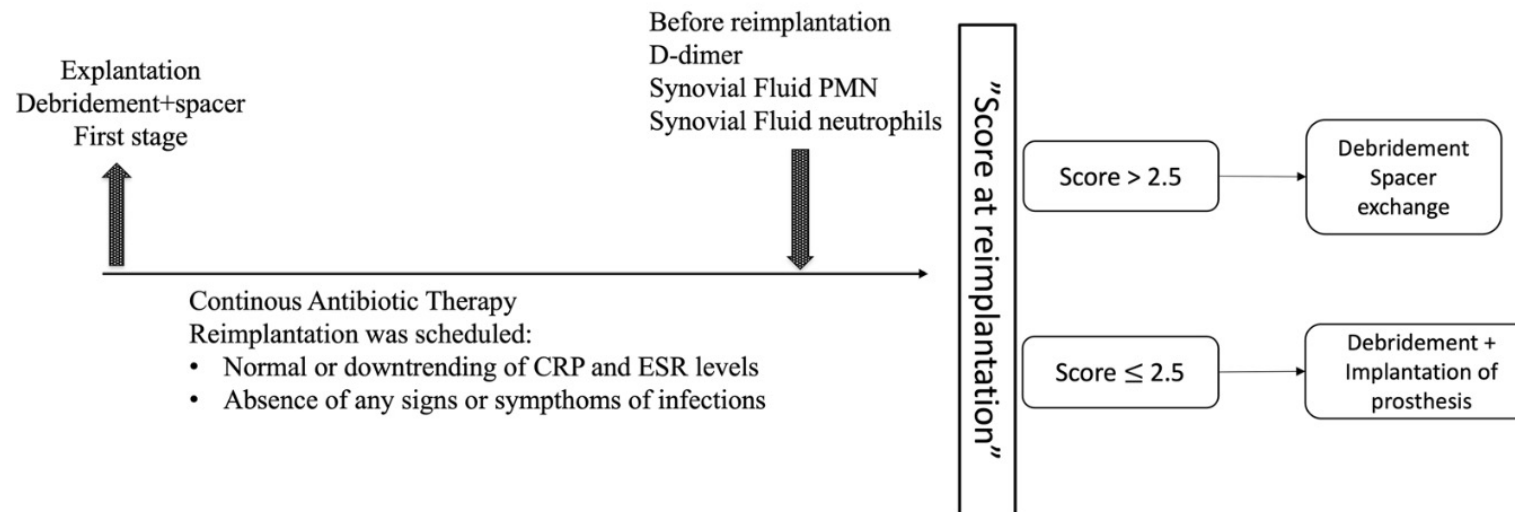
Upcoming evidence in clinical practice of two-stage revision arthroplasty for prosthetic joint infection



Tiziana Ascione^{1*} , Giovanni Balato² and Pasquale Pagliano^{3,4}

Journal of Orthopaedics and Traumatology , (2024)

- No antibiotic holiday before reimplantation
- CRP, ESR, D-Dimer (this last the only reliable marker in predicting recurrence of infection)



Repeat 2 stage?

> [Arch Orthop Trauma Surg](#). 2023 Apr;143(4):1731-1740. doi: 10.1007/s00402-021-04330-z. Epub 2022 Jan 4.

Repeat two-stage exchange arthroplasty for recurrent periprosthetic hip or knee infection: what are the chances for success?

A C Steinicke ^{# 1}, J Schwarze ^{# 1}, G Gosheger ¹, B Moellenbeck ¹, T Ackmann ¹, C Theil ²

- **Success Rates:** Repeat two-stage exchange arthroplasty for recurrent periprosthetic joint infection (PJI) of the hip or knee achieves **infection eradication in approximately 60–70% of cases.**

- **Risk Factors for Failure:**

- **Highly virulent organisms** (e.g., MRSA, fungal infections).
- **Severe bone loss** or soft tissue damage.
- **Multiple previous surgeries**, leading to compromised local anatomy.

Functional Outcomes: Even when infection is controlled, functional recovery tends to be lower

1.5-Stage Revision

> [J Arthroplasty](#). 2024 Sep 20:S0883-5403(24)00962-8. doi: 10.1016/j.arth.2024.09.024.

Online ahead of print.

Can a 1.5-Stage Revision Be an Effective Alternative for Chronic Periprosthetic Hip and Knee Infections? A Systematic Review and Meta-Analysis

Enrico Festa ¹, Tiziana Ascione ², Domenico De Mauro ³, Donato Di Gennaro ¹, Andrea Baldini ⁴, Giovanni Balato ¹

Affiliations + expand

PMID: 39307205 DOI: [10.1016/j.arth.2024.09.024](#)

D

1.5-stage Revision

1.5-Stage Revision

A hybrid approach combining one-stage and two-stage revision techniques for managing chronic periprosthetic joint infections (PJIs)

D

1.5-stage Revision

Procedure:

- Use of an articulating spacer made from semi-definitive prosthetic components.
- Components are fixed with antibiotic-loaded cement to deliver localized infection control.
- Allows partial joint functionality during treatment.

1.5-Stage Revision

Advantages:



- Balances infection eradication and functional outcomes.
- Reduces the need for multiple surgeries compared to traditional two-stage revisions.

Evaluation:

- Following targeted antibiotic therapy, components may be retained or replaced based on infection resolution and patient status.

1.5-Stage Revision

One and a Half-Stage Revision With Prosthetic Articulating Spacer for Definitive Management of Knee Periprosthetic Joint Infection

[Ahmed Siddiqi, DO, MBA^{a,b,c}](#) · [Yusuf Mahmoud, MD^b](#) · [Salvador A. Forte, DO^d](#) · [Thomas A. Novack, MD^e](#) ·
[James Nace, DO, FAOAO, MPT^e](#)  

comparable reinfection rates to traditional methods

Proper patient selection and
meticulous surgical technique
are essential for its success

Contraindications of 1.5-Stage Revision

- **Uncontrolled Systemic Infection**
- **Severe Soft Tissue Damage**
- **Multidrug-Resistant Pathogens**
- **Bone Loss**
- **Poor Host Factors:**
 - Immunocompromised patients (e.g., HIV, chemotherapy, or advanced diabetes).
 - Severe comorbidities that increase surgical risk or limit recovery.
- **Non-compliance:** Patients unable or unwilling to follow postoperative care, including antibiotic therapy and physical therapy.
- **Joint Instability or Structural Damage:** Conditions that compromise the ability to achieve stability with an articulating spacer.

Conclusions : Two stage revision indications

- DDT Bacteria
- Host: frail/malnourished (but it could be a valid indication for One Stage)
- Previous surgeries
- Less aggressive surgery compared to One Stage
- Consider the 1.5 Stage Revision



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