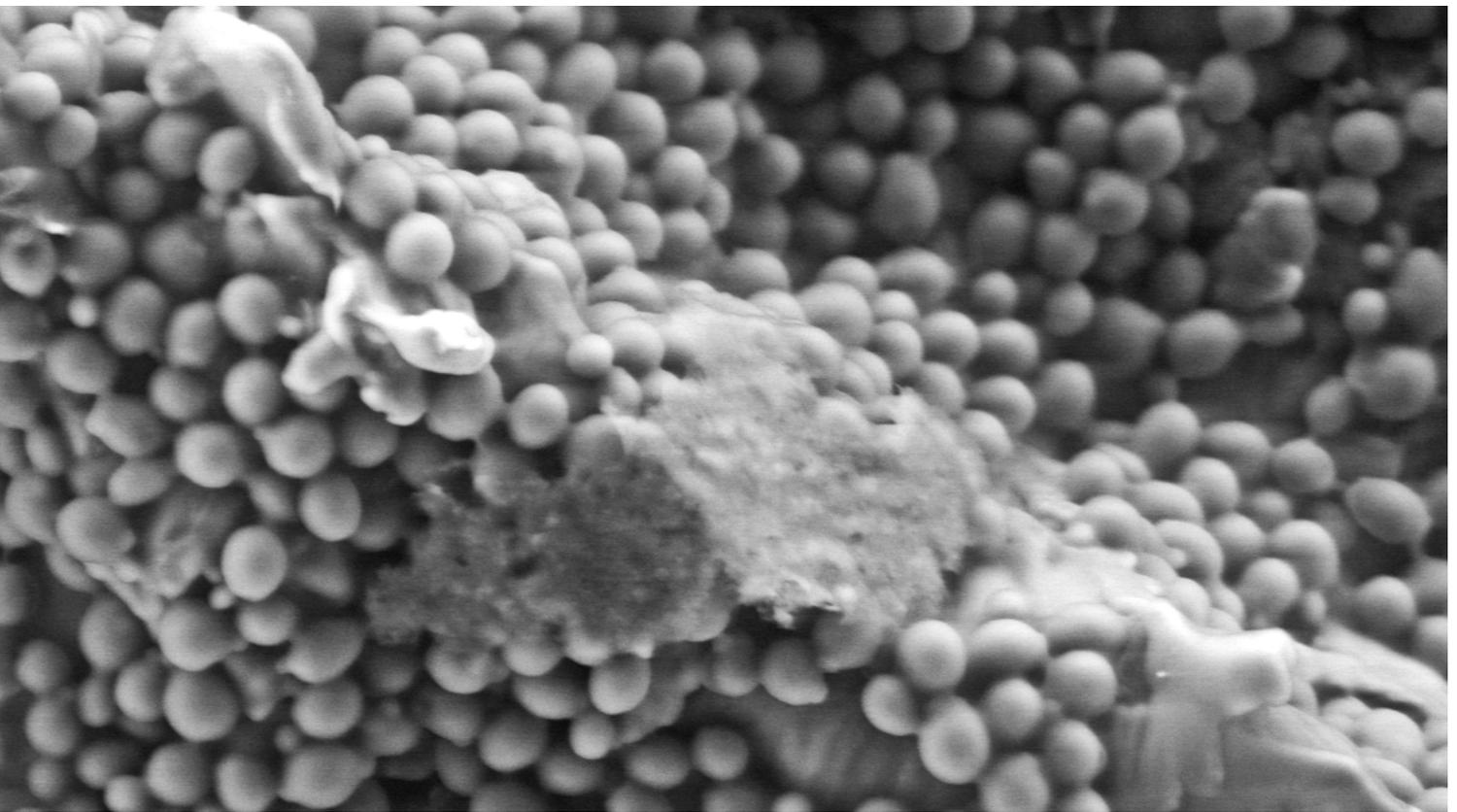


CeraNews

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The Orthopaedic Landscape Information Journal

Focus: Periprosthetic Joint Infection



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 **Cover:** Biofilm on
Implant Surface (SEM)
Source: A. Trampuz, MD,
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Dear Colleagues,

The development of biomaterials and their now routine use in arthroplasty have led to enormous progress in patient care. Nevertheless, a number of unresolved problems still exist. For example, foreign body-associated infections are one of the most frequent reasons for implant failure.

For primary total hip and knee replacement, current registry data show infection rates of over 2%, with significantly higher rates for revision surgery. Due to the demographic development, the growing number of patients undergoing arthroplasty and improved detection methods, a significant increase in the number of periprosthetic joint infections is anticipated. Using additional hygienic measures cannot reduce the incidence of infection. For all of these reasons, in the future, we will be increasingly confronted with more and more complex periprosthetic infections and require efficient concepts for diagnosis and treatment.

Prosthetic infection is a dreaded complication that limits the treatment success of arthroplasty and is associated with severe consequences for the affected patients and, increasingly, also with socio-economic problems. The average age of a patient at the time of infection is 71. A prosthetic infection often drastically compromises patients' quality of life, causing them chronic pain and immobility, and, generally, it requires two additional operations entailing bone, muscle and soft tissue loss. In many cases, this also means an additional hospital stay lasting from several weeks to months. This hospital stay, the operations, anesthesia and immobility expose the patients to multiresistant pathogens, putting them at greater risk of contracting secondary complications or even death (pulmonary embolism, catheter-associated sepsis, antibiotic-associated diarrhea, pressure sores etc.). Therefore, no effort should be spared to minimize the risk of infection and to reliably detect and efficiently treat already occurring infections.

At present, however, no uniform interdisciplinary treatment algorithms exist for treating periprosthetic joint infections. There is no unequivocal definition of the clinical symptoms, especially for distinguishing them from aseptic failure, and there are ongoing controversies about standards for diagnosis, for the choice of suitable antibiotics or for surgical procedures. No generally binding evidence-based guidelines for expedient therapeutic methods are in place. Patients with persistent or recurring infections must undergo surgery repeatedly, which can lead to deterioration of the anatomic structures (e.g. muscle contractures, bone defects, lack of soft tissue cover) and to arthrodesis, resection arthroplasty (girdlestone) and even amputation. Patients with persistent infections are often subjected to severe emotional strain due to chronic pain. For all of these reasons, improving patient care is imperative.

While the International Consensus Meeting on Periprosthetic Joint Infection (Philadelphia, 2013), led by Javad Parvizi (Rothman Institute, Philadelphia) and Thorsten Gehrke (Helios Endo-Klinik, Hamburg), took stock of the current state of knowledge on all aspects of periprosthetic joint infection, this did not result in the introduction of new or more efficient surgical and antibiotic treatment concepts. Therefore, there is still no clear treatment concept leading to long-term success rates of >90% (that is, freedom from infection and pain combined with good function).

The problems associated with bacterial and fungal biofilm formation have been underestimated to date. Microorganisms on the implant surfaces play a key role here. They mature into a biofilm that defies the antibiotics and the body's own immune defense. Hence, in the future, an interdisciplinary approach should be used to more actively deal with the epidemiology, pathogenesis,

diagnosis and treatment of the biofilm, because the only way to achieve long-term treatment success is to combine surgical, microbiological, infectious disease and pharmacological expertise.

The question as to the actual number of cases of septic loosening cannot be adequately answered at present. They are frequently misdiagnosed as aseptic loosening. In a study already conducted back in 1996 positive bacterial cultures were obtained from surgical specimens in 76% of the cases of diagnosed aseptic loosening. Our own studies also showed that an infection was present in about 25% of the cases due to aseptic loosening.

The reliability of retrospective studies identifying the infection rates of different bearing couples is severely compromised by the heterogeneity of the patient cohort and the range of other parameters (for example, surgery time, surgical technique, blood transfusions, "traffic flow" in the OR) that have a major impact on the infection process. Furthermore, there is often no sensitive testing of the implants for biofilms, for example, by sonication and PCR, which allow quantitative and qualitative determination of the pathogens on the implant surface. For the same reasons, evaluations from joint registries can lead to distorted results with limited reliability and the lack of information about septic infections. It is therefore clear that new scientific approaches are needed to obtain valid results with respect to the resistance of bio-materials to infection.

In order to more successfully prevent and treat infections as well as preserve implant function in the future, interdisciplinary collaboration among the different medical disciplines and material sciences is needed. This issue of CeraNews, which focuses on periprosthetic joint infection, aims to provide further impetus for research to this end.



Andrej Trampuz, MD



Olivier Borens, MD, PhD

Literature

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International multicenter prospective study: Call for collaboration

We invite you to participate in the European Implant Cohort Study (EICS), an international multicenter prospective study, which will include 5,000 patients with PJI in about 100 centers across Europe and other continents.

The study's aim is to collect data on microbiology, surgery, local and systemic antimicrobial treatment as well as long-term functional and infection outcome in order to determine factors associated with clinical success and improved life quality.

The project is funded by the PRO-IMPLANT Foundation (www.pro-implant-foundation.org), which supports innovative medical research, professional education and patient care in the field of bone, joint and implant infections. The PRO-IMPLANT Foundation is a non-profit organization recognized by the State Government of Berlin, cooperating with academic and industrial partners to form an international expertise network

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medicine board in 1997 and at the infectious diseases board in 2001. He completed his postdoctoral research fellowship at the Mayo Clinic in Rochester, Minnesota, USA in 2001-2004, where he established the sonication procedure of removed implants. Thereafter, he established a research group at the University Hospital Basle, Switzerland, relocated to the University Hospital Lausanne, Switzerland in 2009 and was appointed as Head of the Interdisciplinary Septic Unit in 2013 at the Charité – University Medicine Berlin in Germany.

His laboratory research involves the development and validation of novel methods for diagnosis and treatment of implant-associated infections, including animal models, the emergence of antimicrobial resistance and the development of new diagnostic methods. He is one of the founders of the European Implant Cohort Study (EICS), which will include infected joint prostheses from over 100 institutions across Europe and other continents. In addition, he is principal investigator of clinical trials involving implant-associated infections. He authored 96 peer-reviewed publications and 6 book chapters related to biofilm, implant infection, microcalorimetry, sonication and rapid microbiological diagnosis.

Together with Olivier Borens, MD, PhD, Head of the Interdisciplinary Septic Surgery Unit of the University Hospital in Lausanne (Switzerland), he organizes interdisciplinary workshops on periprosthetic joint infection in Berlin (www.pro-implant-foundation.org). In addition, the Charité hospital offers clinical observerships for osteoarticular infections as the Collaborative Centre of the European Society for Clinical Microbiology and Infectious Diseases (ESCMID, www.escmid.org).

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He has received his medical education at the University of Basle and specialized in orthopaedics and traumatology at the hospitals of Liestal and Lausanne. After a one-year fellowship at the Hospital for Special Surgery in New York his work concentrated on the traumatology of the acetabulum and the pelvis and on infections of the musculoskeletal system, especially following joint replacement.

He has made his department a reference center for orthopaedic infections of the European Society for Clinical Microbiology and Infectious Diseases (ESCMID), welcoming visitors from Europe, North and South America as well as Australia. Olivier Borens is intensely involved in scientific activities and regularly invited to present at national and international conferences. His research focuses on the prevention, diagnosis and treatment of periprosthetic infections, biofilm, local antibiotics and minimally invasive techniques in traumatology, among others.

He is a member of the European Trauma Society (ETS) and of the Swiss AO Trauma Committee as well as board member of the European Bone and Joint Infection Society. He takes active part in the education of medical students and the training of under- and post-graduate physicians. His publication list includes more than 60 journal articles, several book chapters and a great number of abstracts.

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Implant Associated Infection: Victorious Germs or Avoidable Complication?

An interview with Javad Parvizi, MD, PhD, FRCS,
and Thorsten Gehrke, MD, PhD

Increasing numbers of implantations are naturally associated with an increasing number of complications. Implant-associated infection is regarded as one of the most challenging complications following total joint replacement surgery. It confronts the surgeon and the patients with serious consequences and is, therefore, widely feared in the orthopaedic surgical community. According to some studies, implant-associated infection constitutes the most common cause of revision total joint replacement during the first 5 years of primary implantation. Although progress has been made in the area of pre- and peri-operative measures, as well as post-operative care in arthroplasty, no significant decrease in the infection rate has been observed over the last two decades. Quality improvements in total joint arthroplasty are apparently not effective in the reduction of infection.

Our major enemy on the infection frontline is the alarming increase in bacterial resistance to antibiotics. We are increasingly confronted with multi-drug resistant pathogens such as the familiar methicillin-resistant *Staphylococcus aureus* and *epidermidis* and for some time now the more challenging and more threatening 3MRGN and 4MRGN pathogens. These are multi-drug resistant bacteria known as gram-negative rods that are resistant to 3 or 4 of the known antibiotic groups, which leaves the medical community effectively defenseless against them.

The only thing that still helps in these cases is systematic infection prevention or adequate treatment, which for periprosthetic infections involves radical debridement of all infected soft tissues and bone. The result can be devastating to the patient.

In an effort to gain a more complete understanding of the issues, we sat down with the organizers of the International Consensus Group on Periprosthetic Joint Infection, Professors Javad Parvizi of the Rothman Institute in Philadelphia and Thorsten Gehrke of the Helios Endo-Klinik in Hamburg, Germany, in order to ask some question on this complex subject.

The International Consensus Group on Periprosthetic Joint Infection met in Philadelphia on August 1, 2013. What were the objectives of this newly formed group?

Thorsten Gehrke: Both Dr. Parvizi and I came up with the idea to organize a meeting of this type. It's necessary because right now there are no global standards for prevention, diagnostics and treatment; no scientific evidence is available; and there is great uncertainty worldwide regarding the treatment of periprosthetic infections.

Because it is extremely difficult and ethically problematic to justify conducting evidence-level-1 clinical studies (prospective randomized studies), we decided that if there's no evidence then there should at least be consensus. Using the Delphi method, consensus is achieved if the majority of experts has a single opinion regarding a particular issue based on whatever scientific data and related publications are available.

Javad Parvizi: In order to create this consensus effort, we contacted about 500 experts from roughly 60 countries and formed 15 working groups in order to address various sections of the issue (e.g., definition, prevention, diagnostics, irrigation and debridement, spacers etc.). The working groups reviewed more than 3,500 medical publications leading to more than 24,000 e-mails being exchanged. The groups formulated more than 220 questions. These were presented to the entire group and voted upon as part of the International Consensus Meeting held in Philadelphia in early August 2013.

Different definitions of a prosthesis infection are described in the medical literature. When is the diagnosis of an implant-associated infection considered to be accurate?

Javad Parvizi: As part of the consensus, a majority of 85% of the experts agreed that an implant-associated infection is considered confirmed if the following criteria are met:

- evidence of phenotypically identical organisms in at least two positive periprosthetic cultures or

- a fistula communicating with the joint or
- evidence of at least 3 of the following criteria:
 - increase in the erythrocyte sedimentation rate (ESR) and the C-reactive protein (CRP) in the serum
 - increased number of white blood cells (WBC) in the synovial fluid or
 - positive reaction of leukocyte esterase test strips
 - increased percentage of neutrophils in the synovial fluid (PMN%)
 - positive histological analysis of the periprosthetic tissue
 - a single positive culture.

Infections are often classified as early or late. Current registry data contain evidence indicating that infections can also occur considerably later than once thought. Is this classification still up to date based on what we know now?

Thorsten Gehrke: There are a number of different classifications of periprosthetic infections, each of which consider different criteria. The simplest, most sensible and most conventional classification is actually the classification into early and late infections. An early infection is one which occurs in the first 3 weeks after the implantation of the prosthesis or after the appearance of the first symptoms. All infections that become evident at a later time are called late infections, which means these can develop as hematogenous infections years or even decades later.

There is consensus that the attempt to preserve the prosthesis in early infections appears justified, whereas in the case of all late infections the prosthesis, all foreign bodies, and infectious bony and soft tissues should be removed. Agreement on this was universal.

The clinical finding of a periprosthetic infection is often unspecific. Do you have a tailor-made, standardized algorithm for determining findings at your hospitals?

Javad Parvizi: Every clinic that treats periprosthetic infections should follow a generally recognized standard as well as diagnostic and therapeutic algorithms. In our hospitals the clinical determination of findings is as follows:

First, as a rule the patient presents with pain, the most important clinical symptom of infections. It is particularly suspicious if pain suddenly develops after an interval free of symptoms. A clinical examination is then carried out. If local signs of infection such as redness, swelling, heat or formation of effusion are present in the affected joint, the next step we recommend is to determine the inflammatory parameters in the serum, although as a rule determining the CRP value is sufficient. At the same time

we also carry out a puncture of the affected joint in every case of suspected infection. It is necessary to make sure that the puncture is carried out in rooms specifically set up for this purpose or in operating theaters under strictly aseptic conditions. The puncture specimen should then be sent to the closest qualified laboratory as soon as possible; if this is not possible, temporary interim storage in pediatric blood culture bottles is recommended.

Thorsten Gehrke: The puncture specimen should be incubated for at least 14 days to ensure that pathogens that grow slowly are also detected. The patient should be free of antibiotics for at least 10–14 days before the puncture. If the culture is negative despite high-grade clinical and serological suspicion of a periprosthetic infection, we recommend taking open biopsies because these are more accurate. About 98% of all periprosthetic infections can be diagnosed using this algorithm.

Have the strategies for prevention, diagnosis, and treatment of periprosthetic infections changed over the past years, and what is your assessment of the results?

Javad Parvizi: The strategies for prevention, diagnosis and treatment have, in my opinion, clearly undergone positive developments in the last few years. Most hospitals adhere to the algorithms specified by the major professional associations. Because periprosthetic infection has increasingly come under scrutiny as the most serious complication associated with arthroplasty in recent years, centers have been created in most countries for the purpose of treating this complication.

Nevertheless, we are still in the early stages with these strategy measures. The consensus meeting last August was intended to play a part in ensuring that appropriate algorithms are adhered to and treatment principles are implemented, particularly in those countries, which are at a lower level of development. The results of the consensus meeting provide good guidelines for health professionals treating periprosthetic infections.

How should future primary and revision implants in hip and knee arthroplasty be fashioned so that the complex issue of infection can be brought under control? What scientific approaches are there?

Thorsten Gehrke: Implant manufacturers across the board have been working on antibacterial or antiseptic surface treatment of the implant (coatings), for at least two decades. In recent years relatively promising approaches of antibacterial coatings have been developed, which have concentrated increasingly on the use of silver ions as a protection against infection on the implant surface. Silver has the ad-

vantage that there is almost no resistance and the bone in-growth behavior is good despite the proven toxic effect of the silver. Currently, there are only rudimentary evidence-based scientific approaches available, at least for practical application. Nevertheless, there are vast amounts of in-vitro results and theoretical considerations. Meaningful in-vivo data is still rare. Only in recent years have truly promising results in treatment or prevention been shown in cancer patients.

A periprosthetic infection can put a serious strain on the relationship between a doctor and his patient. Can you give your colleagues some advice from your clinical practice on how to deal with affected patients?

Javad Parvizi: The only effective and ultimately also the only correct recommendation is to openly deal with the complication of periprosthetic infection. The patient must be informed as soon as possible about the probability of an infection and undergo appropriate diagnostics. This can only be done in an open and honest dialog with the patient. Recriminations are redundant and irrelevant because of the hygiene standards maintained in most operating theaters around the world. As a rule, periprosthetic infections should be considered a matter of fate. Blame can only be placed on the surgeon or treating physician if there are delays or a wait-and-see approach is taken with the diagnostics and the resulting treatment. To put it in a nutshell, honesty is the best policy. ■

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International Consensus Meeting on Periprosthetic Joint Infection

A Brief Summary

by Thorsten Gehrke, MD, PhD, Javad Parvizi, MD, PhD, FRCS

Periprosthetic joint infection (PJI), with all its disastrous implications, continues to pose a challenge for the orthopaedic community. Practicing orthopaedic surgeons have invested great efforts to implement strategies that may minimize surgical site infection (SSI). Although high-level evidence may support some of these practices, many are based on little to no scientific foundation. Thus, there is a remarkable variation in practices across the globe for prevention and management of PJI.

Should one use a laminar flow room for elective arthroplasty? How much and which antibiotic should one add to cement spacers? What metric should one use to decide on the optimal timing for reimplantation? What are the indications and contraindications for irrigation and debridement? How much irrigation and debridement in a joint should be attempted before resection arthroplasty needs to be considered? These are among the many questions that the orthopaedic community faces on a daily basis.

The medical community comprehends the importance of high-level evidence and engages in the generation of such whenever possible. The community also recognizes that some aspects of medicine will never lend themselves to the generation of high-level evidence nor should one attempt to do so. It is with the recognition of the latter that the International Consensus Meeting on Periprosthetic Joint Infection was organized. Delegates from various disciplines, including orthopaedic surgery, infectious disease, musculoskeletal pathology, microbiology, anesthesiology, dermatology, nuclear medicine, rheumatology, musculoskeletal radiology, veterinary surgery, pharmacy, and numerous scientists with an interest in orthopaedic infections travelled to Philadelphia in order to participate in the meeting held on July 31-August 1, 2013. Their goal was to evaluate the available evidence at hand. If no sufficient evidence was found, then the objective was to develop a consensus on current practices for the management of SSI/PJI. This entire process required a great deal of preparatory work over a 10-month

period in order to gather all of the supporting information required. Every stone was turned in search of evidence for the questions that were generated by the delegates; over 3,500 related publications were evaluated. The evidence, when available, was assessed. In the case of questions that were not adequately supported in the medical literature, the cumulative wisdom of the more than 400 delegates from 52 countries as well as over 100 different organizations was evaluated and combined in order to present it to the delegates for their consensus vote.

The delegates were engaged every step of the way by communicating through a "specialized website" created for this purpose (www.ForMD.com). This website handled over 25,000 communications during the process. The consensus document was developed using the Delphi method under the leadership of Dr. William L. Cats-Baril, a world-renowned expert in consensus document development.

The entire consensus process included as many stakeholders as possible, allowed participation in multiple forums, and provided a comprehensive review of the literature. The topics that were covered included the following: mitigation and education on comorbidities associated with increased SSI/PJI, perioperative skin preparation, perioperative antibiotics, operative environment, blood conservation, prosthesis selection, diagnosis of PJI, wound management, spacers, irrigation and debridement, antibiotic treatment and timing of reimplantation, one-stage versus two-stage exchange arthroplasty, management of fungal or atypical PJI, oral antibiotic therapy, and prevention of late PJI. Every consensus statement underwent extreme scrutiny, especially by those with expertise in a specific area, in order to ensure that implementation of the proposed practices could indeed lead to improvement of patient care.

After analyzing the literature and assembling a preliminary draft of the consensus statement, over 300 delegates attended the face-to-face meeting at Thomas Jefferson University in Philadelphia, Pa., USA. They were involved in active discussions and

voted on the questions / consensus statements. The delegates first met on July 31 in smaller workgroups to discuss and resolve any discrepancies and finalize their particular statements. After revising the consensus statements, the finalized consensus statements were assembled and forwarded to the Audience Response System that evening in order for voting to take place the next day. On August 1, 2013, the delegates gathered into the general assembly hall and voted on the 207 consensus statements that were being presented. The voting process was conducted using electronic keypads, where one could agree with the consensus statement, disagree with the consensus statement, or abstain from voting. The strength of the consensus was judged by the following scale: 1) Simple Majority: No Consensus (50.1-59% agreement), 2) Majority: Weak Consensus (60-65% agreement), 3) Super Majority: Strong Consensus (66-99% agreement) and 4) Unanimous: 100% agreement. Of the 207 statements, there was unanimous vote on only one (controlling OR traffic), 202 statements received super majority (strong consensus), two statements had weak consensus, and only two statements did not achieve any consensus.

The document¹⁻³ generated is the result of innumerable hours of work by the liaisons, leaders, and delegates dedicated to this initiative. We are certain that the "best practice guide" set forth by this initiative will serve many of our patients for years to come. It is essential to state that the information contained in this document is merely a guide for practicing physicians whose patients have a musculoskeletal infection; it should not be considered as a "standard of care". Clinicians should exercise their wisdom and clinical acumen in making decisions related to each individual patient. In some circumstances this may require implementation of care that differs from what is stated in this document. ■

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Periprosthetic Joint Infection: Could Bearing Surface Play a Role?

by Javad Parvizi MD, PhD, FRCS

Due to its disastrous consequences and rising incidence, periprosthetic joint infection (PJI) has taken center stage in orthopedics to become one of the challenges of the decade.¹ Numerous studies have identified some of the important risk factors for PJI. A recent international consensus meeting held in Philadelphia evaluated the available literature and identified the following as the main host-related issues predisposing a patient to PJI: a history of previous surgery, poorly controlled diabetes mellitus (glucose > 200 mg/L or HbA1C > 7%), malnutrition, morbid obesity (BMI > 40 kg/m²), active liver disease, chronic renal disease, excessive smoking (> one pack per day), excessive alcohol consumption (> 40 units per week), intravenous drug abuse, recent hospitalization, an extended stay in a rehabilitation facility, male gender, the diagnosis of post-traumatic arthritis, inflammatory arthropathy, a prior surgical procedure in the affected joint and severe immunodeficiency.²⁻⁵

Although the link between numerous host-related and environmental factors and PJI is better understood, the link between the use of different prosthetic biomaterials and PJI has not been clearly defined. PJI is caused by the attachment of infecting organisms to the prosthesis surface and the formation of biofilm, as a result of this one would expect that the "affinity" of organisms to attach themselves to the different biomaterials surfaces would vary. This issue has not been explored to a great degree as there is little clinical data studying the potential influence of different biomaterials on PJI. The international consensus group concluded that, based on the available medical literature, the incidence of PJI does not vary regardless of whether cemented arthroplasty components (without antibiotics) or uncemented arthroplasty components are used, and that the presence of hydroxyap-

atite on the uncemented surfaces does not seem to influence the incidence of PJI. The same workgroup analyzed the potential link between the type of bearing surface and the subsequent PJI, and 78% of the delegates felt that the available observational data confirmed a higher incidence of PJI following the use of a metal-on-metal bearing surface.

There are a number of potential reasons as to why the incidence of PJI may be higher after the use of a MoM bearing surface. For example, the failure of a MoM bearing surface can result in adverse local tissue reactions (ALTR) and extensive soft tissue destruction, which could then provide a favorable environment for bacterial proliferation.⁶ A systematic review conducted by Hosman et al. found that metal particles generated by the MoM bearing surface increased the potential risk of PJI because of the ability of metal particles to modulate the immune system and bacterial growth.⁷

The question that remains is whether other bearing surfaces influence the incidence of PJI as well. We are very interested in this question and have been exploring various databases to search for a possible pattern. The first analysis that we conducted was on the Nationwide Inpatient Sample (NIS) database, which is the largest publicly available, all-payer, inpatient care database in the United States. It contains data collected from approximately 8 million hospital stays each year, which amounts to roughly 20% of all patients treated in US hospitals.⁸ Using the ICD-9 codes for defining infection, we found that the incidence of infection was statistically higher in patients with metal-on-polyethylene bearings (1.1%) compared to patients with ceramic-on-polyethylene (0.87%) or ceramic-on-ceramic bearings (0.54%). A similar investigation of the Rothman Institute da-

tabase revealed a 0.8% incidence of PJI (as defined by Musculoskeletal Infection Society criteria)⁹ with metal-on-polyethylene compared to 0.4% with ceramic-on-polyethylene bearings, although the latter difference was not statistically significant. We are aware that our findings have limitations, resulting from the fact that neither the NIS data nor our institutional data were subjected to multivariate analyses. The findings could, for example, be a reflection of the younger age and lower medical comorbidity of patients who receive ceramic bearing surfaces versus those who receive metal-on-polyethylene bearing surfaces. However, the pattern detected is interesting and deserves further exploration. We are therefore evaluating the possibility of conducting a multi-institutional study that can collect granular data and explore the potential link between the type of bearing surface used and subsequent PJI. ■

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Does the Bearing Type Influence the Incidence of Periprosthetic Infections of the Hip?

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Keywords:

- periprosthetic infection
- bearing couple
- revision
- total hip arthroplasty

Introduction

Each year, orthopaedic implants provide 2.7 million patients worldwide with improved function and freedom from pain. However, infection after joint replacement (PJI) and fixation of bone fractures can lead to high morbidity, increased mortality and substantial costs.^{1,2} Due to a growing number of implantations and extending follow-up periods, the incidence of device-associated infections is also likely to increase.^{3,4,5} A microbiological cure for chronic device-associated infections is invasive and frequently necessitates the removal of the implant and cement in conjunction with a debridement of all devitalized tissues, which leads to a long-term antimicrobial treatment, resulting in a two-stage revision.^{6,7,8,9,10,11,12} Acute PJI may also be treated by less invasive one-stage replacement, debridement and retention; however, this forms of treatment should probably be restricted to centers with dedicated bone infection teams.¹³

Contemporary articulating surfaces in total hip arthroplasty (THA) predominantly consist of a metal part (usually cast cobalt-based Co28Cr6Mo alloys, ASTM F799 and ASTM 1537, ISO 5832) articulating with a plastic polymer (in most cases various types of ultra-high molecular weight polyethylene: MoP), or different types of irradiated polyethylene (MoXPE). Other types of bearings are also widely used, such as ceramic-on-polyethylene (CoP), ceramic-on-irradiated polyethylene (CoXPE), metal-on-metal (MoM) and ceramic-on-ceramic (CoC). New types of bearings have been introduced to increase THA longevity, which prevent the implant loosening usually caused by polyethylene particles-induced osteolysis around one or both of the components.¹⁴

Although many published studies look at the overall performance of various bearings^{15,16}, none report exclusively on how the bearing type influences the incidence of THA infection. We found one THA registry¹⁷ that collects information about the failure rate of different bearing systems, but there is no report on the failure mode. The lowest revision rates in this registry are associated with MoM (1.6%: 96

revisions out of 6,119 primaries) and CoC (2.9%: 750 revisions out of 25,918 primaries).

We used very broad criteria to diagnose infections when analyzing our series of MoM THA from the 1990s, and noticed a disturbing infection rate of 4.2%.¹⁸ Since the overall revision rate for infection was approximately 1.5%, we have concluded that the bearing type might have influenced the PJI rate.¹⁹

Materials and methods

In order to detect potential differences in the incidence of PJI for different bearing combinations, we analyzed the data in the Valdoltra Arthroplasty Registry²⁰, which was founded in 2002. We used the database to identify all patients fitted with a total hip arthroplasty (THA) between 1.1.2002 to 12.31.2012, and then grouped them according to which bearing had been implanted  (Table 1). The rate of revisions due to deep infection for each bearing type was then determined. In the 11-year follow-up period there were 4,770 primary THA in the MoP group, 2,813 in the MoXPE group, 72 in the MoM group, 512 in the CoP group, 376 in the CoXPE group and 1,323 in the CoC group. The number of THA that were revised due to infection was 30 in the MoP group, 29 in the MoXPE group, 0 in the MoM group, 3 in the CoP group, 0 in the CoXPE group and 6 in the CoC group. We calculated the revision rate for infection in each group and compared these rates with the chi-squared test. We excluded the MoM group from the statistical analysis on account of it being too small in comparison to the other groups.

A prosthetic joint infection was diagnosed if at least one of the following criteria was present:

1. growth of the same microorganism in ≥ 2 cultures of synovial fluid or intraoperative tissue specimens
2. purulence of aspirated fluid or intraoperative tissue (as determined by the surgeon)

3. acute inflammation in the histopathological sample of intraoperative permanent tissue sections (as determined by the pathologist)¹³
4. a fistula communicating with the joint

Statistical analysis

Statistical analysis was performed using version 19 of IBM SPSS. To analyze the differences between the groups, a chi-squared test and a two-tailed t-test were performed. We compared the group with the best revision rate result (CoXPE) to the other 4 groups, setting the significance level at $p=0.05$.

Results

The infection rate was 0.63% among the 4,770 patients with MoP bearings, 1.63% among the 2,813 patients with MoXPE bearings, 0.00% among the 376 patients with CoXPE bearings and 0.45% among the 1,323 patients with CoC bearings. We excluded the 72 patients with MoM bearings because their numbers were low and the statistics would have been biased. We found statistically significant differences in the infection rates between patients with MoP and CoXPE bearings and between those with MoP and CoC bearings. We did not find any statistical differences between CoXPE and CoC bearings.

Discussion

Periprosthetic tissue is limited in its ability to eradicate infective agents if introduced into the wound during the surgery, especially if a foreign body is present.²¹ Adhesion of biomolecules (e.g., proteins) as well as whole organisms, like bacteria or host cells on biomaterial surfaces, is important for the biomaterial's behavior.^{22,23,24} It has been proposed that prompt and firm bacterial attachment combined with a poor host cell attachment can lead to implant-related infections (the "race for the surface" hypothesis).²⁵ An overt infection occurs if the dose and virulence of the organisms overcome the defense mechanisms. Subsequently, biofilm commonly forms, protecting pathogens against phagocytosis, complement and antibiotics²⁶ with its extracellular polymeric substance.

If PJI develops, clinical presentations depend, as with other types of infections, on the strength of the host's defense mechanism and the virulence of the pathogens. The presence of the foreign material and the propensity of bacteria to develop a protective biofilm on it make PJI different and difficult to eradicate. Two extreme scenarios are expected, with most PJI falling between these two limits. A patient with a strong immune system and an affecting organism of a very low virulence will possibly mani-

Status/ bearing	MoM	CoXPE	CoC	CoP	MoP	MoXPE
Non-revised	72	376	1,317	509	4,740	2,784
Revised	0	0	6	3	30	29
Total	72	376	1,323	512	4,770	2,813

Table 1: Number of hips implanted with each bearing type within the study period and the number of those revised due to PJI.

fest a state of persistent subclinical infection, meaning that host defense mechanisms have control over biofilm-laden bacteria. A subclinical infection therefore persists but will not manifest itself unless the defense mechanism weakens. Studies that use sensitive diagnostic tools to reveal bacterial presence in presumably aseptic cases support the existence of this extreme scenario.^{27,28} In weak hosts, on the other hand, a virulent organism can cause fatal fulminant sepsis. Most PJI fall somewhere in between these two extreme scenarios, depending on the host's defense strength and the pathogen's virulence.

Consequently, it can be expected that certain infections will never become clinically evident or may only result in a presumably aseptic loosening sooner or later.^{24,29,30} The incidence of this subclinical infection is not known; however, some studies state that the incidence of septic loosening within a range of 5% among the apparently aseptic is not negligible.²⁸ We may speculate that, in these cases, host defense mechanisms and bacterial virulence factors could stay in balance permanently, for a long time or until a certain interference weakens the local or systemic immune mechanisms. This points to the possibility that natural non-specific mechanisms, such as those involving toll-like-receptors (TLR), and specific mechanisms, such as antigen mediated immunity, may be powerful enough to keep a very low-grade infection under control for an indefinite period, provided there is no disturbance in the balance.

It is important to recognize the possibility of subclinical infections because they may have many real clinical consequences. There are indices pointing in favor of this concept. As has been previously demonstrated, the infection rate following revision surgery depends on the power of the diagnostic tools. Sonication of the explants caused more infections than conventional periprosthetic cultures, further suggesting that more failures are septic than previously suspected.³¹ Applying still more sensitive diagnostics, such as PCR technology, seems to result in an even higher number of infection-related revisions.³²

Systemic disorders, like inflammatory diseases, and therapeutic agents, such as corticosteroids, biologic drugs and chemotherapeutics that induce immunosuppression, are associated with an increased incidence of infection and can cause asymptomatic PJI to become symptomatic.

It is thus possible that the bearing type influences local and, eventually, also systemic, host defenses. We predict that wear particles released from the bearing and their influence on local tissue could represent the mechanism of action. The influence depends on the quantity, size, shape and chemical composition of the particles. Studies have shown^{33,34} significantly elevated levels of blood metal ions (cobalt, chrome, titanium, vanadium) and far higher levels are present in the periprosthetic space of some bearings. In-vitro tests have demonstrated the toxic effects that increased levels of metal ions have on lymphocytes and sensitization to metals has also been observed in certain patients.³⁵

It has been shown that different particles have different biological activities and subsequently propensities for macrophage activation and osteolysis formation.^{36,37} According to some studies, ceramic particles are the most bio-tolerant.³⁷ On the other hand, the corrosion products of metal particles can induce profound derangements of local tissue,³⁸ resulting in pseudo-infections or pseudotumors in some patients. The relative bio-tolerance of polyethylene debris stays between that of ceramic and metal.

Toll-like receptors may also be involved in the pathogenesis of a decreased local immune response to metal ions. A paper by Pajarinen³⁹ has shown that foreign body presence in mouse bones down-regulates TLR, particularly in the presence of metal debris. Innate and adaptive immune responses, in which TLR plays an important role, are consequently decreased. Low-grade infections that would otherwise remain permanently under control are prone to actuate in an immunosuppressed milieu.

Metal ions activate antigen presenting cells (APC), which lead to an enhanced expression of the MHC-peptide and costimulatory molecules. The fate of the response, however, depends on which type of T-cell receptor the costimulatory molecules act on.

The whole spectrum of immunological changes in the local and systemic environment caused by the release of particles from the bearings is not known in detail. However, growing evidence demonstrates that important derangements do occur, which alter local and systemic immunologic mechanisms and induce a status of relative immunodeficiency, resulting in higher infection rates.^{40,38,41} (Figure 1) The profound influence of metal ions on periprosthetic tissues has been summarized by Kontinen.³⁸

It seems that metal ion release influences the incidence of clinically manifested PJI. Articulation is probably the main source of metal ions (particularly in MoM implants), and the importance of taper junctions has also recently been acknowledged. Tapers are prone to crevice corrosion⁴³, particularly in high torque conditions that occur with larger heads.

Our results indicate that implants with articulations involving a metal component are more prone to becoming infected than those involving ceramic-on-ceramic or ceramic-on-polyethylene bearings, where no metal ion release occurs from the bearing and only minimal release occurs from the taper junction. The presenting results and working hypothesis are in line with the high incidence of infection in our MoM series from the 1990s.^{18,44} A direct cause and effect, however, has yet to be proven.

The study has weaknesses. Although all of the surgeons included in the study practice operated on patients in the same hospital, discrete differences in surgical techniques and patient selection were unavoidable. Selection bias may also have influenced the results since the indication for the bearing selection was not always consistent. The homogeneity of the compared groups in terms of age, primary diagnosis and activity level was not checked.

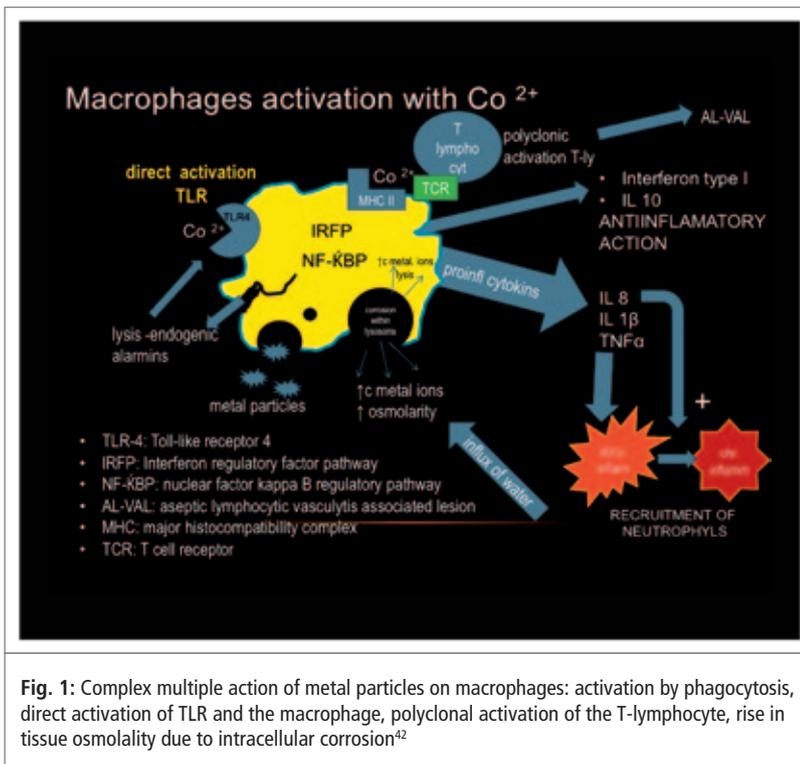


Fig. 1: Complex multiple action of metal particles on macrophages: activation by phagocytosis, direct activation of TLR and the macrophage, polyclonal activation of the T-lymphocyte, rise in tissue osmolality due to intracellular corrosion⁴²

Despite these weaknesses, the results and circumstantial evidence from the literature provide us with enough suspicion to warrant further investigation into the influence of the bearing pair on the incidence of PJI. ■

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Rihard Trebše's research is mainly focussed on prosthetic joint infections. He wrote his PhD thesis on the "Treatment of orthopedic device related infection with device retention and defined antibiotic therapy". His ongoing research projects examine, among others, the influence of perioperative antibiotics on intra-operative tissue cultures and the role of endotoxin in the loosening of artificial joints. He is also conducting a study on allergic reactions in metal-on-metal total hip arthroplasty.

Rihard Trebše is member of several professional societies, including the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) as well as the European Study Group for Implant Associated Infections (ESGAI).

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The Taper in Hip Arthroplasty: What Does the Surgeon Have to Pay Attention To?

by Leslie F. Scheuber, Sylvia Usbeck, Florence Petkow

Modular principle for hip arthroplasty

Modern hip arthroplasties are based on a modular construction. This modular construction, particularly the combination of a stem and femoral ball heads of differing neck lengths, is an accepted solution that enables flexible adjustment to the individual situation of patients during surgery. This modularity enables the surgeon to optimize reconstruction of the original joint anatomy and to achieve the best possible biomechanics for the patient. Modular taper fixation also enables different materials such as metal and ceramics to be joined together. Taper locking has proven itself to be practicable in both its manufacturing process and its application. A further advantage is its high stability, which prevents corrosive phenomena. During revision surgery it is possible to loosen the locked fixation and to replace the femoral ball head in accordance with the manufacturer's instructions.

On the history of taper fixation

The taper fixation between a femoral ball head and a stem, familiar in hip arthroplasty, was developed at the start of the 1970s by the industry partners Sulzer AG (endoprosthesis manufacturer and predecessor of Zimmer, Winterthur, Switzerland) and Feldmühle AG (ceramics manufacturer and predecessor of CeramTec GmbH, Plochingen, Germany). The aim was to realize reliable and durable fixation between a ceramic femoral ball head and a metal stem. Dörre et al.¹ attached special importance to the force-fit connection (taper locking) between the ceramic femoral ball head and the metal taper: a hip arthroplasty with taper fixation was used in a patient for the first time in 1974. The principle behind this taper fixation was protected in a Swiss patent (No. 1060601). At the start of the 1990s intense efforts were made to standardize a uniform taper (the Eurotaper) with the International Organization for Standardization (ISO, document ISO/TC150/SC4 N117) but these efforts failed. There is still no standard for the stem taper. Implant manufacturers continue to use tapers with their own specifications (for example, various 12/14 tapers), which differ in

terms of geometry, structure and surface properties (Fig. 1). The intervals between the neck lengths (s, m, l and xl) (Fig. 4) are also not standardized and can vary from manufacturer to manufacturer by several millimeters.

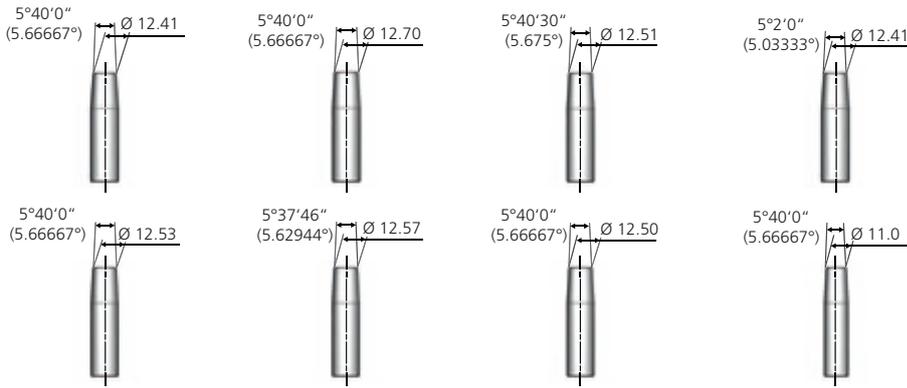
Features of an implant taper

A taper fixation is made up of a stem taper and a taper in the femoral ball head (drill hole). Each of these tapers has characteristic properties (Fig. 2a-b) such as taper angle, diameter, straightness and roundness and surface properties, which are essential for a precise matching of the components. For secure taper locking, the fit of the taper fixation between the femoral ball head and the stem taper is very important.

Compatibility

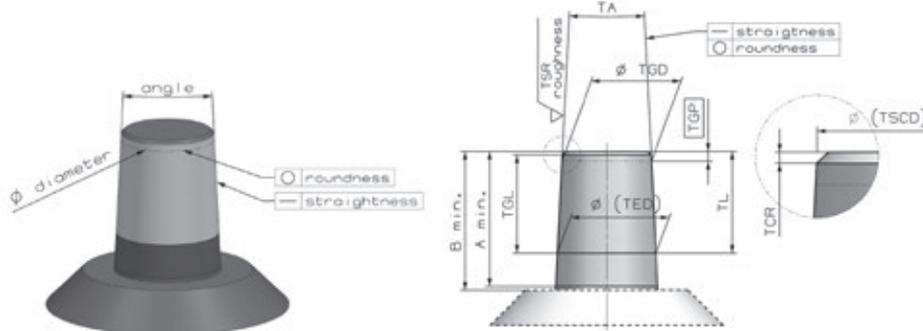
It is vital that surgeons combine only those arthroplasty stems and femoral ball heads that the implant manufacturer has declared to be compatible.² The implant manufacturers are responsible for the release of the stem taper/femoral ball head combinations and supply the components to the hospitals. The surgeon must comply with the details regarding approved combinations provided by the implant manufacturer in the instructions for use and other written information. In case of failure to observe compatibility of individual arthroplasty components (Fig. 3), clinical consequences, e.g. with regard to joint geometry with effects on leg length and soft-tissue tension as well as increased metal wear combined with adverse tissue reactions (pseudotumor) and implant failure ahead of time³ cannot be ruled out. A meta-analysis indicates that there are insufficient studies of this issue. Information regarding the mechanical behavior of taper locking with inadequately fitting arthroplasty components may be provided by laboratory investigations. ■

Fig. 1: Different tapers all of which are designated "12/14"



Source: CeramTec

Fig. 2a/2b: Characteristics of an implant taper



Source: CeramTec

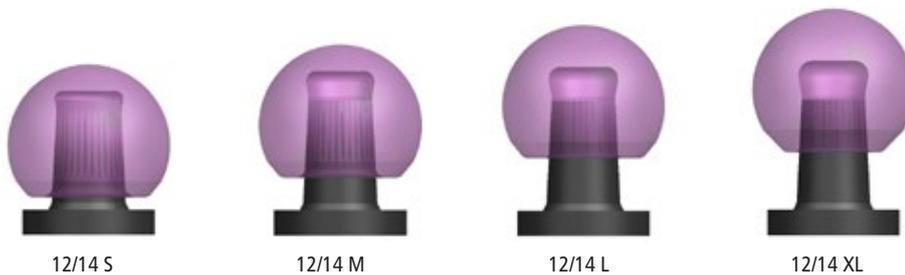
Abbreviation	Description
TGP	Taper gage plane
TGD	Taper gage diameter
TA	Taper angle
TL	Taper length
TCR	Taper chamfer/radius
TSR	Taper surface roughness
TS	Taper straightness
TR	Taper roundness
TGL	Taper gage length
TED	Taper end diameter
TSCD	Taper sharp corner dia.

Fig. 3: Compatibility example: Design difference between two nominally similar 12/14 tapers demonstrated with the fit with a ceramic femoral ball head



Source: CeramTec

Fig. 4: Different neck lengths



Source: CeramTec

TAKE HOME MESSAGE

- There is no uniform, standardized stem taper.
- Numerous stem tapers are called “Eurotaper 12/14” but this only represents a general size designation and provides neither an indication about compatibility with arthroplasty components from other manufacturers nor information about the precise manufacturer’s specification for a stem taper.
- You must therefore query terms such as **12/14 Eurotaper** or **Standard Taper 12/14!**
- It is essential that you check the compatibility of femoral ball heads and stem tapers!

GLOSSARY

Eurotaper

Not a standard term in hip arthroplasty

Taper

Technical element in the shape of a cone or truncated cone

Taper diameter / conical taper (example 12/14 or 10/12 etc.)

Simple characterization of the taper using a rounded and imprecise size definition of the smallest and largest taper diameter with undetermined distance between the two diameter elements

Taper angle

Precise angle of inclination of the cone in its axial direction

Taper diameter

Exact nominal diameter or tested diameter at the defined measurement height on the cone

Femoral ball head minimal definition

Example: 32 12/14 M 0 5° 46' defines a femoral ball head with:

- Ball diameter = 32mm
- Taper diameter:
 - start of taper = approx. 12mm
 - end of taper = approx. 14mm
- Neck length = M (medium)
- Taper angle = 5° 46'

The implant manufacturer must release the ceramic femoral ball head for use with the particular type of implant.

Straightness

The term describes the straightness of each line on a conical surface in the axial direction.

Roundness

The term describes the roundness of the circumference of any cross-section.

Surface roughness / structure

The term describes the properties and parameters of the surfaces of a technical element.

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Selection of Bearing Couple in Revision Surgery After a Fractured Ceramic Component

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 The abstract is available on the ISTA website: www.istaonline.org (registration required)

INTRODUCTION

From a tribological point of view and clinical experience, a ceramic-on-ceramic bearing represents the best treatment option after rare cases of ceramic component fracture in total hip arthroplasty (THA).

Fractured ceramic components potentially leave small ceramic fragments in the joint capsule, which might become embedded in PE acetabular liners.

PURPOSE

This in-vitro study compared for the first time the wear behaviour of femoral ball heads made of ceramics and metal tested with PE liners in the presence of ceramic third-body debris.

The contamination of the test environment with third-body ceramic debris, insertion of ceramic fragments into the PE liners and implementation of continuous subluxation simulated a worst-case scenario after revision of a fractured ceramic component.

MATERIALS AND METHODS

Ceramic femoral ball heads (Ø 32mm) made of alumina matrix composite (AMC; BIOLOX[®]*delta*, CeramTec, Germany) were tested in combination with PE and cross-linked liners and compared to metal femoral ball heads (CoCrMo) of the same diameter. All PE liners were fixed into Ti-6Al-4V metal shells by conical fixation as intended for clinical use. The tests were performed based on ISO 14242-1 utilizing a hip simulator (EndoLab, Germany). Alumina ceramic debris (BIOLOX[®]*forte*, CeramTec, Germany) of about 2mm diameter (maximum 5mm) was inserted into the PE liners in predefined specific points

corresponding to the main load transfer area before the test. The acetabular liners were tested at an inclination of 45° in the medial-lateral plane with the specimens placed in an anatomically correct position. During the test, additional alumina ceramic debris was introduced into the articulation area as a part of the test fluid (calf serum) used in the simulator test chambers. All specimens were tested up to 5 million cycles. Damages to the surfaces of the materials were assessed visually. The wear of the femoral ball heads was measured gravimetrically.

RESULTS

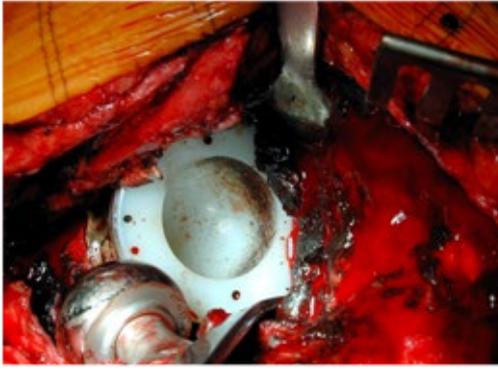
High wear rates were found for metal femoral ball heads, being 1,010 times higher when compared to ceramic femoral ball heads tested with XPE liners and 560 times higher when compared to ceramic femoral ball heads tested with conventional PE lin-

ers. The conventional and crosslinked PE liners used in combination with metal femoral ball heads clearly exhibited a scratched surface, whereas the surface of the liners tested with ceramic femoral ball heads exhibited significantly less scratching.

DISCUSSION AND CONCLUSION

This study demonstrates that apart from the recommended ceramic-on-ceramic option also ceramic-on-PE and ceramic-on-crosslinked PE bearing couples may be a viable treatment option after fracture of a ceramic component. The use of a ceramic femoral ball head after fracture of a ceramic articu-

lation component minimizes wear and wear-related complications caused by third-body wear. Based on the results of this in-vitro study and clinical findings, the use of a metal femoral ball head in articulation with any PE liner after a ceramic fracture is contra-indicated. ■



MoP treatment in a case of ceramic ball head fracture. The use of the MoP articulation after a ceramic fracture is contra-indicated. Ceramic particles can be lodged into the PE insert articulating surface, resulting in severe destruction of the metal femoral ball head and metallosis.

(Source: Courtesy of Stephan Horn, MD, Department of Orthopaedic Surgery at the Hospital Barmherzige Brüder, Munich, Germany)

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Is Metal Ion Release also a Concern for Ceramic-on-Ceramic Couplings?

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Keywords:

- chromium ions
- ceramics
- ICP-MS
- tribology

Introduction

The latest member of the BIOLOX® family, BIOLOX® *delta*, is a ceramic composite material containing homogeneously dispersed zirconia grains and strontium hexaaluminate platelets, which provide an increased level of fracture toughness, strength and wear resistance compared with monolithic alumina. It's an extremely popular choice for hip replacement devices; since its launch, 2.6 million BIOLOX® *delta* femoral ball heads and 1.1 million inserts have been implanted worldwide.

Some metal-on-metal hip devices that are known to release chromium and cobalt metal ions have been shown to produce toxicological effects. BIOLOX® *delta*, however, also contains trivalent chromium ions, which randomly replace the trivalent aluminum ions in the alumina matrix. Despite being strongly bound to the alumina lattice, it has yet to be experimentally proven if the chromium ions are eventually released into the body. If BIOLOX® *delta* is completely biocompatible in terms of ion release, it could offer an excellent alternative to metal-based bearing couples.

Objectives

This study aims to detect the in-vivo release of chromium ions in ceramic BIOLOX® *delta* bearings by analyzing patients' blood, erythrocytes and urine.

Methods

20 patients who had undergone the total hip arthroplasty with BIOLOX® *delta*-BIOLOX® *delta* couplings (patients) and 21 subjects with no implanted prostheses (controls) were enrolled once other forms of exposure to chromium had been ruled out. Blood samples were obtained from the radial vein using a butterfly needle. The first 3 ml was discarded and further samples were withdrawn in order to obtain whole-blood, serum and erythrocytes. Clean-catch urine samples (10 ml) were collected in universal sample pots. All samples were frozen and stored at -20°C until the analysis. Inductively coupled plasma mass spectrometry equipped with a

dynamic reaction cell (DRC) was used for determination. The solutions of calibration curve and the sample solutions were pumped into the spray chamber using a peristaltic pump. Blank samples were used to correct for any contamination in each batch. The method's accuracy was determined on the basis of the mean values obtained from the certified reference materials (environmental and occupational) of G-EQUAS for blood, serum and urine.

Results

The patient group consisted of 10 females and 10 males, mean age 59.9, mean body weight 71 kg, 15 of which had a 32mm femoral ball head and 5 a 36mm femoral ball head. Follow-up took place between 6 and 63 months afterwards.

The control group consisted of 7 females and 14 males, mean age 57.2, mean body weight 75 kg, wearing no implants.

The Cr ion values in the patient group were as follows: 0.21 µg/l (SD 0.09) in mean blood, 0.21 µg/l (SD 0.12) in serum, 0.13 µg/l (SD 0.09) in normalized erythrocytes and 0.12 µg/l (SD 0.13) in normalized urine.

The Cr ion values in the control group were as follows: 0.22 µg/l (SD 0.14) in mean blood, 0.17 µg/l (SD 0.08) in serum, 0.13 µg/l (SD 0.11) in normalized erythrocytes and 0.07 µg/l (SD 0.08) in normalized urine.

The lab reference values were 0.1–5.0 µg/l for blood, 0.1–0.5 µg/l for serum, 0.14–4.58 µg/l for normalized erythrocytes and 0.05–2.2 µg/l for urine

■ (Fig. 1a-d).

Conclusions

All of the blood, serum, urine and erythrocyte (marker for hexavalent chromium) samples in the patient and control groups contained chromium levels within the internal reference range, as set by the laboratory conducting the analysis. A power analysis was shown to be sufficient (95%).

This study has demonstrated that BIOLOX® *delta* ceramics is completely safe in terms of ion release. It is an excellent alternative to metal couplings. ■

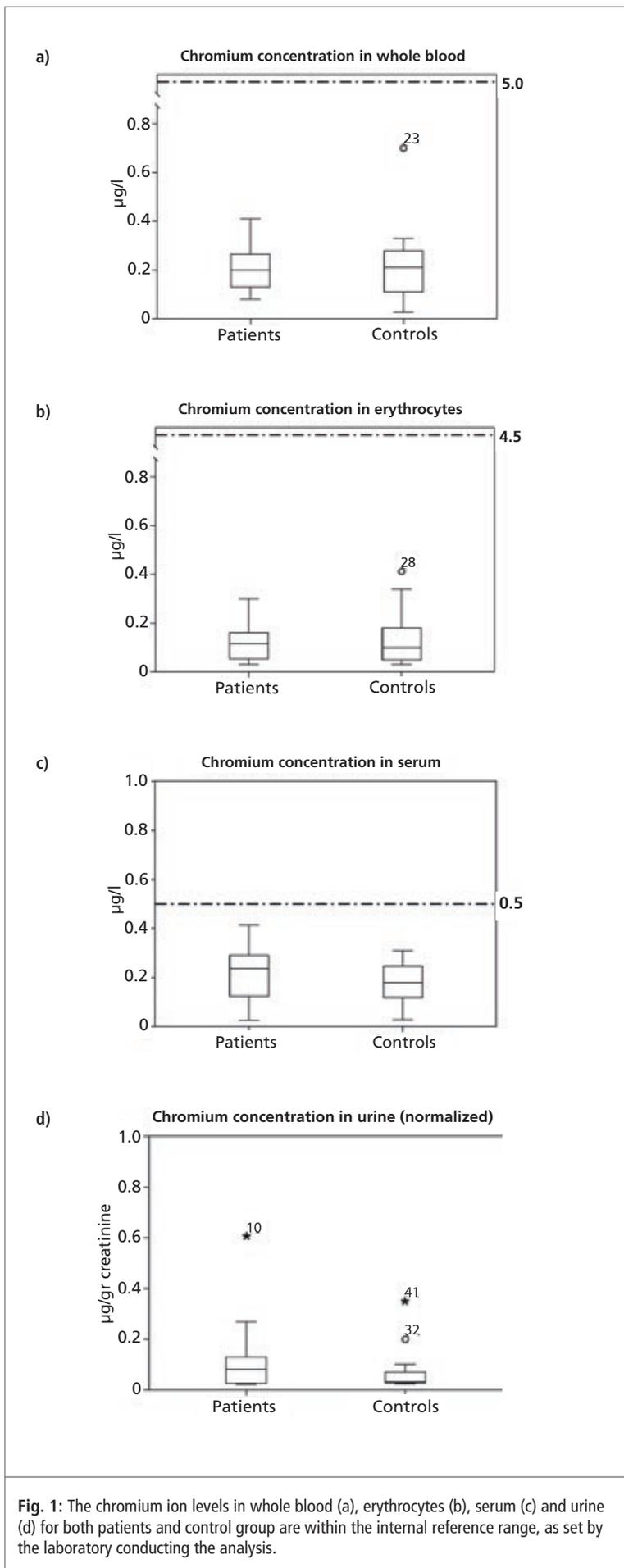


Fig. 1: The chromium ion levels in whole blood (a), erythrocytes (b), serum (c) and urine (d) for both patients and control group are within the internal reference range, as set by the laboratory conducting the analysis.

Laboratorio di Tecnologia Medica in Bologna

The mission of the Laboratorio di Tecnologia Medica (Medical Technology Laboratory) in Bologna, Italy, is to develop, validate and transfer into clinical practice every single innovative technology that could help to prevent, diagnose, treat, monitor or rehabilitate musculoskeletal diseases.

Together with the Department for Orthopaedic-Traumatology and Prosthetic Surgery and Revisions of Hip and Knee Implants, the laboratory forms a clinical and research unit directed by Dr. Aldo Toni.

The laboratory consists of approximately 40 members of staff, including senior and junior researchers as well as graduate and undergraduate students. It is organized into 5 research units.

Headed by Susanna Stea, PhD, the Biology Unit is conducting research on the following topics, some in co-operation with other research structures within and outside of the Rizzoli Institutes:

- Isolation of wear particles inside the synovial liquids and tissues of patients with a prosthesis using SEM-EDS and morphological analysis
- Dosage of metal ions using ICP-AES in the hair of patients with a prosthesis
- Bone histomorphometry
- Cytokine dosage inside the synovial liquids of patients with a prosthesis
- Histology of periprosthetic soft tissue – quantitative evaluation of wear
- Definition of crystallinity degree and oxidation products in ex-vivo polyethylene specimens
- Microhardness evaluation of healthy and pathologic bone tissue and different biomaterials related to the implant
- Bone cell culture for the in-vitro evaluation of bone homeostasis

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Bearing Exchange in the Management of Pathologic Findings Associated with Metal Components in Hip Replacement

by Sylvia Usbeck

The past several years have seen an increase in the number of case reports published on a broad spectrum of pathologic findings associated with metal (CoCrMo) components in hip replacement. Surgeons should be aware of this as a possible cause for complications when investigating unexplained pain or swelling around a well-performed hip replacement. Most of the case reports did not measure or analyze the presence and amount of metal or PE debris, however, which reveals a limitation in these studies and means that no definitive conclusions can be drawn.

It has not yet been investigated whether predisposing patient factors, such as diabetes mellitus, autoimmune disorders and other inflammatory diseases associated with lower pH values, contribute to the corrosion behavior of metal implants, which is influenced by a change in local environmental conditions caused by hyperglycemia or alterations to pH value. This has already been demonstrated with dental implants in a recently published study.

Adverse reactions to metal debris, corrosion phenomena, allergic reactions to implants and periprosthetic infections in arthroplasty must also be coherently considered and investigated with greater regard for patient-specific factors. Because of the complexity of the issue, an essential growth in knowledge can only be expected from cooperation between experts from the various specialties in medicine, dentistry and materials science.

CASE REPORTS

Bearing Exchange in the Management of Pathologic Findings Associated with MoXPE and MoP THA

Mao et al. (Australia) diagnosed a greater trochanter pseudotumor formation in a 71-year-old female patient with a well-fixed, uncemented MoXPE THA (32mm head diameter) 7 years after surgery. Significant surface corrosion was noted on the femoral head-neck junction. A 20-cm-long greater trochanter bursa cyst filled with fluid was found intraoperatively.

The patient's implant was successfully revised to a CoC bearing couple (32mm head diameter). There were no postoperative complications. The authors reported that the patient is now completely asymptomatic. She has since remained systemically well and free from pain, with no recurrence of the bursa cyst.

Scully et al. (USA) discussed the preoperative symptoms, imaging results and operative findings of an inflammatory pseudotumor associated with a well-fixed hybrid MoXPE THA (32mm head diameter). Over a period of 2 years approximately 7 years after surgery, an 80-year-old male patient complained of slow, progressive pain in his right hip and the gradual development of soft tissue prominence in the

greater trochanter area. Physical examination and a metal artifact reduction sequence MRI revealed a tender, large, anterolateral, soft tissue thigh mass and fluid build-up. Intraoperative findings included an extensive tissue necrosis involving the entire hip capsule, shortened external rotators and a tendinous portion of the gluteus medius muscle. Necrotic bone with cavitory lesions was discovered about the acetabulum and greater trochanter. The authors observed corrosion at the head-neck junction. An intraoperative arthroscopic image revealed surface corrosion and debris along the trunnion within the metal femoral ball head. Minimal repair of the capsule and shortened external rotators was performed due to the damage found to these structures. The metal femoral ball head (32mm) was replaced with a ceramic femoral ball head (BIOLOX® *delta*, 36mm) and the XPE insert was exchanged. The authors reported that the patient had complete resolution of his preoperative symptoms. As the patient has had persistent problems with dislocations, a future revision to a constrained liner is planned.

Walsh et al. (Canada) presented a typical extrapelvic inflammatory pseudotumor following an uncemented MoXPE THA (36mm head diameter), associated with histopathological changes consistent with ALVAL. The authors identified hypersensitivity in response to the MoXPE bearing couple as the cause. Approximately 2 years after surgery, the 79-year-old male patient with comorbidities complained of a growing mass over his left buttock accompanied by pain, a decrease in appetite and weight loss. A radiological investigation showed no evidence of cup migration or measurable wear. The inclination was 46°, with an anteversion of 24°, and the stem anteversion measured 15°. A biopsy of the soft tissue mass was performed. The histological findings were consistent with an inflammatory pseudotumor and the patient underwent revision surgery. The authors reported that the cup was well fixed and the taper of the stem was undamaged. The MoXPE articulation was replaced with a CoC bearing couple. The explanted metal femoral ball head and the XPE insert showed no signs of abnormal wear. There were no postoperative complications and the patient became completely asymptomatic. At the 1-year follow-up, the patient had complete resolution of his preoperative symptoms.

Picardo et al. (UK) described a MoP pseudotumor with the histological features of ALVAL. They reported on the case of a 71-year-old female patient who developed a pseudotumor extending into the pelvis 5 years after being fitted with an uncemented MoP THA (28mm head diameter). The pseudotumor compressed the femoral vein causing deep venous thrombosis. Clinical findings included groin pain, a

leg length discrepancy of 3cm and a palpable mass, which had reduced the distance she was able to walk. X-rays revealed no signs of prosthesis loosening. The MRI showed a mass surrounding the prosthesis measuring 4.3cm x 5.2cm. A biopsy revealed necrotic tissue with macrophage and lymphocyte infiltrate. The patient underwent revision surgery. Intraoperative findings showed a large amount of dense, yellow-gray inflammatory tissue extending into the hip joint and surrounding the cup. The authors noted that the PE insert showed some signs of wear. The histological examination showed no metal wear particles. The authors suggested that the patient may have had a hypersensitivity reaction to a normal amount of metal debris. The mass was removed and samples taken from the tissue revealed findings consistent with a pseudotumor. The cup was exchanged, and the MoP bearing couple was revised to a CoC bearing couple (40mm head diameter). The revision to a CoC bearing couple was performed without complications and led to symptom resolution. The authors reported that the patient's recovery was uneventful. The patient recovered normally without experiencing any adverse reactions or complications. The CoC THA seems to have solved the problem.

“Revision of the components to ceramic on ceramic bearing surfaces removed the source of the problem and the pseudotumour was seen to be fibrosed on MRI six months later, and causing no symptoms.”

– Picardo et al., p.764

CASE REPORTS

Bearing Exchange in the Management of Pathologic Findings Associated with MoM Hip Replacement

Algarni et al. (Canada) reported on the case of a 59-year-old female patient who developed an iliopsoas bursal cystic lesion 5 years after undergoing a MoM THA (28mm head diameter). The MRI showed an iliopsoas bursal cyst measuring 9cm x 4cm x 4cm that was compressing the femoral vein. The determination of metal ions concentration of the aspirate revealed high levels of chromium (83µg/g) and cobalt (17µg/g). Based on these findings and on a malpositioned cup causing edge loading and excessive metal debris, the authors suggested an inflammatory reaction to metal debris as the cause. Intraoperative findings showed a highly inflamed, metal-stained synovium and milky, gray fluid. There was no evidence of corrosion at the head-neck junction. The authors reported that the patient underwent fluid drainage, an aggressive synovectomy and a partial bursal excision. A histological examination of the removed cyst showed evidence of ALVAL and

a classic reaction to foreign bodies. The malpositioned cup was removed and the MoM bearing couple was revised to a CoC bearing couple (BIOLOX® delta), with excellent results. Postoperatively, the patient had complete resolution of his preoperative symptoms. At the 1-year follow-up, the patient had recovered normally without complications or any signs of adverse reactions.

“In the current case, the authors preferred a ceramic-on-ceramic bearing over metal-on-polyethylene because of the relatively young age of the patient and to reduce any further burden of chromium and cobalt metal particles and ions.”

– Algarni et al., p. 1069

A report by **Kemp et al.** (UK) describes 3 cases of pseudotumor formations in which the revisions of MoM HR to a large-diameter CoC hybrid THA resulted in rapid clinical resolution of the associated soft tissue reactions, both clinically and on the subsequent MRIs. In all cases, the diagnosis was confirmed histologically to be ALVAL.

A 49-year-old female patient presented a painless 20cm x 8cm soft tissue mass in the superficial tissue of the left thigh 6 years after MoM HR surgery. Intraoperative findings showed an enlarged bursa, a thickened psoas tendon and a loose stem. An extensive debridement of the lesion was not performed. The MoM HR was revised to a CoC hybrid THA.

A 52-year-old female patient developed pain in the right groin, buttock and greater trochanter region 6 months after MoM HR surgery, which had progressed to signs of psoas impingement by the 18-month mark. Intraoperative findings revealed a large pseudotumor involving the iliopsoas muscle, extending into the pelvis, and a loosened stem. A limited resection of the soft tissue mass was performed. The MoM HR was revised to a CoC hybrid THA. 6 months postoperatively, an MRI showed an atrophy of the gluteal muscles, but no identifiable lesion.

A 58-year-old female patient developed severe pain in the left hip and a large swelling in the groin 63 months after MoM HR surgery. The MRI showed an 8cm x 5.5cm thin-walled cystic structure. The patient underwent revision surgery 66 months after the primary surgery. Intraoperative findings showed a fluid-filled necrotic mass anterior to the hip, extending under the femoral nerve into the medial aspect of the thigh. The MoM HR was revised to a CoC hybrid THA. The groin swelling was resolved and, 11 months after surgery, an MRI revealed a significant reduction in the size of the lesion.

Limited debridement was performed during revision surgeries in all cases. The patients' previous implants were replaced with CoC hybrid THA. Rapid clinical resolution of the swelling was observed in all cases. The 52-year-old female patient with the large pseudotumor extending into the pelvis experienced progressive resolution and her lesion disappeared. The authors noted a clear gradation in the severity of the lesions, ranging from relatively benign cystic swellings to osteolysis and extensive tissue necrosis. They pointed out that, in the early stages, using a conservative approach to soft tissue debridement when replacing MoM bearing couples with CoC bearing couples reduces recovery time and appears to be an adequate option.

Rajpura et al. (UK) described the cases of 13 patients (8 male, 5 female) with MoM hip prostheses (mainly HR), which had failed due to ALVAL. According to the authors, the degree of soft tissue destruction can render revision surgery difficult. In

their opinion, soft tissue defects are of more concern than bone defects.

The patients' mean age at the time of primary surgery was 56 (22-67) years. The mean follow-up was 21 (12-40) months after surgery. The diagnosis of ALVAL was confirmed histologically. All patients experienced unexplained groin pain, 4 experienced masses in the greater trochanter area, 1 experienced recurrent large bursal swelling, 3 experienced mechanical phenomena such as "grinding", "locking" and "grating", 3 experienced recurrent dislocations and 1 experienced sciatic nerve palsy. A radiological examination showed cup loosening in 3 patients and neck thinning in 2 patients. Intraoperative findings included extensive soft tissue necrosis (6 patients), bursal swelling and creamy brown fluid. Destruction of soft tissue was detected in 6 patients. Osteolysis was rarely observed. Visible metal debris was not seen in any patient. The authors noted that surgical findings were typical and symptoms were usually resolved after exchanging the bearing surface.

Revision was performed at a mean of 45 (15-87) months after surgery. 12 patients received a THA and one patient was left with pseudoarthrosis due to extensive bursal swelling with necrosis of the abductors. The authors emphasized that a MoM bearing couple should not be used in such revision cases. They pointed out that sensitization to cobalt and chromium cannot be excluded if ALVAL has occurred due to impingement or malposition.

CoC bearing couples (36mm head diameter) were used in 10 patients and MoP bearing couples in 2 patients. All patients reported an immediate improvement in pain. The authors noted that 5 patients were still experiencing slight residual pain, but that it had significantly improved from their preoperative situations. No further postoperative complications were reported. The authors concluded that the long-term outcome remained uncertain in the cases with extensive soft tissue destruction.

Werle et al. (Canada) reported on a 45-year-old female patient with bilateral MoM HR. She complained of limited activity in the left hip, pain and swelling in the left thigh, which was slowly increasing in size. The examination showed no signs of psoas tendonitis or impingement. An MRI showed an 18cm x 9cm x 5cm pseudotumor formation that was encasing the sciatic nerve, explaining the sciatic nerve paresthesia.

The condition was managed by exchanging the implants and excising the pseudotumor. The MoM HR was revised to a CoC THA. The authors reported that the patient had complete resolution of her preoperative symptoms and that her metal ion levels had returned to baseline, suggesting a well-functioning MoM HR on the right side. ■

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AAOS American Academy of Orthopaedic Surgeons

ALTR Adverse Local Tissue Reactions

ALVAL Aseptic Lymphocyte-dominated Vasculitis Associated Lesion

AMC Alumina Matrix Composite

APC Antigene Presenting Cells

CoC Ceramic-on-Ceramic

CoCrMo Cobalt-chromium-molybdenum

CoP Ceramic-on-Polyethylene

CoXPE Ceramic-on-XPE

Cr Chromium

CRP C-Reactive Protein

DDH Developmental Dysplasia of the Hip

DGOOC Deutsche Gesellschaft für Orthopädie und Orthopädische Chirurgie (German Society of Orthopaedics and Orthopaedic Surgery)

DKOU Deutscher Kongress für Orthopädie und Unfallchirurgie (German Congress of Orthopaedics and Traumatology)

DRC Dynamic Reaction Cell

EBJIS European Bone and Joint Infection Society

EICS European Implant Cohort Study

ESCMID European Society for Clinical Microbiology and Infectious Diseases

ESGAI European Study Group for Implant Associated Infections

ESR Erythrocyte Sedimentation Rate

ETS European Trauma Society

HR Hip Resurfacing

ICP-MS Inductively Coupled Plasma Mass Spectrometry

ISOC International Society of Orthopaedic Centers

ISTA International Society for Technology in Arthroplasty

MHC Major Histocompatibility Complex

MoM Metal-on-Metal

MoP Metal-on-Polyethylene

MRI Magnetic Resonance Imaging

MoXPE Metal-on-XPE

NIS Nationwide Inpatient Sample

PCR Polymerase Chain Reaction

PE Polyethylene

PJI Periprosthetic Joint Infection

SEM Scanning Electron Microscopy

SSI Surgical Site Infection

TCR T-Cell Receptor

THA Total Hip Arthroplasty

THR Total Hip Replacement

TKA Total Knee Arthroplasty

TLR Toll-Like Receptors

TSA Total Shoulder Arthroplasty

UKA Unicondylar Knee Arthroplasty

WBC White Blood Cells

XPE Crosslinked Polyethylene

Survival Analysis of 2,395 Hard-on-Hard Bearing Couples in Patients with Developmental Dysplasia of the Hip (DDH)

by Kusaba A, MD, PhD¹, Sunami H, MD¹, Kondo S, MD, PhD¹, Kuroki Y, MD, PhD¹, Katsui M, MD², Tsuchida M, MD², Hakuta N, MD², Maeda A, MD²

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Keywords:

- hip dysplasia
- osteolysis
- ceramic-on-ceramic
- metal-on-metal
- total hip arthroplasty

Even for young and active patients with DDH, CoC bearing couples form the basis of increased longevity of hip arthroplasties from a tribological point of view. There are only a few scientific publications on the medium- and long-term results derived from large case series with CoC bearing couples in patients with DDH (Crowe I–IV). Recent study results were presented by Atsushi Kusaba MD, PhD, at the German Congress of Orthopaedics and Trauma Surgery (DKOU) on October 25, 2013, in Berlin. The chairs acknowledged his presentation as the highlight of the session.

ABSTRACT

Issue

To date there have been very little data derived from large case series of the medium- to long-term results of cementless primary total hip arthroplasty in young and active patients with DDH. With the expectation of a reduced osteolysis rate and longer survival times for the implant, we used hard-on-hard bearing couples. The aim of the study was to analyze the rates of revision and complications.

Methodology

We evaluated the clinical and radiological results of 2,395 cementless hip arthroplasties with hard-on-hard bearing couples, which were implanted in 1,879 patients between 1997 and 2012. CoC bearing couples made from aluminum oxide ceramics (1,772 hips 28mm, 42 hips 32mm, BIOLOX[®] forte, CeramTec GmbH) were implanted in 1,814 hips. From 2011 onwards CoC bearing couples made from mixed oxide ceramics (32mm BIOLOX[®] delta, CeramTec GmbH) were implanted in 29 hips. Low-car-

bon MoM bearing couples (28mm, Sikomet[®], Endoplus AG) were used in 479 hips and high-carbon MoM bearing couples (28mm, Metasul[®], Zimmer AG) were used in 73 hips. The mean age of the patients at the time of surgery was 57 years. The mean follow-up was 5.3 years (0.1–15.5). The preoperative diagnosis was DDH, which included 155 failed osteotomies (Fig.1) and 47 congenital hip dislocations (Crowe IV) (Fig. 2). The survival rate with the endpoint revision was determined using the Kaplan-Meier method and log-rank test.

Results and conclusion

Osteolysis was not detected radiographically in patients with CoC bearing couples. On the other hand, osteolysis was detected in one hip (1.4%) with a high-carbon MoM bearing couple and 40 hips (8.4%) with low-carbon MoM bearing couples. In 2 hips (0.1%) with CoC bearing couples (28mm, BIOLOX[®] forte), the ceramic insert was fractured as a result of using an unsuitable instrument. It was necessary to revise 24 hips (5.0%) with low-carbon

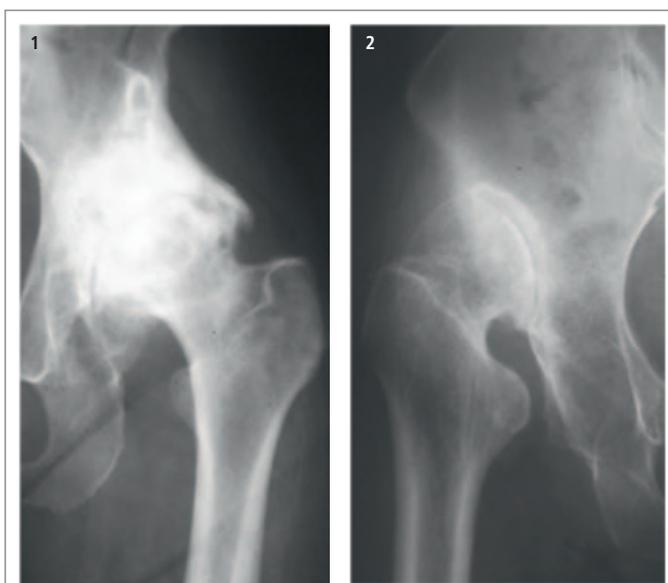


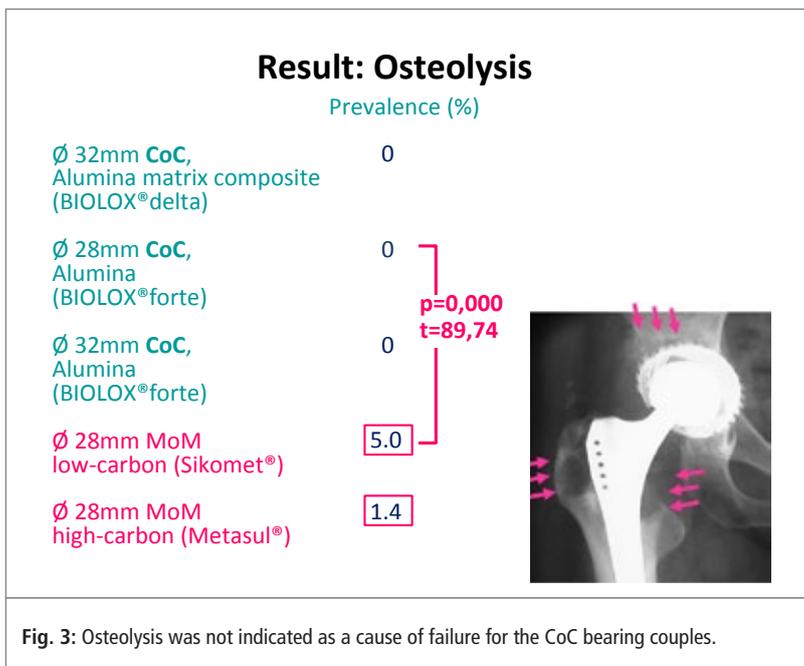
Fig. 1: Preoperative diagnosis: 155 failed osteotomies

Fig. 2: Preoperative diagnosis: Crowe IV (47 hips)

MoM bearing couples due to complications (metallosis, hypersensitivity reaction, osteolysis). One revision due to metallosis was carried out in one hip (1.4%) with a high-carbon MoM bearing couple.

The survival rate after 5 years was 100% for CoC and high-carbon MoM bearing couples and 99.8% for low-carbon MoM bearing couples. After 10 years the survival rate was 99.4% for CoC bearing couples, 96.4% for high-carbon MoM bearing couples and 96% for low-carbon MoM bearing couples. The survival rate after 14 years was 98.2% for CoC bearing couples, 96.4% for high-carbon MoM bearing couples and 80% for low-carbon MoM bearing couples.

Periprosthetic osteolysis was not indicated as a cause of failure in this case series only for the CoC bearing couples (Fig.3). Additional long-term data are still pending. ■



Atsushi Kusaba, MD, PhD, is director at the Institute of Joint Replacement and Rheumatology at the Ebina General Hospital, Japan. He is a Supervisory Doctor and Boardman of the Japanese Association of Rheumatol-

ogy and holds a Specialty Board Certification of the Japanese Orthopaedic Association.

Dr. Kusaba is Member of the German Orthopaedic Society (DGOOC) and the International Society for Technology in Arthroplasty (ISTA).

He is the only Japanese surgeon to present every year at the annual meeting of German Orthopaedic Society. He has authored 5 textbooks, 45 original publications and 127 presentations in English or German, not counting numerous publications in his country.

Dr. Kusaba holds medical licenses for Japan and Germany. His policy in hip replacement is "bearing couple first" even for very difficult hips, such as Crowe IV dysplasia, revision, etc.

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Heinz Mittelmeier Research Award for Study of Wear in CoC Bearing Couples

Jan-M. Brandt, PhD, technical director of the Biotribology Team of the Concordia Joint Replacement Group (CJRG) in Winnipeg, Canada, was awarded the Heinz Mittelmeier Research Award on 25 October, 2013, at the German Congress of Orthopaedics and Traumatology (DKOU).

He received the honor from the German Society for Orthopaedics and Orthopaedic Surgery (DGOOC) for his study "Clinical failure analysis of contemporary ceramic-on-ceramic total hip replacement." The award, which is endowed with 5,000 Euros, was donated by CeramTec.

The subject of the study was in-vivo wear in hip arthroplasty with ceramic-on-ceramic bearing couples (BIOLOX[®]*delta* and BIOLOX[®]*forte*, CeramTec, GmbH). To this end, Brandt and his research team analyzed 34 explants. He reached the conclusion that stripe wear develops if the inclination angle is too high and the best possible lubrication state can be negatively impacted by metal transfer.

ABSTRACT

Clinical failure analysis of contemporary ceramic-on-ceramic bearing couples in THA

A failure analysis of ceramic-on-ceramic bearing couples in THA was carried out to determine in-vivo wear behavior. The analysis of 34 explants included a quantitative assessment of surface changes, roughness and roundness measurements, and an electron microscopy evaluation.

The extent of the surface changes for ceramic femoral ball heads and inserts correlated with the implantation period. The linear wear of the ceramic femoral ball heads also correlated with the degree of metal transfer and adhesive wear (stripe wear). It was observed that the surface changes with ceramic inserts were 2.2-fold greater if the cup was implanted with an inclination angle $>45^\circ$. The linear wear rate for the ceramic femoral ball heads was $25.5 \pm 21.3 \mu\text{m}/\text{year}$ with cup inclination angles $>45^\circ$. This linear wear rate was 6-fold greater than the linear wear rate of $4.2 \pm 2.3 \mu\text{m}/\text{year}$ for cup inclination angles $\leq 45^\circ$. The metal transfer onto the ceramic-on-ceramic bearing couples can reduce the optimal lubrication state and, when combined with an elevated inclination angle, lead to adhesive wear (stripe wear).

Over a period of 10 years, 815 ceramic-on-ceramic bearing couples (BIOLOX[®]*forte*) were implanted in the Orthopaedic Innovation Centre (Winnipeg, Canada). Of this cohort 9 patients were revised, which corresponds to a survival rate of 98.9%. Ceramic-on-ceramic bearing couples, therefore, continue to be a safe option for young, active patients. ■



Jan-M. Brandt, PhD, has been technical director of the Biotribology Team of the Concordia Joint Replacement Group (CJRG) in Winnipeg, Canada, since 2009. In 2009 he obtained his doctorate at the University of Water-

loo, Canada, with a thesis on the tribological behavior of artificial knee joints.

Brandt is an Assistant Professor in the Department of Surgery, University of Manitoba, a member of the Canadian Orthopaedic Association, and a technical consultant in the Orthopaedic Innovation Centre, Winnipeg, Canada.

The Biotribology Team of the CJRG has made it its mission to advance the development of medical technology based on research in engineering science. Thanks to the collaboration with the Orthopaedic Innovation Centre (OIC), the CJRG has access to state-of-the-art facilities such as the explant and analysis laboratory, simulators, FEA, rapid prototyping, and measurement equipment.

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READING TIPS

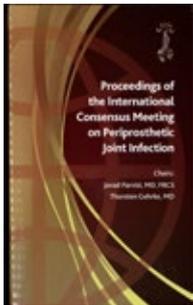
Pocket Guide and eBook on Handling Ceramic Implants

A clinical guide for handling ceramic implants in primary surgery will be published in the fourth quarter of 2014 by Springer.

This Pocket Guide is aimed at orthopaedic surgeons who would like to have quick access to comprehensive information.

It is designed as a helpful guide and contains valuable tips for handling ceramic implants in primary care, presenting this information in a clear and compact format.

➤ The Pocket Guide will be available in **English** and **German**.

**Proceedings of the International Consensus Meeting on Periprosthetic Joint Infection**

More than 400 orthopaedic surgeons from around the world attended the International Consensus Meeting on Periprosthetic Joint Infection in Philadelphia (US) on July 31 and August 1, 2013, chaired by Javad Parvizi, MD, PhD, FRSCS (USA) and Thorsten Gehrke MD, PhD (Germany). The participants prepared a systematic summary of current knowledge on the preven-

tion, diagnosis and therapy of periprosthetic infection and on results achieved in this area.

➤ The complete report can be obtained free of charge on the EFORT website:

https://www.efort.org/wp-content/uploads/2013/10/Philadelphia_Consensus.pdf

Infections of the Musculoskeletal System: Principles, prophylaxis, diagnostics and treatment

In 2006, the Swiss Society for Orthopaedics and Traumatology (swiss orthopaedics) founded the expert group "Infections of the Musculoskeletal System", which cooperates across disciplines with specially trained and experienced infectious disease specialists and microbiologists.

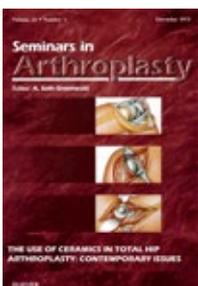
Since 2013, this expert group has provided all orthopaedic and trauma surgeons and infectious disease specialists with a succinct reference work as a tool for education and as a guide in critical situations. The guideline indicates what procedure is recommended for particular situations so that important information is readily available for a concrete case. The principles, prophylaxis, diagnostics and treatment of infections of the musculoskeletal system are explained, and common errors in the treatment of these infections are

also described in a clear and compact format. This publication emphasizes the importance of the close collaboration between orthopaedic surgeons and infectious disease specialists – which should be apparent to the patient bedside, as urged by the experts from both professional associations.

The pocket book is currently available in German only. It contains an "Infectious Disease Passport". Both its use and the supply sources are noted in the book. An English edition of "Infections of the Musculoskeletal System" is to be published in Europe this year.

➤ The free pocket book and the Infectious Disease Passport can be ordered here:

Schweizerische Gesellschaft für Orthopädie und Traumatologie (swiss orthopaedics)
E-mail: info@swissorthopaedics.ch
www.sgotsot.ch

Seminars in Arthroplasty, Issue 4/2013

(Source: Elsevier)

The journal *Seminars in Arthroplasty* (editor Dr. Seth Greenwald) provides a comprehensive, current overview of a single topic in arthroplasty. Issue 4/2013 includes an update on ceramics as well as much-discussed issues in arthroplasty such as corrosion, implant pathology, implant allergy issues and the influence of BMI/body weight on the choice of implant and the outcome of hip arthroplasty.

➤ The journal is available online: www.semearthroplasty.com (registration required)

LATEST NEWS

CeraNews Online

CeraNews has become established worldwide as a valid source of information for orthopaedic surgeons. It appears in print twice a year in 10 languages with a circulation of more than 20,000. From 2014 the printed journal will be published in a new, modern layout and will also be available in digital format. The usual editorial articles will be supplemented by additional multimedia options such as videos, picture galleries and animations.

► If you would still like to receive a print copy, please let us know by e-mail (ceranews@ceramtec.de) or fax (+49 7153 611950).



www.ceranews.com

Latin American CCJR Meeting: The Journey Continues

CCJR is proud to announce the Latin American CCJR Meeting: The Journey Continues to be held in Iguassu Falls, Brazil, from September 17–20, 2014. The BIOLOX® Academy will sponsor the Advanced Bearing Symposium presided by Javad Parvizi, MD, PhD, FRCS.

► For more information, please visit
www.biolox-symposium.com
www.ccjr.com

Call for Papers

The German Society for Orthopaedics and Orthopaedic Surgery (DGOOC) will once more be awarding the Heinz Mittelmeier Research Award with a 5,000 € endowment in 2014. The research prize, which is donated by CeramTec GmbH, is awarded to clinicians, engineers or scientists up to 40 years old for outstanding contributions to research and development in the field of bioceramics and problems associated with arthroplasty wear and tear, as well as with regard to clinical results from ceramic implants.

Submissions to the DGOOC must be postmarked by August 31, 2014, or before. The prize will be awarded at the German Congress for Orthopaedics and Trauma Surgery (DKOU), to be held October 28–31, 2014, in Berlin.

► For further details on the application process:

Deutsche Gesellschaft für Orthopädie und Orthopädische Chirurgie e.V. (DGOOC)
Langenbeck-Virchow-Haus
Luisenstr. 58/5
D-10117 Berlin, Germany
Phone: +49 3084 71 21 31
Fax: +49 3084 71 21 32
E-mail: info@dgooc.de
www.dgooc.de

CONGRESSES & WORKSHOPS

Interdisciplinary Workshop on Prosthetic Joint Infection

The PRO-IMPLANT Foundation (Charité-University Medicine, Berlin) plans 3 interdisciplinary workshops (English) for 2014, which will cover all the relevant issues in periprosthetic infection from diagnosis to medical and surgical therapy. The courses include presentations by experts, interactive case discussions and practical hands-on workshops. The European Implant Cohort Study (EICS) will also be presented.

Course date: September 18–19, 2014
Location: Berlin, Germany

► Information and online registration:
www.pro-implant-foundation.org



www.ceranews.com/plus

33rd Annual Meeting of the European Bone and Joint Infection Society (EBJIS)

The interdisciplinary 33rd EBJIS Meeting (Utrecht, Netherlands, September 11–13, 2014) will be dedicated to current issues in infections of the musculoskeletal system, including principles, diagnostics and treatment of the infections, as well as biofilms and microbiology.

► Information and online registration:
www.ebjis.org/

EFORT Tribology Day

Tribology Day will take place on June 4 at the 15th EFORT Congress (London, June 4–6, 2014), chaired by **Karl Knahr, MD**. The focus of the event is an update on implant materials as well as wear problems in hip and knee arthroplasty.

► Information and online registration:
www.efort.org/tribology2014

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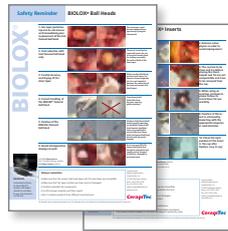


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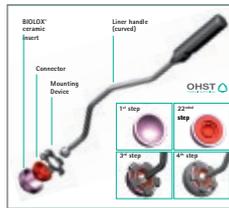


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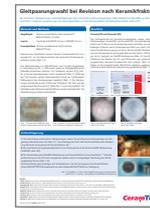
Safety Reminder
What a surgeon should bear in mind when implanting BIOLOX® femoral ball heads and BIOLOX® inserts

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