One-Stage Septic Revision Arthroplasty

Principles and Management

Mustafa Citak
Mustafa Akkaya
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Editors

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Foreword 1

We Need Evidence: In All Its Forms

Evidence-based orthopedics informs decisions for the care of our patients. This approach refers to using the best clinical evidence to aid in patient care and, in turn, consider both physician expertise and the preferences of the patient. Evidence-based surgeons consider the hierarchy of evidence in all its forms, from systematic reviews to randomized trials. The point is that the totality of the information available should be considered, analyzed, and disseminated.

The more serious, and common, the health care issue the greater the care we must take to ensure a transparent, data-supported argument to support our recommendations. Periprosthetic joint infection (PJI) is an uncommon but devastating complication of patients undergoing total joint arthroplasty. Unquestionably, efforts to identify factors associated with the incidence, diagnosis, and treatment of PJI are critical. Drs. Citak, Akkaya, and Gehrke with a global community of experts present evidence and approaches to the management of PJI. Together, they have carefully curated the data and used their expertise to distill decades of information into practical recommendations for patient care.

This textbook serves as an important contribution to the field—and the ongoing discussion in the management of PJI. The hallmark of evidence-based orthopedics, after all, is to expose ourselves to all the evidence—and consider all approaches in optimal surgical care of patients.

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Mohit Bhandari

Foreword 2

One-Stage Exchange Arthroplasties: Principles and Management

Throughout my career, I have always had an interest in the diagnosis and treatment of Prosthetic Joint Infection (PJI). However, my passion for PJI hit close to home when I personally underwent a two-stage procedure for an infected knee. Going through this I experienced firsthand the problems of a two-stage solution to PJI, especially the psychological challenges for the patient struggling to recover from the first stage and having to look forward to another major procedure.

In addition to the morbidity of this approach, the economic ramifications of a two-stage approach warrant a reevaluation of the standard of care in the United States. To this end, 5 years ago we initiated a randomized trial of over 300 patients to determine if the results of a one-stage approach would be similar to the traditional two-stage approach.

We recently presented data at the 2024 American Academy of Orthopedic Surgeons meeting. Our 1-year comparative data between a one- and two-stage approach showed that the success of one-stage was 98% compared to 92% of those patients treated with a two-stage approach. While the one-stage data is encouraging, we cautioned our audience to not change their present practice patterns until we have 2-year data.

If in fact the one-stage results remain similar to two-stage treatment, a book of this nature will be a valuable addition and a real resource for surgeons contemplating moving to one-stage PJI treatment.

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Foreword 3

We have come a long way and yet not far at all. Over 20 years ago I became interested in periprosthetic joint infection. I started clinical and basic science research to address some of the issues that we were facing. When I reflect on the issues then and now, depressingly I come to realize that we have made little progress over the last two decades. Our patients still suffer a miserable life when handed the diagnosis of periprosthetic joint infection. They have to face surgical interventions, usually multiple of those, undergo long periods of antimicrobial treatment with their adverse consequences, and still face the risk of failure. Perhaps the only great progress that we have made, thanks mostly to the work of our European colleagues, in particular Dr. Thorsten Gehrke, is the shift towards one-stage exchange arthroplasty.

I recall a meeting that I attended over a decade ago when two renowned surgeons declared that one-stage exchange will NEVER be accepted in North America. Thankfully, they were both wrong. With the emergence of evidence, there has been a great shift towards one-stage exchange arthroplasty in the US and globally. I have personally been doing one-stage exchange over the last 5–6 years. We have come to realize that the outcome of one-stage exchange may not be much, if at all, inferior to two-stage exchange. Considering the advantage of a single operation and elimination of the interim stage, which is extremely disabling for our patients, it should not come to anyone as a surprise why one-stage exchange is gaining so much traction in the US. Europeans were way ahead of us!

The current book comes at a great juncture. Some of the issues related to one-stage exchange needs to be addressed and we need great authorities to address them for us. The editors of this book, namely Drs. Citak, Akkaya, and Gehrke, have the appropriate experience, knowledge, and authority to do just that. The 12 chapters that have been assembled provide guidance about causes of PJI, diagnosis of PJI (which I was fortunate to write), and surgical treatment of PJI. The chapters are concise, relevant, and provide state-of-the-art information.

Congratulations to my great friends who have edited a timely and worthy book. We should all read this book from cover to cover. Let us hope we will start to make some strides in the years to come and minimize the morbidity and mortality for our patients with PJI.

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The Philosophy of One-Stage Septic Exchange

Seper Ekhtiari, Mustafa Akkaya, Thorsten Gehrke, and Mustafa Citak

Total joint arthroplasty (TJA) is one of the most successful medical interventions performed today. Total hip arthroplasty (THA) was named the operation of the century by the Lancet [1], and both THA and total knee arthroplasty (TKA) have patient satisfaction rates of over 85% [2]. As well, both THA and TKA have been found to be highly cost-effective based on high-quality studies [3]. Nonetheless, these major surgeries carry risks of major complications, with periprosthetic joint infection (PJIs) being among the most common causes of revision surgery [4, 5]. While the absolute rates of PJI are low (0.5–2%) [6], the overall large volume of TJAs worldwide [7] mean PJI represents an important and challenging issue. Periprosthetic joint infections represent a devastating complication, with important implications for patients and a major burden on healthcare systems [8]. As such, the diagnosis and treatment of PJIs continues to be studied and discussed in the literature.

There are multiple described strategies to treat PJIs, and choice of strategy depends on surgeon and institutional protocols, patient characteristics and preferences, chronicity and severity of infection, and a range of other factors. With the exception of a small number of patients who are too unwell to undergo any surgery, the treatment for PJI almost always includes surgical intervention. The least invasive surgical method for treating PJI is Debridement, Antibiotics, and Implant Retention (DAIR), which involves thorough irrigation and debridement, usually with exchange of modular implants but retention of well-fixed implants [9]. There is debate around the role DAIR plays in the management of PJI; typically, this

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strategy is reserved for acute infections. Outcomes are variable, and reported success rates vary widely, ranging from 11% to 100% [10, 11], though most studies report 50–65% infection control rates [12].

The two gold standard strategies for the treatment of PJI are one-stage exchange arthroplasty and two-stage exchange arthroplasty. The technique for two-stage revision was first described in 1983 by pioneering British orthopedic surgeon John Insall [13]. This strategy includes, at minimum, two-staged procedures. In the first stage, the prior implants are removed, a thorough irrigation and debridement is performed, and a temporary 'spacer' which incorporates antibiotic cement is implanted. The patient is then placed on intravenous antibiotics, typically for 6–8 weeks. This requires an extended initial hospital admission, the placement of a central venous catheter, and, depending on the antibiotics used, regular bloodwork. Following this period, some surgeons institute an "antibiotic holiday," followed by bloodwork and possibly a joint aspiration, before proceeding with the second stage. In the second stage, the spacer is removed, and definitive implants are placed [14]. Thus, the full two-stage process can involve two operations, a total of 2–3 months, prolonged parenteral antibiotics, and frequent visits to clinical environments. Infection eradication rates are variably reported, but typically range between 70% and 85% [15, 16].

The one-stage exchange arthroplasty was first introduced in the 1970s by Professor Hans-Wilhelm Buchholz at the ENDO-Klinik in Hamburg, Germany [17]. In a 10-year series of 583 patients, Buchholz et al. reported a 77% success rate after a first attempt one-stage exchange arthroplasty [18]. The one-stage protocol continues to be a mainstay at the ENDO-Klinik, accounting for over 85% of all PJI revisions to this date [17]. Interest in the one-stage exchange arthroplasty has increased in recent years [19], and recent high-quality evidence has not shown a clear difference in infection eradication rates between one-stage and two-stage exchange arthroplasty [20, 21].

Certain requirements must be in place before deciding to pursue one-stage exchange arthroplasty. At minimum, the causative organism must be known through culture from aspirate or open biopsy [17]. As well, the organism must be amenable to treatment with available local and systemic antibiotic therapy. Furthermore, the host must be able to tolerate this lengthy and complex surgery, and this includes the soft tissue envelope around the joint, which must be in reasonable condition. Indications and contra-indications are discussed in further detail later in this book.

The philosophy behind the one-stage exchange arthroplasty is multifaceted and starts with an understanding that the one-stage exchange arthroplasty is not simply a surgical technique, but rather a comprehensive, multidisciplinary, perioperative protocol, which starts with the first suspicion of infection, and extends well beyond the operating room into the post-operative follow-up period. This book will outline in detail each step of the process, starting with appropriate diagnosis, multidisciplinary involvement, detailed surgical technique, post-operative antibiotic and rehabilitation protocols, and salvage options. Overall, however, the

philosophy behind the one-stage exchange arthroplasty can be thought of in terms of two broad categories: (1) the dangers of missed infection and (2) the potential benefits to be gained from a one-stage operation compared to two-stage exchange arthroplasty.

The Dangers of Missed Infection

Long before any consensus meetings were held to discuss the issue of PJIs, unrecognized infection was a topic of concern and discussion among arthroplasty surgeons in the 1970s and 1980s. Hunter et al., in a careful evaluation of a series of presumed aseptic revision THAs, reported that 32% of cases in fact turned out to be infected [22]. In their clinical series, Buchholz et al. refer to this paper with an ominous warning: "*The dangers of unrecognised infection at revision arthroplasty should not be underestimated"* [18]. While certainly applicable to presumed aseptic revision TJA, this ethos also forms the basis of the philosophy behind one-stage exchange arthroplasty.

At its core, one-stage exchange arthroplasty operates on the principle that, if every effort is made to identify, remove, and treat the causative organism of the infection, then a one-stage exchange arthroplasty should be successful in most cases. This principle must be applied at each stage of the process. At the diagnosis stage, this means not missing a diagnosis of infection, including latent, subclinical, and low-grade infections which may not present classically. This demands a rigorous diagnostic workup, including prolonged culture times to avoid missed diagnosis of slow-growing organisms [23], and a high index of suspicion when faced with negative aspirate results despite a clinical picture consistent with PJI. The ENDO-Klinik protocol includes aspiration of *all* revision arthroplasties, even if they are presumed aseptic; as well, the protocol includes aspiration of all other prosthetic joints a patient has if a diagnosis of PJI is established—unrecognized synchronous infections can act as an occult source of infection, seeding recurrent infections in the revised joint [24]. The diagnostic principles and process are discussed in detail in chapter "Diagnosis of Periprosthetic Joint Infection".

The entire process also demands a close working relationship with a range of other healthcare providers, including microbiologists, operating room staff, nursing, physiotherapy, and others. While "multidisciplinary approach" is a vogue term that has garnered much attention and discussion in recent years, the meaning of the term has long been a part of the one-stage exchange arthroplasty philosophy—Prof. Buchholz worked closely with the microbiologist Prof. Lodenkämper, who was also a co-author on their 10-year clinical series discussed earlier [18]. The importance of the multidisciplinary nature of this technique is discussed in chapter "Multidisciplinary Team Management of Periprosthetic Knee Infections".

The philosophy of leaving no infection behind is perhaps most obviously and concretely applied in the operating room, the details of which are discussed in detail in chapters "Surgical Technique, Bone Loss, and Muscle Insufficiency" and "HIP; Surgical Technique: Bone Loss and Muscle Insufficiency". As per the original

Buchholz technique, previous scars and sinuses are excised, and the key concept here is radical debridement—"*the aim is to excise radically all infected or devascularized scar tissue and necrotic bone"* [18]. As Prof. Buchholz himself pointed out, no two cases are identical [18], and experience in managing PJI is critical in judging the amount of excision required—regardless, one must remember the goal here is to leave no infected tissue behind, in other words, 'leave no stone unturned'. The old surgical adage of 'if in doubt, cut it out' may be applied cautiously and expertly here.

Despite all best efforts and rigorously applied protocols, a perfect infection eradication rate is not realistic—at least not at the present time. Thus, understanding how to diagnose and manage recurrent infection is a critical aspect of the process. This also speaks to the importance of patient expectations—patients must be counseled thoroughly and accurately on the possibility of recurrent infection, and what that may mean for them. This is true regardless of if the patient is treated with DAIR, one-stage, or two-stage revision. These issues are discussed in chapters "Management of Reinfection After One-Stage Exchange Arthroplasty" and "Knee Arthrodesis: Salvage Procedure After Failed Total Knee Arthroplasty".

The Benefits of One-Stage Exchange Arthroplasty

When it was first introduced by Prof. Buchholz, one-stage exchange arthroplasty was one way in which to attempt to deal with a difficult problem, and the knowledge was shared with the surgical community in hopes of helping other surgeons facing a similar situation. This was nearly a decade before Drs. Gordon Guyatt and David Sackett from McMaster University coined the term 'Evidence-Based Medicine' [25], and before the many changes in the technology, implants, and perioperative protocols of TJA which have taken place in the last 30+ years. While the underlying philosophy remains largely the same, the lens with which we evaluate one-stage exchange arthroplasty, and the volume of data and clinical cases available for us to do so, has expanded considerably.

Though the concept has been for a long time, it is no secret that modern medicine has only very recently begun to seriously incorporate a patient-centered approach to healthcare. Within arthroplasty, a patient-centered approach is almost inherent, given that the very disease being treated is most commonly being treated due to its impact on the patient's quality of life, and thus, patient preferences are almost inevitably included in the decision making. Prof. Buchholz, in his clinical series, outlines the importance of patient function—"*Exchange arthroplasty is not justified in terms of eradication of infection alone: the functional result and its duration are important"* [18]. When comparing two interventions in today's paradigm, it is essential to consider the differential impact of each intervention on patient function and quality of life.

Early evidence has demonstrated similar performance of one-stage exchange arthroplasty compared to two-stage in terms of patient-reported outcomes [26]. A recent RCT comparing one- to two-stage exchange arthroplasty reported significantly better function in the one-stage group in the first 3 months post-operatively,

with no difference thereafter [21]. Future studies are needed to further investigate this topic, and patient preferences must be explicitly examined—if functional outcomes are similar, and potentially better with one-stage exchange in the short-term, which of the protocols described above would patients likely prefer? This question can only be definitively answered empirically with rigorous methodology.

Health economics is another field which has grown massively since the introduction of the one-stage protocol and must be considered when comparing interventions—in fact, many governmental research funding organizations require this to be a planned component of any new randomized controlled trial (RCT) proposal. The economic burden of PJI in the USA is projected to reach nearly $2 Billion USD by 2030 [27]; thus, the evaluation of any PJI intervention must consider its economic impacts. Limited evidence exists on the economics of one-stage versus two-stage exchange arthroplasty, though recent studies have begun to evaluate the topic. A recent RCT comparing one-stage to two-stage exchange arthroplasty demonstrated that a one-stage strategy was cost-effective over the two-stage strategy, at an incremental net monetary benefit of £11,167 [21]. As well, a retrospective cohort demonstrated no significant difference in quality-adjusted life years (QALYs) between the two strategies [26]. Another potential benefit of the one-stage strategy has recently come to light—the COVID-19 pandemic has demonstrated the tenuous state of many healthcare systems across the world, as well as the potential benefits of limiting contact with healthcare environments as much as possible. A well-established one-stage protocol may be more sustainable in the face of future similar events and may be a safer strategy overall for vulnerable patients [28].

Conclusion

"The dire results of infection involving an implant fixed by means of acrylic cement were appreciated as early as 1965" [18]. These words ring as true today as they did when Prof. Buchholz used them to start his landmark study, published in 1981. There remains no single "silver bullet" solution to PJI—even the diagnosis of PJI remains elusive at times. Nonetheless, great strides have been made in orthopedics, infectious disease, and evidence-based medicine since then, and the ability to collaborate on a global level represents an opportunity to continue to advance the science of PJI management while adhering to the sound principles and philosophy of infection management.

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