Knee Revision Solutions

Revision is possible
REVISION IS POSSIBLE
“Sharing ideas and thoughts of common and rare problems in TKA revision is an important opportunity for personal improvement. Discussions with colleagues about limitations and solutions can help everyone to avoid their own problems and makes life definitely easier.”
Prof. Heiko Graichen

“We should remember that every case represents a patient with a problem to be resolved. Individual case discussions are an excellent way of discussing principles of revision knee replacement and always give an opportunity to debate the options. This case book is no exception and I’m sure for each case, different options might be considered. However, I hope we have given a clear strategy and solution for each problem that would help patients and improve outcomes. The case book does not stand alone and is part of a comprehensive revision TKA education programme and we hope that these cases alongside the cadaveric workshops, where a practical approach to problem solving using metaphyseal sleeves and mobile bearings can be experienced and refined, will help you manage the challenges of revision knee surgery and find solutions in your practice.”
Mr. Rhidian Morgan-Jones
Total Knee Arthroplasty (TKA) is indisputably very successful. The complaints of pain, lack of motion and instability of the knee are largely solved in the great majority of patients after the intervention. However a certain percentage does fail, sometimes even very early after the implantation. Revision surgery is then needed. As the number of implanted knee prostheses is growing year by year, the amount of revision cases is growing as well. Revision surgery for failure of a knee implant is, or will soon be, part of the daily practice of the already busy orthopaedic surgeon.

Revision TKA is not easy. The circumstances are very different from those encountered in primary TKA. While in primary TKA the bone is the strong partner of the surgeon and defects are relatively small, in revision TKA the bone defects may be large and the bone itself changed by infection, osteolysis due to polyethylene wear or mechanical damage due to loosening of a component. Removing an implant may contribute to this problem as more bone is removed. Fixation of components to these damaged bony structures may be seriously compromised. Prostheses with other fixation possibilities may be required to solve the problem of fixation.

However the soft tissues may offer even more difficult problems. This may well start at the level of the skin and subcutaneous tissues. The incision chosen by the surgeon performing the primary implantation and particularly what the surgeon has done with the subcutaneous tissues is of great importance. Previous destruction of subcutaneous blood vessels may cause serious wound healing problems and even necrosis of the skin after an otherwise successful revision, causing the failure of it.

It is often difficult to make a good estimation of the quality of the soft tissues before and during revision. Knees may have become unstable. But why? The surgeon needs to try and understand the instability. Unfortunately reports of the primary surgery often give little information of what exactly has been done by the surgeon performing the primary surgery. Which bone cuts were made and in what order following which surgical principle? Were releases performed and where? Was the posterior capsule involved in the surgery? The estimation of the quality of the soft tissues is particularly difficult in knees with loose prostheses and bone loss resulting in instability of the knee. Ligaments may be intact and sufficient even in great instabilities. However soft tissues may also have undergone plastic changes, particularly after infection.

It is very important to establish the quality of the soft tissues, because this will dictate the type of prosthesis and the amount of intrinsic constraint required to stabilize the knee joint. The real amount of instability can be measured only when the joint lines have been reconstructed. It is important to understand that intrinsic constraint between the components may be helpful in stabilizing the knee in a passive non-dynamic way, but may be disadvantageous as well. Free anatomical movement between the components eliminating the conduction of too many rotational and shear forces to the bone-prosthesis interface remains necessary in order to protect the fixation of the components. Therefore intrinsic constraint should not be exaggerated. Protection of the soft tissues should be a keystone of the surgical technique in revision TKA.

Surgeons must analyze the problem of failure very well before surgery. No revision surgery should be performed without knowing the cause of failure! Real understanding of the failure mechanism is of utmost importance in order to make a correct planning of the revision, make the adequate choice of implant and use the required optimal surgical technique. Important is not to make the same mistake twice and even more important is not to make the situation worse!
Pain as such is no diagnosis and no reason for revision. Obviously the possibility of an infection should always be investigated, but further analysis of the pain is needed before any revision surgery is considered. There is a great variety of causes and each of these causes has different consequences for the procedure that should be followed. The problem causing failure is often complex with more than one factor involved.

After studying the failure mechanisms of knee replacement it became obvious that while late complications are usually the consequence of the design of the prosthesis and the materials used, the early failures causing revision are mostly due to insufficient surgery: insufficient fixation, improper balancing of the ligaments causing instability, limited range of motion, mal tracking of the patella and infection. Interestingly the study of the failure mechanisms of primary TKA not only helps the surgeon to better plan the revision but also offers surgeons a great opportunity to improve the results of their primary implantations.

Because of the complexity of TKA revision and because the role of the surgeon was found to be of paramount importance for the result of primary and revision surgery, it was clear to the organisers of the course of revision TKA that an educational programme was needed to support surgeons on their long way to become a successful revision surgeon. The complete educational package incorporates a cadaver course, a specialized topics course and the possibility to visit an expert visitation centre, all supported by a range of integrated online/digital materials.

Guided by an expert faculty all steps needed for a successful revision will be dealt with:

- introduction of the general principles of revision TKA
- evaluation and diagnostic work-up
- pre-op planning
- surgical reconstruction and implantation

When, before revision surgery, the surgeon has found the answers to the questions: “why did the TKR fail, how did it fail, what is left to reconstruct and what do we need for reconstruction?” then he will be able to make a careful planning and perform adequate revision surgery. During revision surgery it is important to do everything in the right order:

1. restoration of joint lines / reconstruction of bone in the order proximal tibia, posterior femur condyle, distal femur

2. restoration of joint stability using bearings with the amount of constraint that corresponds with the amount of soft tissue instability

As one of the founders of the revision TKA education package I hope that all participants may benefit well from this education in their future daily practice.
FACULTY INTRODUCTION

Prof. Dr. Heiko Graichen

Medical Director and Chief surgeon of Orthopaedic Hospital Lindenlohe, Schwandorf (Greater Munich Area), Germany

Specialities
Arthroplasty Surgery of the Knee, Hip and Shoulder; Revision Surgery of Knee and Hip

Career steps
1997          Exam as Orthopaedic Surgeon
1997 - 1999   PhD student University of Munich, Germany
1999 - 2004   Assistant Professor Orthopaedic University of Frankfurt Germany
Since 2005    Medical Director and Chief Surgeon Asklepios Orthopaedic Hospital Lindenlohe, Germany
2000          PhD Orthopaedic Department University of Frankfurt
2000 - 2008   Head of the Biomechanics Lab, Orthopaedic Department University of Frankfurt
since 2006    Adjunct Assistant Professor at the University of New York (NYU)
since 2011    Medical Board of the Asklepios Hospitals, Schwandorf county

Orthopaedic Societies
DGOU – German Society of Orthopaedic and Trauma Surgeons
GOTS – Gesellschaft für Orthopaedisch Traumatologische Sportmedizin
DVSE – Deutsche Gesellschaft für Schulter und Ellbogenchirurgie

Other activities
Editorial Board – Clinical Biomechanics
Constant reviewer – J. Biomech.

Passion in Orthopaedics
Revision Arthroplasty Surgery of the Knee
Navigation
Biomechanics of the Knee

Activities beside Orthopaedics:
Family and Sports

About DePuy Synthes Revision System:
• Metaphyseal Sleeves add a superb option for fixation for the implant in compromised bone
• Additionally sleeves help me to reconstruct the joint line
• One Tibia for all kinds of inserts/constraints
• Fixation is independent of ligamentous status
• Instrumentation is the same for primary and revision
FACULTY INTRODUCTION

Mr. Rhidian Morgan-Jones

University Hospital of Wales, Cardiff, UK

Specialities
Revision knee, soft tissue & primary knee replacement, Chronic Osteomyelitis & lower limb deformity correction.

Career steps
1984 - 1989  University of Wales College of Medicine, Cardiff
1990 - 1994  South Wales Surgical Rotation
1994 - 1999  West Midlands Orthopaedic Training Rotation (Oswestry/Stoke)
1999   Osteomyelitis Fellowship (Dr Charles Lautenbach), Johannesburg, RSA
1999 - 2000  Knee Fellowship (Dr Mervyn J. Cross), Sydney, Australia
2000 - present  Consultant Orthopaedic Surgeon & Honorary Lecturer, Cardiff

Orthopaedic Societies
BASK – British Association for Surgery of the Knee
BOA – British Orthopaedic Association
EBJIS – European Bone and Joint Infection Society (UK Country rep.)

Other activities
Reviewer: Bone & Joint Journal, Ann RCS (Eng), Welsh Orthopaedic Journal
Founder: National Orthopaedic Infection forum (UK)

Passion in Orthopaedics
Education & Training, Putting Cardiff on the map!

Activities beside Orthopaedics:
All things Welsh

About DePuy Synthes Revision System:
Unique, effective products with a proven history & a commitment to education & best practice
REVISION KNEE PRODUCT PORTFOLIO OVERVIEW

The DePuy Synthes Knee Revision Portfolio offers surgeons a comprehensive array of implant options for cases that require varying levels of constraint. From moderate soft tissue laxity and minor bone defects through end-stage revision, and all systems can be combined with the M.B.T. Revision tray.

System Options:

- P.F.C. SIGMA® TC3 RP
- LCS® Complete™ Revision
- S-ROM® NOILES™ Hinge
- Limb Preservation System (LPS™)
- M.B.T. Revision with sleeve and stem

ADDRESSING TWO OF THE MAJOR REASONS FOR KNEE FAILURE:

Addressing Loosening
with Rotating Platform

Addressing Fixation
with Metaphyseal Sleeves

Addressing Efficiency
with High Performance Revision Instruments
INTRODUCTION TO REVISION TKA
REVISION TOTAL KNEE ARTHROPLASTY

Why do knees fail today?

Prof. Heiko Graichen

Many different reasons will lead to a significant increase in knee revision arthroplasty over the coming years. One major contributing factor will be the increased number of primary TKAs implanted in the recent years. Due to the improved results and greater acceptance of this procedure, an enormous increase in numbers will be observed world-wide. A changing society and greater patient expectations are both less accepting of physical incapacity, again leading to increased numbers of joint replacements. At the same time, global changes are producing greater obesity and an aging population which also contribute to the dramatic increase in total knee replacement and inevitably knee revision surgery.

Case specific analysis of the failure mode should first of all differentiate between early and late failures. Early failures are those within the first 2 years of implantation, most of these are surgery and thereby surgeon related problems e.g. malposition, instability. We should further keep in mind that the most common cause for early failure is infection, which therefore should always be excluded in any early failure. Late failures on the other hand are more implant related. For example, polyethylene wear, asptic loosening.

Instability:
Since instability is one of the commonest causes of early and late failures a thorough analysis of the type of instability is essential to solve this problem at revision knee arthroplasty. As Graichen et al. (2007) described, most patients with instability suffer from this problem since day 1 after surgery; the authors have described this type of instability as primary. In contrast, secondary instability occurs later on and is mainly caused by polyethylene wear or trauma. Differentiation of the clinical type of instability needs to be assessed meticulously. While in most cases the instability is a combined form in extension, midrange and flexion. The reasons for this are multiple including implant malposition, ligament damage and loosening. In this study, nearly one third of cases were found to have an isolated instability in flexion. The two most common causes for this type of instability were a malposition of the femoral component or an undersized sagittal diameter of the femoral component. In some cases an isolated instability in extension is obvious. This was mainly caused by a overresection of the distal femur thus proximalising the joint line. Additionally a midrange instability was also obvious in most of these knees when looked for.

Bone loss:
The reasons for bone loss in most cases are polyethylene wear and/or implant loosening. Therefore one important aspect of pre-op analysis is assessment of bone loss on x-ray. However, you have to be aware that in most cases the intra-operative bone loss is more severe than anticipated from pre-operative x-rays. AORI classification should be used to analyse the amount of bone loss. In Type 1 the defects are small and joint line is not affected. Filling these defects with bone or cement is sufficient and no specific implant is needed. In Type 2, the most common type, defects are larger and can be contained or uncontained. Treatment options for these defects are multiple. While in young patients bone graft augmentation can be an option, in older patients normally metal augmentation is more reliable. With augmentation, diaphyseal stem fixation is mandatory. Another recently more popular option is the use of sleeves. In this concept the fixation is built up in Zone 2. In Type 3 defects the insertion of the collateral is involved in the bone loss therefore a hinged knee is needed. Since fixation in zone 1 is impossible, again a Zone 2 and 3 fixation should be favoured.

In conclusion, we will all see more TKAs that will fail in the coming years due to a variety of different reasons. Each TKA needs a thorough analysis to establish the failure mode before revision surgery is attempted. Early failures are mainly surgeon related and infection should be excluded in all of these cases. Ligament instability and bone defects should be assessed pre- and intra-operatively.

References: Please refer to the back cover for full reference information.
Mobile Bearings in Revision TKA

Prof. Heiko Graichen

In primary TKA there has been a long and ongoing discussion about the potential benefits of mobile bearings, however, national register data as well as large series could not prove any difference regarding long term survival rate or clinical result (LIT). Future studies in a subgroup of very young and active patients there will be difference shown, as in the in vitro testing.²

In revision TKA the failure modes beside infection are implant loosening and polyethylene wear. This can be a consequence of the increased amount of constraint in a fixed bearing design, because it is non-tolerant of rotational malalignment. Furthermore, even small amounts of tibial and/or femoral malrotation will lead to an increased stress at the peg leading to peg wear. The fixed bearing designs do not taken into account the physiological rotation between the femur and the tibia during all daily activities. Dennis et al. (2004) could show in vivo that this rotation occurs in all individuals and showed a mean of rotation of 12° at 120° of knee flexion.³ The different fixed bearing semi constrained designs of the companies however allow only for 2° - 4.3° of femoro-tibial rotation. This will again lead to a stress at the peg and over time an accelerated polyethylene wear. Additionally the rotational forces are transmitted further down to the fixation interface of the tibial implant a possible explanation for the increased loosening of tibial components in revision TKA.

Retrieval studies have proven this theoretical construct to be true. Puloski et al. (2001) showed that in all fixed bearing explants the pegs had polyethylene wear.⁸ The second important finding was that the wider the dimensions of the posts, the more wear could be found. This confirms that greater constraint leads to greater wear and therefore as a general rule the amount of constraint should be minimized.

Different in vivo and in vitro studies have shown on the other hand the theoretical benefit of a mobile bearing in a revision TKA. Bottlang et al. (2006) for example could show that mobile bearing reduces torque by 68-73% and thereby reduces strain at the proximal tibia.⁹ This will hopefully lead to an improved survival rate in revision TKA and a decreased tibia loosening rate. Early and midterm analysis (Callaghan et al. 2005) could demonstrate a minimal loosening rate in mobile bearing R-TKA.¹⁰ Of course other factors such as the fixation type and the fixation zone are relevant for the long term result in R-TKA.

Conclusion

In conclusion, one important part of an improved long term survival rate is minimizing the polyethylene wear. This can be done by minimizing the amount of constraint. Nevertheless in certain revision knees a higher amount of constraint is required in order to achieve a stable knee. In such, more constrained knees rotational platform overcomes the problems of 1) increased peg wear, 2) non-tolerance of malrotation and 3) transmission of rotational forces to the tibial interface and should therefore be advocated.

References: Please refer to the back cover for full reference information.
REVISION TOTAL KNEE ARTHROPLASTY

Implant Fixation Options

Prof. Heiko Graichen

Different reasons are leading to implant failure. PE wear and loosening being the most frequent ones. Especially in those two, bone loss is a major problem that makes implant fixation in the revision case often a challenge.

Before we start the surgery of revision thorough planning and evaluation is important. For fixation the zonal concept is very helpful. Zone 1, the epiphysis is often compromised, therefore additional fixation in Zone 3, the diaphysis is the recommended. For fixation in this zone stems are applied. Those off load the stress to the diaphysis and thereby the metaphyseal interface area is protected. However, Zone 2, the metaphysis in this stem based fixation concept is only partially used.

Cemented or uncemented stems
Both fixation methods have advantages and disadvantages. Cemented stems have the advantage of excellent resistance to lift-off and shear. Because the stems do not fill the diaphysis some latitude for placement exists. This can be an advantage in canal geometry deviations. Further these stems provide good initial and long term stability. This has been documented in numerous studies, all showing almost 90% of long term survival after 10 years.

The disadvantage on the other hand is that they are difficult to remove and that they have a proximal strain shielding effect. This can sometimes be seen as bone resorption in the metaphysis.

Uncemented stems on the other hand have advantages in terms of alignment in straight bones and in case of a re-revision they are easy to remove. Although they only bypass Zone 2 no strain shielding effect in the metaphysis can be found with this fixation method. The disadvantage is that they do provide only little true long term fixation. This can be documented with the high rate of radiolucency’s. Another disadvantage is the problem of stem pain. In cases of a bowed diaphysis they can further guide into mal alignment.

Despite consideration of the many advantages and disadvantages identified, a final conclusion regarding the optimal fixation method has still not been reached. Many other questions also remain unanswered, for example, optimal stem length, thickness and surface.

To overcome the problem of diaphyseal fixation in revision cases an additional metaphyseal fixation might be advantageous. The concept of cementless metaphyseal sleeves is based on an optimised load transfer in the metaphysis. By that bone re-growth is stimulated. Another advantage is that by fixation of the implant close to the joint, also joint line reconstruction becomes easier. It further helps to fill defects and to simplify the surgical technique. Positioning of the sleeve is dependent on the defect and independent of the implant orientation.

In addition, sleeves have been available and on the market for a long time, there are almost 40 years of experience and up to 30 years in the S-ROM rotating hinge system. In this rotating hinge system sleeves have proven excellent long term results.

Based on the principle of zonal fixation, sleeves should be used with stems if the fixation in Zone 1 is compromised. If however, fixation in Zone 1 is sufficient, bone quality overall good, alignment and ligament balance reconstructed, a stemless fixation can be an option. In case a tibial stem is used the thickness should be 14 mm or less in order to make removal easier.

In summary, three zones for fixation exist. Since the classical stem based fixation technique has shortcomings independent of whether cemented or cementless stems are used an additional metaphyseal fixation is an alternative. Since this cementless sleeve is part of the implant, loading of the metaphyseal bone is achieved and by that bone growth to the sleeve can be observed. Beside the advantage of fixation some technical benefits are obvious. So reconstruction of the joint line becomes easier and the surgical technique overall faster.

References: Please refer to the back cover for full reference information.
REVISION TOTAL KNEE ARTHROPLASTY

Challenges in Managing the Joint Line

Mr. Rhidian Morgan-Jones

The initial challenge in managing the joint line is to have a working diagnosis and an appreciation of the reference anatomical landmarks in the normal knee.

Definition: The joint line is the articulating surface of the femoral component in extension, flexion and all points in between.

Anatomical Landmarks:

- One finger above the fibula head
- One finger below the inferior patella pole
- 30 mm distal to the medial femoral epicondyle
- 12-16 mm distal to the femoral insertion of the PCL origin
- Old meniscus scar

Re-establishing the correct joint line is paramount in achieving good functional outcome in revision knee replacement. To achieve this, the surgeon must understand the principles of bone reconstruction, implant positioning and ligamentous and balance.

Bone reconstruction: Reconstruction is a combination of implant fixation and augmentation. The surgeon should be familiar with the concept of Zonal Fixation and the options for augmentation which include metaphyseal sleeves, metal blocks, trabecular metal cones, cement and bone graft.

Implant positioning: As a rule, the femoral implant needs to be positioned distally (extension gap) and posteriorly (to close the flexion gap); the tibia should be proximalised to minimise the thickness of the bearing.

Ligament balance: A fundamental principle of successful knee arthroplasty is achieving ligament stability and balance whilst using minimal constraint. By re-establishing the correct joint line, in extension and flexion, the revision knee will be balanced with appropriate ligament tension, minimising the need for constraint.
Introduction: The Challenge
Fixation in compromised bone is a major challenge in revision TKA. Therefore the survival rate of R-TKA is not as good as in primary TKA. Traditional fixation is performed at the surface and additionally with cemented or uncemented stems and augments mainly in Zone 1 (joint surface) and 3 (diaphysis). Additional fixation in Zone 2 (metaphysis) might be advantageous.

Key Points
The advantages of metaphyseal sleeve fixation are multiple:

- Based on Wolff’s Law bone re-growth is stimulated by optimising the load transfer. The principle is ‘Use it or lose it’.
- Allows fixation of the construct close to the joint line and thereby helps in restoration of the joint line.
- Provides axial and rotational stability even in the presence of bone defects, 100% coverage of the sleeve is therefore not necessary.
- Simplifies the surgical technique, by allowing a direct cut over the broach surface.
- Sleeve position depends on the bone defect and component orientation is independent of sleeve orientation.
- Treatment of bone defects is independent of the ligamentous status of the knee.
- There are proven long term clinical results. The S-ROM NOILES System has been on the market for more than 30 years.

In most revision systems off-set stems are necessary. This requirement for off-set is dictated by fixation in the diaphysis. With the fixation in the metaphysis, problems of tibial and femoral bowing can be solved and the need for off-set stems is not necessary in the tibia and reduced in the femur. On the tibial side the rotational platform gives greater freedom in positioning of the tibial plate. Due to the additional metaphyseal fixation, less than maximum coverage of the tibia is possible.

Good bone quality, contained defects, a stable joint and a correct leg axis are required to use a sleeve without a stem. On the femoral side however, short stems are recommended to stay distal of the femoral bowing. On the tibial side stems of 14 mm and thinner are recommended just for the rare case of sleeve revision.

My indications for sleeves:

- Bone defects AORI 2 and 3
- Primary and revision TKA with very osteoporotic bone
- Severe obesity and in all other cases where an additional metaphyseal fixation might be helpful.

Summary
The major problem in revision TKA is fixation and a subsequent increased rate of aseptic loosening has been observed. Additional metaphyseal fixation might be helpful. Sleeves have proven to give excellent rotational and axial stability enhancing long term results. In clinical practice sleeves make surgery easier and reconstruction of the joint line more reliable.

References
Revision is possible in infection.
INFECTION

Case 1

History
A 68 year old male presents 12 months after primary TKR with persistent pain and swelling.
The Surgeon who performed the original procedure believes nothing is wrong.
Skin envelope is intact and the patient has no significant comorbidities.

Investigations
FBC showed slight anaemia, ESR and CRP within normal parameters.
Joint aspiration grows a coagulase negative staphylococcus sensitive to all routine antibiotics.

Problem
Infected TKR

What would you do?
1 – Investigate further as not convinced the knee is infected?
2 – Debride knee, exchange bearing and give prolonged antibiotics?
3 – Manage with a 2-stage protocol? What type of spacer and what interval between stages?
4 – Consider a 1-stage protocol? What factors might make this an option?

Pre-revision AP & lateral x-rays showing an area of medial tibial plateau lysis suggestive of infection and similar but less obvious femoral changes.
Solution

In this case the surgeon opted for a 1-stage protocol. The patient (host) had no co-morbidities, the organism was multi-sensitive to antibiotics, the soft-tissue envelope was intact and the reconstruction was not complicated by major bone loss. All 4 of these factors are important in determining successful outcome with a single-stage revision for infection.

Further investigation and repeat aspiration can always be justified but was felt unnecessary in this case. Given the bony changes (medial tibial plateau and posterior femoral condyles), and the prolonged history, debridement and bearing exchange was felt inappropriate. A 2-stage protocol is clearly an option. In this case an articulating antibiotic loaded spacer would have been a good option with the interval between stages determined by the clinical condition, mobilisation and function of the spacer.

Revision was performed using metaphyseal sleeves and stems. Antibiotic loaded cement (Vancomycin & Gentamicin) are used as secondary fixation, to fill dead space between implant and bone, and deliver local therapeutic antibiotics.

Post-revision AP & lateral x-rays following a one stage revision. Patient is now 5 years post revision and infection free.
INFECTION

Case 2

History
A 71 year old male had an ‘uncomplicated TKR’ 7 weeks earlier, referred with a wound healing problem.

Investigations
ESR & CRP both elevated. Clinical examination confirmed exposure of implants (see photo).

Problem
Failure of primary wound healing with infection of joint.

What would you do?
1 – Debride knee, exchange bearing and ask for soft tissue coverage from plastic surgeons?
2 – A 2-stage protocol using a static spacer in extension to aid soft tissue coverage?
3 – A 2-stage protocol with an articulating spacer?
4 – A 1-stage protocol?
5 – Arthrodesis?

Pre-revision AP & lateral x-rays showing minor lytic changes around the implants.
Pre-revision wound photo in flexion.
Post-revision AP & lateral x-rays with interval prosthesis in situ. Note the dead space, behind the implants, is filled with antibiotic loaded cement (Vancomycin & Gentamicin) to deliver local antibiotics and secure implant macro-lock fixation. Primary wound closure has been achieved without tension.
Solution
Debridement and bearing exchange is not indicated with major soft tissue defects as in this case. Similarly a one stage protocol is not indicated as it fails the criteria outlined in Case 1 above. Plastic surgical input is always helpful and discussion as part of pre-operative planning is recommended in such cases. A 2-stage protocol, with either a static or articulating spacer can be supported. The type of spacer should be determined on-table based on the ease of soft tissue coverage. Arthrodesis should be kept in reserve for limb salvage should other options fail.

In this case the operating surgeon opted for a 2-stage protocol using an articulating, interval spacer (standard femoral component and all polyethylene tibia) with antibiotic loaded cement to achieve fixation, fill dead space between spacer and bone and deliver therapeutic local antibiotics. Fortunately, primary soft tissue closure was possible. The patient is mobilised full weight bearing with free movement on a balanced knee. After completing a 6-week course of appropriate antibiotics the patient was monitored with serial blood tests and clinical assessment. The second stage was performed ‘electively’ at 6 months following the first stage.
INFECTION

Case 3

**History**
An 88 year old male underwent a 3rd revision for infection using a rotating hinge implant in a stiff knee. Post-operatively he suffered faecal incontinence and the wound became infected with E.coli and a deep joint infection developed. The patient had a persistent infection and a discharging wound.

**Investigations**
Patient is pyrexial. WCC, ESR and CRP all elevated. Clinical condition is seen in the photograph opposite.

**Problem**
Deep infection in a multiply revised knee.

**What would you do?**
1 – Debridement, bearing exchange and antibiotics suppression?
2 – A 2-stage re-revision? What type of spacer would you use?
3 – A 1-stage revision?
4 – Arthrodesis?
5 – Amputation?

Post-re-revision AP & lateral x-rays with Noiles rotating hinge in situ.  
Clinical photograph of coliform infected knee.
Debridement and bearing exchange, and a 1-stage protocol are not recommended due to the host, organism, soft tissue and bone defects being contrary to success. A 2-stage protocol using a static, reinforced antibiotic loaded spacer might be an option, however this has been tried previously and the patient has undergone multiple operations. Amputation can only be recommended in life-saving scenarios as such patients will not ambulate afterwards. In this case the surgeon chose to undertake an arthrodesis as definitive management. After a radical compartmental debridement a long intra-medullary nail was used to achieve bone and soft tissue stability. Immediate full weight bearing was permitted. The nail was used dynamically to promote union.

12 month post-operative x-rays showing bony union. The patient remains infection free and mobile 3 years later.
Revision is possible.

Instability
INSTABILITY

Case 1

History
A 68 year old female presents 6 years after left TKR. She reports the knee was ‘never right’.

Investigations
All blood parameters are normal. Joint aspiration negative. Plain X-rays reveal significant osteolysis of lateral tibial plateau and femoral metaphysis. Asymmetric bearing wear is noted suggestive of polyethylene bone granuloma. The stabilised ‘plus’ bearing is indicative of poor balance at the initial primary TKR.

Problem
Excessive constraint, in an unbalanced knee, leading to early polyethylene wear and bone lysis.

At explantation bone loss will inevitably be greater than pre-operative films indicate once the granuloma have been removed to healthy bone.

What would you do?
1 – Simple bearing exchange or full revision?
2 – How would you achieve fixation?
3 – How would you reconstruct the bone defects?
4 – How much constraint will be needed at revision?

Pre-revision AP & lateral x-rays showing asymmetric polyethylene wear and major proximal tibial and femoral lysis.
INSTABILITY

Case 1 (continued)

Solution
A full revision is required to reconstruct bone defects and achieve secure fixation. The surgeon used 2 zone fixation (metaphyseal sleeve in zone 2 and stems in zone 3). The sleeves also provide secure reconstruction and load the metaphysis to regenerate bone stock (Wolff’s Law). By re-establishing the joint line in extension and flexion, the ligaments can be balanced and reduced constraint is needed (from stabilised plus to PS).

Post-revision AP & lateral showing a balanced knee with reduced constraint. Reconstruction and fixation in Zone 2 of femur and tibia is achieved with metaphyseal sleeves.
3 year review showing secure fixation and significant regeneration of the proximal tibia through physiological loading (Wolff’s Law) by the metaphyseal sleeve.
INSTABILITY

Case 2

History
An 89 year old female presents 6 months following TKR which has ‘never worked’. Unable to walk without left knee pain and giving way. Significant medical comorbidities are noted.

Investigations
Examination confirmed medial collateral ligament insufficiency. X-rays reveal a grossly oversized and malrotated femoral component with a laterally dislocating patella. All blood parameters are normal.

Problem
An elderly female patient with significant medical comorbidities and a painful dysfunctional, unstable TKR.

What would you do?
1 – Reconstruct the MCL plus stabilise the patella?
2 – Revise the TKR and reconstruct the MCL?
3 – Revise the TKR using a varus-valgus constrained bearing?
4 – Revise to a rotating hinged knee replacement?

Pre-revision AP & lateral showing oversized, mal-rotated femur, subluxed patella and valgus mal-alignment.
Solution
Revision TKR to rotating hinge, corrects alignment, rotation and compensates for the MCL insufficiency in a single operation allowing this elderly patient immediate mobility.

Post-revision AP & lateral x-rays showing reconstruction using a Noiles rotating hinge implant.
**INSTABILITY**

**Case 3**

**History**
An 84 year old male with a successful knee replacement 14 years previously. Over the last 12 months he has suffered pain, recurrent swelling and the feeling of ‘giving way’. He has never been pyrexial, nor had any wound problems.

**Investigations**
Examination revealed a varus alignment and an obvious intra-articular effusion/swelling. Increased collateral laxity was noted in flexion. X-rays confirmed asymmetric polyethylene bearing wear with the suggestion of erosion of the posterior tibial tray. All routine blood parameters were normal and joint aspirate was reported as no growth.

**Problem**
Significant polyethylene bearing wear with probable Metallosis secondary to tibial tray erosion. Tibial bone loss is noted beneath the tray but ‘hidden’ femoral bone lysis must be suspected. This knee therefore presents problems of balance, bone loss and fixation at revision surgery.

**What would you do?**
1 – Prescribe an Orthosis/brace?
2 – Simple polyethylene bearing exchange?
3 – Revise to both components, if so how would you achieve fixation?
4 – Arthrodesis?
INSTABILITY

Case 3 (continued)

Post-Operative
Solution

An Orthosis / brace would not remove the progressive symptoms in this patient. Bearing exchange in isolation would not balance the knee and is contraindicated by damage to the femoral articulation. Intra-operative pictures confirms significant Metallosis. A radical synovectomy and debridement of bone surfaces is required. Often, granuloma are present in the metaphyseal bone from both polyethylene and metal debris. Nevertheless, revision is possible. Bone reconstruction and fixation has been achieved using metaphyseal sleeves in Zone 2. The joint line has been established and balanced using a posterior stabilised mobile bearing.
INSTABILITY

Case 4

History
A 64 year old female with a post-polio limb in which a condylar, cruciate retaining knee replacement was performed 12 months earlier. The patient is unable to weight bear or walk on the limb due to gross instability in the knee.

Investigations
Examination reveals 25 degrees hyperextension and global instability. General muscle wasting is noted in the limb in keeping with previous polio. All routine blood parameters are normal. X-rays confirm an unstable primary knee replacement with a high tibial resection and thin polyethylene bearing.

Problem
Gross instability following a primary TKR in a neuro-muscularly compromised limb.

What would you do?
1 – Prescribe an Orthosis / brace?
2 – Revise to a posterior stabilised implant?
3 – Revise to a rotating hinge implant?
4 – Arthrodesis?

Pre-operative x-rays
Solution
Orthotics would have only a limited role in symptom management and would be unlikely to provide sufficient functional stability. Similarly, revision with increasing constraint (Posterior Stabilised or Varus-Valgus constraint) would not be a lasting solution with recurrent instability over time. Arthrodesis would certainly alleviate instability but is unnecessary. The use of a rotating hinge implant provides stability and function and should have been considered as the primary implant of choice.

1 Year Post-Operative
- Painfree
- Complete activity
- No swelling
- 5/0/120
Revision is possible

Extensor mechanism problem
EXTENSOR MECHANISM PROBLEM

Case 1

History
70 year old male had a fall 1 year following a successful TKR. He presented to Accident and Emergency and x-rays confirmed no bony injury. Physiotherapy was commenced and he now presents 6 months later with extensor weakness.

Investigations
USS confirmed a quadriceps rupture. All blood parameters normal. Lateral x-ray confirms decreased patella height compared to previous films.

Problem
Initial non-operative management was tried but the patient reported progressive ‘weakness’ in the leg.

What would you do?
1 – Accept current situation and continue with physiotherapy / bracing?
2 – Undertake quadriceps repair?
3 – Repair and reconstruct with graft augmentation?
4 – If you were to reconstruct which graft would you use?

Lateral x-rays before and after fall showing post-trauma patella baja.
Intra-operative photographs of (a) clinical defect, (b) V-Y plasty and (c & d) insertion of TA allograft.

**Solution**

The patient presented with a symptomatic failure of non-operative treatment therefore surgical intervention is indicated. The patient underwent a quadricepsplasty to reattach to the patella. A Tendo-Achilles allograft to provide augmentation to the repair and reduce the risk of failure of the reconstruction. Post-operatively the patient was allowed full weight bearing but with an extension brace for 6 weeks. Thereafter, gradual increased flexion was allowed whilst still protecting the knee in a brace to prevent forced, excessive flexion. Other graft options include a commercially available synthetic mesh or possibly hamstring autograft.
EXTENSOR MECHANISM PROBLEM

Case 1 (continued)

AP & lateral x-rays at 3 year review showing incorporation of allograft and functional extensors despite residual baja.
EXTENSOR MECHANISM PROBLEM

Case 2

**History**
Female age 84, six weeks following primary TKR complicated with deep infection and wound breakdown.

**Investigations**
Peripheral pulses present. WCC, ESR & CRP all raised. Clinical examination reveals wound breakdown and loss of patella tendon.

**Problem**
An elderly patient with loss of soft tissues and extensor mechanism overlying an infected TKR.

**What would you do?**
1 – Amputate?
2 – Apply a vacuum dressing and give antibiotics?
3 – Revise in 2-stages and raise a medial gastrocnemius flap to cover the defect?
4 – Revise in 1-stage and raise a medial gastrocnemius flap to cover the defect?
5 – Arthrodesis?

Post primary TKR x-rays showing significant soft tissue problem and patella alta.
Solution
Although it is technically possible to revise this knee it was considered inappropriate in this elderly patient. A 1-stage procedure cannot be supported as this case has a poor host and extensive soft tissue loss. A 2-stage procedure is possible, using a reinforced, static cement spacer and a medial gastrocnemius flap to cover the defect. Extensor allograft would be needed at the second stage. In a younger, healthier individual this might have been a reasonable option.

In this case it was felt that Arthrodesis was the correct salvage solution. Implants were removed, a radical debridement performed and the joint stabilised with a long intra-medullary nail. A medial gastrocnemius flap was raised to cover the anterior defect and re-vascularise the infected field. The knee went onto a solid union without further intervention.

Clinical photograph showing wound.

Intra-operative images of medial Gastrocnemius flap and wound closure.
12 month review of arthrodesis, around a long nail, showing bony union and clearance of infection.
EXTENSOR MECHANISM PROBLEM

Case 3

**History**
Male age 80, suffered a patella tendon rupture following a revision TKR and was referred for reconstructive surgery 6 months later.

**Investigations**
X-rays confirm a significant patella alta. Clinical examination an extensor lag of 40 degrees. All blood parameters were normal.

**Problem**
A chronic patella tendon rupture resulting in a clinically significant extensor lag.

**What would you do?**
1 – Use a brace to lock the knee in extension to aid mobility?
2 – Direct surgical repair of the patella tendon?
3 – Repair of patella tendon plus graft augmentation? What graft would you choose?
4 – Arthrodesis?

Lateral x-ray at presentation confirming patella tendon rupture and patella alta.
Solution
The patient had already failed conservative management and had been referred for extensor reconstruction. Direct repair alone is not recommended in chronic ruptures and should always be augmented with graft. Potential grafts include hamstring autograft, synthetic mesh or tendo-achilles allograft as used in this case. Arthrodesis should be the reserved as a limb salvage option.

Clinical photograph of TA allograft before implantation.

Lateral x-ray after TA allograft insertion. The bone plug is secured with circlage wires in the proximal tibia and sutures anteriorly to the reduced patella and into the quadriceps above.
Bone loss revision is possible.
History
An active male age 66 presents with painful right knee with worsening bowing, 8 years after TKR

Investigations
Examination confirmed collateral pseudo-laxity and a full range of movement. X-rays reveal significant tibial bone loss and implant subsidence. All blood parameters are normal and joint aspirate negative.

Problem
Failure of tibial fixation with progress and significant medial bone loss.

What would you do?
1 – Use metal / bone graft augments to reconstruct the bone loss and support with diaphyseal stems?
2 – Use a rotating hinge implant as collateral ligaments cannot be balanced?
3 – Use a tibial porous metal reconstruction cone and achieve implant fixation with a cemented stem?
4 – Use a metaphyseal sleeve to achieve bone reconstruction and implant fixation?

Pre-operative AP & lateral x-rays of right knee.
Solution
Metaphyseal sleeve reconstruction and fixation in Zone 2 with tibial stem to ensure alignment and secondary fixation in Zone 3. Porous metal cones are an option although more complicated and time-consuming and commitment to cemented stem fixation is needed. Once the joint line has been reconstructed, the ligaments can be balanced and minimal constraint is required.

Post revision AP & lateral x-rays showing metaphyseal sleeve tibial reconstruction.
BONE LOSS

Case 2

History
Male age 85 had a successful left TKR 10 years earlier, presents with increasing discomfort and swelling.

Investigations
Examination reveals collateral pseudo-laxity secondary to loosening and subsidence of the tibial and femoral components. X-rays confirm significant tibial and femoral lysis. All blood parameters are normal and joint aspirate was negative.

Problem
Significant bone loss secondary to polyethylene wear. Revision TKR will need to address problems of bone reconstruction, implant fixation and ligamentous balance.

What would you do?
1 – Revise to cemented stems and a rotating hinge implant?
2 – Reconstruct with metal / bone graft block augments and diaphyseal engaging stems?
3 – Use metaphyseal sleeves to achieve bone reconstruction and implant fixation?
4 – Use porous metal reconstruction cones to overcome bone loss and use cemented fixation?
5 – Arthrodesis?

Pre-operative AP & lateral x-rays showing significant osteolysis and bone loss.
Solution

In this case both reconstruction and implant fixation were achieved using metaphyseal sleeves supported by uncemented stems. Bone reconstruction allowed the joint line to be re-established such that ligament balance allowed a posterior stabilised mobile bearing. Porous cones and cemented stems would also be an acceptable if more complicated option. Metal / bone graft block augments and diaphyseal stems provide a less reliable reconstruction and fixation compared to other methods. A cemented stem, rotating hinge would achieve a satisfactory outcome but is unnecessary, as is arthrodesis.

Post revision AP & lateral x-rays showing metaphyseal sleeve tibial reconstruction.
BONE LOSS

Case 3

History
Female age 52 with severe rheumatoid arthritis. Right total knee replacement revised 5 years earlier. Presents with increasing pain, worse on weight bearing.

Investigations
Examination confirmed proximal medial and diaphyseal tibial pain. MCL is intact. All blood parameters are normal (for a patient with rheumatoid) and joint aspirate negative.

Problem
Aseptic loosening in poor quality rheumatoid bone. Medial tibial bone loss is present.

What would you do?
1 – Revise using metaphyseal sleeves and uncemented stems?
2 – Revise using cemented stems and a rotating hinge?
3 – Revise using porous reconstruction cone and cemented stems?
4 – Revise using a proximal tibial replacement?

Pre-op AP & lateral x-rays showing loose tibial component.
Solution
Revision was undertaken using a metaphyseal sleeve (zone 2) and uncemented stem (zone 3). The metaphyseal sleeve provides bone reconstruction and implant fixation. Post-operative x-rays shows the uncovered medial sleeve and tray where it can be compared to a standard augment. Fixation is achieved circumferentially using anterior, lateral and posterior bone; and over the length of the sleeve.

Post revision AP & lateral x-rays showing metaphyseal sleeve tibial reconstruction.
BONE LOSS

Case 4

History
Male aged 74, previous revision for 'massive bone loss' using a hinged prosthesis. Early post revision return of pain, worse on weight bearing.

Investigations
Examination revealed a ROM 0 – 100 degrees. Collateral pseudo-laxity was noted on stressing and reproduced femoral pain. All blood parameters are normal and joint aspirate negative.

Problem
Failure of fixation from inadequate reconstruction and inappropriate implant choice. Progressive bone loss due to unstable movement of femoral implant.

What would you do?
1 – Observe, apply a brace and increase analgesia?
2 – Revise to a cemented stemmed rotating hinge implant?
3 – Use porous reconstruction cones / bulk allograft and use the same hinge with cemented stems?
4 – Use metaphyseal sleeves to both reconstruct bone defects and achieve implant fixation?

Pre-operative AP & lateral x-rays of right knee.
Solution

In this case a rotating hinge implant with metaphyseal sleeves (Zone 2) and slotted stems (Zone 3) were used to revise the knee. Porous cones and cemented stems are an option, although cemented stems without reconstruction are likely to fail irrespective of using a rotating hinge. Non-operative management cannot be recommended as the femur is at risk of fracture.

Post revision AP & lateral x-rays showing Zone 2 & 3 fixation.
PROBLEMATIC KNEE

REVISION IS POSSIBLE
PROBLEMATIC KNEE

Case 1

History

Investigations
Ext/Flex: 0/20/80
Pain at the distal femur
i.a. effusion
Valgus deformity

Problem
Type 3 fracture of the distal femur.

What would you do?
1 – Revision with ORIF only?
2 – Revision with ORIF and implant removal. If so, what features of the implant are needed? Stems? Cones? Sleeves?
3 – The ROM pre-OP is very limited. Extended approach needed? On the quadriceps side or on the tibial side?
4 – Remove the tibial implant?

Pre-operative x-rays
Because the knee wasn't good before manipulation we decided to combine ORIF and implant removal in one procedure.

With an intramedullary and stable construct we were able to reposition the fracture and to fix it in one. For that a sleeve and a short stem was applied.

Because of the very limited flexion and the additional fracture a tibia crest osteotomy was performed right from the beginning. Due to limited flexion the crest was fixed proximally with 2 screws.
PROBLEMATIC KNEE

Case 2

History
An active male age 77 had a successful TKA 14 years earlier. For the Last 12 months complains of increasing pain, recurrent effusion and ‘giving way’.

Investigations
Examination revealed a full range of movement. An obvious effusion and slight varus alignment. Instability was noted mainly in flexion. X-rays reveal asymmetric polyethylene bearing wear with AP instability. All blood parameters are normal. Joint aspirate negative.

Problem
A progressive instability secondary to bearing wear.

What would you do?
1 – Use an orthosis/brace to stabilise the knee?
2 – Perform a simple polyethylene exchange?
3 – Revise to a balanced knee with increased constraint?
4 – Revise to a rotating hinge knee replacement?
Solution

In this symptomatic patient the instability is such that orthotic treatment would prove unsatisfactory for the patient. Polyethylene exchange alone will not address any residual posterior laxity nor improve any inherent imbalance in the knee replacement. A rotating hinge knee would certainly eradicate the instability but is unnecessary. Revision was performed using metaphyseal sleeves to provide reconstruction and implant fixation. A mobile bearing, posterior stabilised bearing was all the constraint required once the joint line had been re-established and the ligaments balanced.

Post-operative x-rays
PROBLEMATIC KNEE

Case 3

History
71 year old male 8 years following a TKR. Over the last 2 years has suffered from increasing pain, swelling and varus deformity.

Investigations
Examination confirmed an effusion and synovial thickening. Range of movement was from -10 degrees extension to 90 degrees flexion. Medial opening was noted but with a firm end-point. All routine blood parameters are normal. X-rays confirm asymmetric polyethylene bearing wear with erosion/failure of the tibial plate medially. A large synovial thickening is noted and lysis is present beneath both components.

Problem
Initial failure to balance the knee with progressive bearing wear and ultimately tibial plate erosion/failure. Metallosis is anticipated with significant bone loss at explantation.

What would you do?
1 – Prescribe an Orthosis / brace?
2 – Revise the knee, how would you achieve fixation?
3 – How much constraint will be needed?
4 – Arthrodesis?

Pre-operative x-rays
**Solution**

The use of orthotics / bracing will achieve little symptomatic relief in this case. Bone loss is always greater at explantation due to the anticipated polyethylene and metal granuloma in the metaphyseal bone. Reconstruction and fixation will need to be addressed, and in this case metaphyseal sleeves have achieved both. Clinical examination confirmed the collaterals are intact with laxity being secondary to the implant failure. Therefore minimal constraint is needed once the joint line has been established and the knee balanced. In this case a mobile bearing posterior stabilised knee was used.

*Post-operative x-rays*
Revision is possible.

Peri-prosthetic fracture
PERI-PROSTHETIC FRACTURE

Case 1

History
Female age 84, fell at home and sustained a supracondylar fracture above a well functioning TKR. Initial management was conservative but after 8 weeks the position was deemed unacceptable, the fracture un-united and the patient referred for further management.

Investigations
Examination confirmed a painful un-united distal femoral fracture. X-rays revealed a displaced, mal-rotated fracture. All blood parameters were normal.

Problem
Displaced type 2 femoral supracondylar peri-prosthetic fracture with delayed presentation.

What would you do?
1 – Continue non-operative management and anticipate bone union, then mobilise?
2 – Open reduction and internal fixation?
3 – Revision knee replacement to reconstruct and bypass the fracture?
4 – Distal femoral replacement?

AP & lateral x-rays at presentation showing displaced, un-united supracondylar fracture.
Solution

In view of the patients age, unacceptable position and un-united fracture, revision to a rotating hinge using metaphyseal sleeves to reconstruct and provide satisfactory fixation was performed. Immediate full weight bearing post-revision was possible.

Post-revision AP & lateral x-rays at 12 month review showing restored femoral alignment and fracture union.
PERI-PROSTHETIC FRACTURE

Case 2

History
A 78 year old female with a well functioning TKR 6 years previously falls and injures her knee. X-rays confirm a Type 2 distal femoral supra-condylar fracture. Her initial management was by open reduction and internal fixation. 3 months following osteosynthesis the patient presents with increasing pain and deformity.

Investigations
Examination reveals a painful, swollen knee with limited movement. The soft tissue envelope is intact. X-rays confirm failure of fixation. All routine blood parameters are normal. Joint aspiration was negative.

Problem
Failed Osteosynthesis for a displaced supra-condylar distal femoral fracture (Type 2). Painful immobile limb in an otherwise healthy active patient.

What would you do?
1 – Manage non-operatively in a cast?
2 – Revise the fixation, what would you change?
3 – Preserve the TKR, remove the plate and secure fixation with an IM nail?
4 – Revise the TKR, what implant and how much constraint?

Pre-operative x-rays
Post-operative X-rays
Osteosynthesis, TKA in place

3 months following osteosynthesis. Failure of fixation is noted with multiple locking screw breakage and collapse of the fracture site.
PERI-PROSTHETIC FRACTURE

Case 2

Solution
The initial decision to perform Osteosynthesis was a reasonable one. However once it had failed, revising the fixation has little chance of success. Equally, management in cast is unlikely to help with this impending non-union. Retrograde nailing would have been a option for initial fixation but would have been difficult due to minimal distal bone stock and harder still at revision. In this case, a single operation to achieve pain relief and function was deemed an advantage in an elderly patient. A distal femoral replacement with a rotating hinge and cemented fixation was used.
REVISION IS POSSIBLE
SUMMARY OF TERMS

CRP = C-reactive protein
ESR = Erythrocyte sedimentation rate
FBC = Full Blood Count
MCL = Medial Collateral Ligament
ORIF = Open Reduction & Internal Fixation
PCL = Posterior Cruciate Ligament
ROM = Range of Motion
R-TKA = Revision Total Knee Arthroplasty
TKA/TKR = Total Knee Arthroplasty/Replacement
USS = Ultra Sound Scan
WCC = White Cell Count
References


The views and opinions expressed are those of the faculty and do not necessarily represent the views of DePuy Synthes Joint Reconstruction.