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Editorial

TKA revision – reasons, challenges and solutions

1. Reasons for TKA revision

Due to different factors the numbers of TKA revision has increased over the last years and will increase ever more in the future. One relevant factor for that is the increasing number of primary TKA's.¹ An additional factor is reduced patient age for TKA surgery due to good results and higher activity demand in these patients as well as improved acceptance of this procedure. As an additional factor, especially in the western world, there is obesity. Overall the prognosed increase in TKA revisions in the US is by far higher than that for primary TKA, THA or R-THA.¹ Beside the surgical challenges this increase will also challenge the socio-economy of the different countries.

When analysing the individual reason for TKA failure it is very helpful to differentiate between early and late failure.^{2–4} Early failure means revision in the first 2 years. In this failure type most of the patients describe problems from day 1 complaining of different symptoms like pain, swelling, instability and a limited range of motion. Reasons for early failure are primarily caused by the surgical procedure itself while late failures more likely are implant related. Looking more into detail, the most prominent reason for TKA revision in the first 2 years is infection.^{5,6} Other common reasons for early failure are malpositioning, instability and patella-femoral problems. Main reasons for late failure are aseptic implant loosening, instability and again infection. Each of these diagnoses however summarizes a huge variety of different forms of problems. Looking at instability for example, it can be present in extension only, in flexion only or as a general type in all positions.⁴ All of those having different causes like reduced posterior offset, elevated joint line, ligament damage. So defining the cause is only the first step on the long way to a successful revision.

Since the list of failure modes is very long, it is very important to establish a defined diagnostic algorithm for pre-OP analysis. The first column should focus on patient condition and complaints. It should start with some simple questions like “Have you ever had a pain free day after your TKA surgery?” But also the type of instability should be analysed by asking some specific questions. It is also important to get information on current complaints and the cause for primary TKA and leg axis prior to surgery. Beside those patient related

questions it is also important to obtain the surgical notes regarding type of approach, intraoperative steps, potential problems and the type of implant. After obtaining patient history, the next step is clinical examination. It should include the important part of the ligament status. Is it stable or unstable? And if unstable, in which position is it unstable (mid-range, flexion, extension)? Therefore examination needs to be performed in different flexion angles. Active and passive range of motion as well as the status of the extensor apparatus needs to be assessed. The location and number of scars as well as the skin conditions are also important factors before a decision for revision should be made. Third column of pre-Op analysis is X-ray analysis. A long leg, full weight bearing AP view is essential as well as a good lateral view (meaning the posterior condyles should be contoured as one) and a skyline view. Based on these 3 images most types of implant malpositioning, implant loosening and osteolysis can be detected. Only in few cases additional information is needed and a CT scan or scintigraphy may be necessary.

At the end of the pre-OP algorithm the reason for failure must be precisely defined otherwise no indication for a revision should be made. It is very important that patient history, clinical examination and X-ray analysis fit together and yield a conclusive diagnosis. Before starting surgery, however, an additional list of questions should be asked, in order to be prepared for the expected and unexpected problems during surgery. This should start with questions like “Where to perform skin incision” or “Is a standard medial parapatellar approach sufficient or do I need an extended approach?” But also from a logistic point of view you should be prepared for a revision type of implant with special fixation options, like stems, wedges, sleeves or more constrained insert types. Two important questions before making your final decision for revision are the same as in primary TKA “Am I able to make this knee better?” and “What are the expectations of the patients and will he or she be happy?” Only after thorough consideration of all these questions the final decision and plan for revision TKA should be made.

2. Challenges of TKA revision

Compared to primary TKA the surgical challenges in R-TKA are a lot bigger and solid fixation of the implant and creation of

a well balanced knee with equal gaps in extension and flexion needs more advanced techniques to be successful.

2.1. Fixation

Irrespective of the failure mode, bone defect is almost always a topic to face during revision surgery. As part of the pre-OP work-up you might see some osteolysis but especially underneath the trochlear groove the defects are often larger than expected. So a classification of bone defects is relevant for revision surgery. This classification should be used prior to and during surgery. The AORI classification⁷ is widely used and gives some surgical tips for the treatment of bone defects. While in type 1, defects are small and contained and no specific implant is needed, in type 2 defects are more severe and need specific treatment. In most cases a medially localised uncontained defect exists on the tibial side. On the femoral side bone loss due to overresection, implant loosening or implant removal almost always can be found. This problem of distal and posterior bone loss will not only be problematic for implant fixation but even more problematic for restoration of the joint line. To get a good functional result however, the latter is the most important part of revision surgery. While finding the joint line on the tibial side is relatively simple and can be controlled easily during surgery (around 1 cm above the fibular head) it is a lot harder to find on the femur. Another problem is, that on the femoral side distal and posterior cuts affect the joint line independently. While on the tibial side, implant height effects flexion and extension gap equally. Different surgical techniques exist each having specific problems that again the surgeon should be aware of. So if you start restoring your posterior offset in 90° of flexion first and then restore your extension gap you might end up with an elevated joint line. If you start with the extension gap first it is sometimes problematic to fill the flexion gap and you end up with a more constrained insert. The latter problem can mostly be solved by flexing the femoral implant around 3–5°. Irrespective of the method used the surgeon should try to find the anatomical landmarks, which can help him restore the joint line. The best landmark, if it is still there, is a residual of the meniscus. Second best, from my experience, is the medial epicondyle. Depending on femur size it is 25–30 mm distal to this landmark. Since the patella has a large variability in terms of height it is not a reliable landmark for finding the femoro-tibial joint line. Additional information can be obtained from X-ray before first TKA or the contralateral knee.

Treatment of bone loss in zone 1¹⁰ is mainly done with metal augments, both on the tibia and on the femur. In young patient autologous bone augments are an alternative, however, a long period of partial weight bearing post-OP and a frequent rate of bone resorption are disadvantages. Often additional metaphyseal bone loss (zone 2) can be observed needing additional implant fixation in this zone and mostly further fixation in zone 3 (diaphysis). Fixation in zone 3 can be done by cemented or uncemented stems. While uncemented stems are easier to use and remove, the long term results of cemented stems in particular in soft bones are described as favourable.¹¹ However, also cemented stems have great problems especially over a longer time. So bone resorption at the metaphysis can frequently be found. This demonstrates

that in cemented stem zone 2 is not really used for fixation and load distribution. Due to that a second revision often shows even larger bone defects than the first. Beside that a lot of questions about ideal stem length, thickness and surface finish remain unanswered.¹² Therefore future fixation concepts should address and overcome these problems of current fixation options.

2.2. Ligament instability

During revision surgery, one important goal is to obtain equal gaps in flexion and extension as well as equal gap sizes in medial and lateral. This will lead to a balanced and stable knee throughout the entire range of motion. Therefore additional intraoperative analysis of the type of instability is very important. In a lot of cases instability can be solved just by correcting implant position. However, we have to keep in mind that reliance on stem alignment can lead to malalignment of the tibia component due to varus or valgus bowing in a lot of bones. Therefore exact planning of stem length is important.

After positioning the tibia implant, extension and flexion gap sizes are analysed and based on those femoral component positioning is planned. In most cases, stability in extension can be achieved after correct implant positioning. In most cases the surgeon will find a larger flexion gap rather than a larger extension gap. This is then treated by restoration of the posterior femoral offset, the sagittal diameter and by flexion of the femoral component. In most of the cases a balanced and stable knee can be achieved with a non-constrained PS design. However, it has to be kept in mind that a PS design does not give any medio-lateral support. So if there is a medio-lateral instability left, which cannot be solved at least a semi-constraint (TC3, VVC) insert needs to be applied. This is necessary in approximately 20–30% of cases, including those with slight mismatches between flexion and extension. In type 3 defects with displaced, fractured or missing femoral condyles the indication for a rotating hinge is given. In addition to the above mentioned indications there are other factors (large flexion/extension gap mismatch, problematic extensor mechanism, post polio, severe neurologic deficits) that need to be respected as well.

Thorough analysis of the patient and of ligament stability helps to be prepared, but nonetheless the amount of instability can be larger than expected during surgery, so that a rotating hinge should always be on hand in an institution performing TKA revisions. As a general rule it can be stated: “Minimum constraint – maximum stability”. This is based on the observation that a higher amount of constraint leads to increased polyethylene wear and might consecutively lead to loosening and should therefore be minimized. However, sometimes stability can only be achieved with additional constraint. So it is crucial to find the right balance between stability and constraint.

3. Solutions in TKA revision

By analysing the problems of revision TKA, three common causes for failure can be found.^{6,13} The most common failure mode is again infection. The two other common causes are

tibial/femoral implant loosening and polyethylene wear.¹³ The reason for those is insufficient long term fixation and additionally an increased amount of constraint.

3.1. Solution for improved fixation

Standard revision implants use zone 1 (epiphysis) and zone 3 (diaphysis) for fixation. Cemented and uncemented stems are used for fixation in zone 3. Zone 2 (metaphysis) is not used for fixation in most implants. However, good bone is located there and by using this area the fixation in zone 3 becomes less important. Metaphyseal sleeves and cones are available, both giving additional options for fixation in Zone 2. But it has to be kept in mind that both have a different field of application: Sleeves are a part of the implant and allow a cementless fixation in zone 2. Consecutively bone growth to the sleeve is induced and will improve long term fixation. Cones, on the other hand, are used primarily for filling defects. As the implant is independent from the cones, standard loading conditions exist and by that the problem of implant loosening will not be minimized.

3.2. Solution for minimized polyethylene wear

The relationship between the amount of constraint and the increased stress on the polyethylene has been described in a lot of retrieval studies.¹⁴ As maximum constraint can be found in the hinges and due to the known problems of constraint nowadays almost all hinged knees are rotating hinges. In contrast to this implant a non constraint knee, on the other hand, shows no difference between fixed and mobile bearing knees.^{15,16} In between both scenarios there is the semi-constraint insert (VVC, TC3). In those fixed bearing VVC designs, only 2–4° of femoro-tibial rotation is possible. However, it is known from fluoroscopic studies¹⁷ that physiological femoro-tibial rotation of 5–15° occurs during knee flexion in activities of daily living. Therefore only a mobile bearing design can allow for physiological rotation. An additional fact that emphasizes this problem even further is that correct rotational placement of the tibial and femoral component often is not easy to achieve and by that additional rotational stress will arise on the polyethylene of the post. Consequently this will then lead to an increase of transmitted forces to the interface between implant/cement and/or implant/bone and might end in early loosening. With a mobile bearing design the polyethylene wear should be reduced and additionally the long term survival should be improved over time. Midterm results are promising,¹⁸ however, long term results need to be awaited.

4. Conclusion

TKA revision is a topic of marked interest for arthroplasty surgeons due to the dramatic increase in numbers. A thorough pre-OP analysis, based on a standardised algorithm is inevitable. Based on that, the reason for failure needs to be defined prior to surgery, otherwise it is likely that the same mistake will be repeated or that the knee will end up even worse. During surgery, implant fixation, joint line reconstruction and ligament balancing are the main issues on

the way to a good functional result and a good long term survival. The pre-OP analysis should include in which zone a fixation is possible and what implant features (stems, wedges, sleeves) are needed to achieve that. By correcting implant position additional releases will not be necessary in most cases. However, sometimes the quality of the ligaments is so poor, that a semi-constraint implant or even a rotating hinge is needed. Therefore a revision surgeon should always have a rotating hinge on hand. Additional cementless metaphyseal fixation is a promising option to achieve improved joint line reconstruction and better functional results. It should also help to improve long term survival rate. Another promising factor to improve long term survival might be the option of a rotating platform in semi-constraint inserts.

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