Bone loss in total knee arthroplasty (TKA) may be encountered in the primary or revision setting. It is more commonly seen in the latter, and may arise from osteolysis due to polyethylene wear, aseptic loosening, or aggressive debridement for the treatment of infection. It may be exacerbated by iatrogenic damage during surgery.

**Patient evaluation**

The workup for a patient who may undergo revision TKA starts with a careful history and physical examination. The patient’s age and functional status are assessed, as well as the presence of medical comorbidities. Any history of previous wound healing problems or night pain should arouse suspicion for the presence of infection.

The physical exam focuses on alignment, presence of contractures, range of movement, patellar tracking, competency of the extensor mechanism and the integrity of the ligamentous structures. Careful examinations of previous surgical incisions and the neurovascular status of the limb are mandatory. Laboratory studies are necessary to screen for the presence of infection with elevated inflammatory markers (erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP)) warranting aspiration of the joint for further investigation. Imaging studies include weight-bearing anteroposterior, lateral and sunrise views of the knee.

**Classification of bone loss**

The Anderson Orthopaedic Research Institute (AORI) classification system (Table I) is commonly employed to describe bone loss in revision TKA.3

**Pre-operative planning**

Successful TKA revision surgery is dependent upon adequate pre-operative planning. Bone loss can have a detrimental effect on the success of revision knee surgery by adversely affecting the survivorship of the revision TKA, level of the joint line, the rotation of the tibial and femoral components, ligamentous balancing and stability throughout the knee’s range of movement, and patellar tracking. Pre-operative planning must take all of these into account. It is important to determine what implants may be required for the procedure and ensure their availability.

The standard surgical exposure is the medial parapatellar approach, which provides extensiile access to the joint. The quadriceps snip, which has a minimal effect on post-operative rehabilitation, may be useful to improve exposure when the extensor mechanism is noncompliant.2 A thorough synovectomy further improves visualisation. Frozen section and/or tissue cultures are sent to check for the presence of occult infection. It is paramount to remove existing implants with care to minimise iatrogenic bone loss. The remaining bone is debrided to remove the soft-tissue membrane that would prevent proper cement interdigitation or osseointegration. Once the remaining bone stock is exposed, the bone defects are re-classified according to the AORI system.

**Management of bone loss**

**Type I defects**

AORI Type I defects do not require any treatment beyond the use of polymethylmethacrylate (PMMA) cement or cancellous allograft, which adequately fill any contained defects that are < 5 mm in size.

**Type Ila defects**

AORI Type Ila defects may also be filled with PMMA if they are contained. PMMA is inexpensive, readily available, and easily contoured to fill the deficit. Defects between 5 mm and 10 mm in size may be filled with PMMA, although reinforcement with screws is recommended.

Defects > 10 mm in size can be treated with morsellised allograft bone or standard metal augmentation. Morsellised allograft bone is economical, readily available, and has the theoretical advantage of restoring bone stock. Disadvantages include potential for graft resorption, the technically demanding nature of the procedure, and potential for disease transmission. Lotke et al4 reviewed 48 patients who underwent impaction allografting for bone defects, some of whom required wire mesh for uncontained defects. There were no mechanical failures at a mean follow-up of 3.8 years, although the authors did describe the technique as demanding and time-consuming. Not insignificantly, they also reported a complication rate of 14%,5 Impaction grafting may be considered in younger patients where subsequent revision surgery is likely and bone stock restoration is desirable.

Modular metal augments are another option for uncontained bony defects involving the femoral condyle or tibial plateau. The advantages of modular augments include favourable load transfer from metal to bone, allowing immediate weight-bearing by the patient. Disadvantages include size and shape limitations, unsuitability for larger bone defects, and the fact that they do not restore bone stock. They are recommended for use in moderately sized (< 15 mm), non-contained defects. Pagnano et al5 investigated the use of tibial wedge augments in primary TKA. They reported the results of 24 knees in 21 patients at a mean of 5.6 years after surgery, and found excellent clinical results in 67%, with only one knee requiring re-operation.4 Patel et al6 reported on the five- to ten-year results of AORI Type 2 bone defects in 79 knees treated with modular metal augments in revision knee surgery. The survival of the components at 11 years (95% confidence interval (CI) 10.3 to 11.2) was 92% (sd 0.03%).5
Tantalum cones have proved equally effective.

Metaphyseal bone INTACT

Metaphyseal bone DEFICIENT

The 20 patients who had metaphyseal bone DAMAGED

In a combined series, 30 knees with porous metal cones were reported, among 43 patients who underwent revision TKA using tibial trabecular metal cones. The authors recommended the procedure should be reserved primarily for elderly, sedentary patients. Although good outcomes are reported in low demand patients, there is a high risk of complications. Berend and Lombardi reported on 39 revision TKAs in 37 patients with (non-tumour related) massive bone loss and instability. Patients obtained very good clinical and functional outcomes, with average Knee Society scores improving from 39 pre-operatively to 87 at a minimum follow-up of two years.

Stems

Revision implants typically require the use of stems to help
offload stress at the bone-implant interface. Attempts to use primary implants in ‘simple’ revisions typically lead to inferior results compared with the use of revision implants in ‘difficult’ revisions. Stems can be short, narrow and cemented into metaphyseal bone, or longer, cementless and diaphyseal engaging. Cementless stems are easy to use and facilitate component alignment. However, anatomic variation may require the use of offset stems, especially in the tibia. Published reports using cementless stems show a two- to five-year survivorship ranging from 81% to 94%. Cemented metaphyseal engaging stems and cementless diaphyseal engaging stems appear to have equivalent results at mid-term follow-up. However, it should be emphasised that cementless stems must engage the diaphysis. Shorter, so-called ‘dangle’ stems have higher reported failure rates.

**Patellar bone loss**

If the patella was resurfaced at index arthroplasty, the polyethylene button should be retained if possible. Removal of a well-fixed patellar component can result in severe bone loss and compromise attempts at revision resurfacing. Options for management of the non-resurfaceable patella include patellectomy, patelloplasty, gull-wing osteotomy, bone grafting, or use of a porous tantalum implant. Patellectomy has historically been reported as showing a poor outcome, with inferior quadriceps strength, quadriceps fatigue and reduced active range of movement after the procedure.

Hanssen reported significant improvement in post-operative Knee Society pain and function scores in a series of nine patients who had bone grafting of a patellar shell performed at the time of revision. The technique involves creation of a retropatellar soft-tissue pouch that is filled with bone graft. Patellar thickness was largely maintained at final follow-up. Patelloplasty comprises shaving of the patella with removal of osteophytes. It has an inferior result to resurfacing in primary TKA, and while early results following revision surgery are satisfactory, Knee Society scores show deterioration with time. Tracking of the residual patella can be improved by performing a gull-wing osteotomy, which allows the patellar remnant to articulate better with the femoral trochlea. Klein reported on 12 patients after revision TKA with a gull-wing osteotomy of a deficient patellar remnant. One patient had a poor result that was attributed to a concomitant quadriceps snip; the remaining 11 patients had improved range of movement, no significant extension lag, and improvement in Knee Society pain and function scores at the mean three-year follow-up. Radiographs showed successful healing of all osteotomies, and central tracking of the patella.

Porous tantalum-backed patellar components have also shown some success in improving the outcome of revision TKA where the patella is severely compromised. This device aims to restore patellar thickness, thus improving the quadriceps moment arm. These implants, however, add considerable cost to the procedure as compared with the other methods of patellar reconstruction. In one study, 11 patients had the tantalum-backed patella inserted and all showed evidence of incorporation at a mean follow-up of 32 months. Another study reported a successful outcome in 19 out of 23 components at minimum follow-up of five years. The indication for the tantalum-backed patella was revision surgery in which there was residual patellar thickness ≥ 10 mm. Failures were associated with avascular patellar bone and fixation of components directly to the soft tissues, thus emphasising the need to attach these components directly to viable bone.

**Conclusion**

Bone loss in revision TKA presents a challenge for the surgeon. Often, such patients may have had multiple previous procedures, and it is essential to respect the integrity of the soft tissues and ligamentous structures. Pre-operative planning and careful surgical technique is paramount. One must be prepared to have instruments and implants available to address severe bone defects in order to successfully reconstruct the knee. Bone grafting is useful in younger patients who may require later revision. Salvage procedures should be reserved for elderly, low-demand patients.

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**References**
