

Revision Knee Arthroplasty

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Abstract

Total knee arthroplasty (TKA) is a satisfactory procedure regarding functional outcome and pain relief. The ever increasing number of total knee arthroplasties and expanding indications have led to a high number of revisions. The principles of revision arthroplasty are to understand the cause of failure, adequate surgical exposure, restoration of limb alignment, achieving appropriate soft tissue balance, correct implant alignment, restoration of joint line and a good range of motion. The literature on revision TKA is diverse and is not conclusive in many aspects. The results of revision surgery are not as good as the primary TKA with main causes being increased polyethylene wear, aseptic loosening, malalignment of components, instability, extensor mechanism problems, infection and stiffness. Revision knee Arthroplasty is not a repeat primary Arthroplasty but it is a technically and economically demanding procedure and its successful performance requires thorough preoperative planning, adherence to the principles of revision knee arthroplasty, availability of diverse implant options and adequate bone graft.

Introduction

Total knee arthroplasty (TKA) is one of the most successful and commonly performed Orthopaedic surgeries and is a reliable procedure for painful arthritic and inflammatory conditions of the knee. The numbers and indications of Primary knee replacements are expanding and the procedure is now being offered to younger and more active patients

than in the past.¹ This has led to increased numbers of revision procedures. Callahan in a Meta analysis found the rate of revision knee arthroplasty to be 3.8% at 4.1 years of follow up.² Revision TKA is technically more difficult, has a higher rate of failure and is associated with higher complication rate than the primary TKA.³ Longer operations, costly implants and extended hospital stay along with an increased complication rate makes revision surgery more expensive. It is conservatively estimated that the cost of a revision knee surgery is \$21883.⁴ In 1999, 22,000 knee revision operations were done in the United States at an estimated expense of 262 million dollars.

Saleh⁴ performed a literature review to describe



Figure 1. Postoperative X-Rays, nonlinked constrained Revision knee arthroplasty using stemmed femoral and tibial components.

patient outcome after revision total knee arthroplasty procedures using various global knee score ratings. Callahan and Drake defined a GKS as "an instrument that measured patient outcomes in the domains of pain, function, and range of motion and combined these domains in a summary scale."

Examples of such scales include the Hospital for Special Surgery (HSS) score and Knee Society Score (KSS). It was found out that there was a significant increase in pain and function KSS as well as a highly significant rise in HSS score postoperatively. There is no significant correlation between the preoperative score and the amount of improvement in either the overall KS ($r = -0.09$, $P > .7$) or the HSS ($r = -0.263$, $P > .3$) scores. The mean difference increase on both GKS scores up to around 60 months; thereafter, KS and HSS score marginally decline. The percentage of subjects attaining an excellent or good outcome postoperatively was 77.7%. The greater proportion of infected patient series has worse outcomes. Of 46 cohorts, 44 (95.7%) reported complication data on 1,683 subjects who incurred 443 complications (26.3%). There were a total of 217 knee complications in 1,683 subjects necessitating re-revision (12.9%).

There are a number of important steps that need to be followed in revision TKA which are recognizing the cause of failure, adequate exposure; removal of the implants; joint line restoration; soft tissue balancing; restoration of mechanical alignment and effective post operative rehabilitation.

If the failure mechanism is undetermined, the results of revision knee replacement are suboptimal. Mont⁵ revised roentgenographically normal TKAs¹ for pain of unknown origin and found that only 41% of the patients had a clinically successful result. The results were better if the preoperative range of motion (ROM) was less than compared with patients with good ROM preoperatively. Even if the problem was identified at surgery, only 25% had successful outcome. Sharkey⁶ retrospectively reviewed the etiology of failure of 212 revisions. The causes of failure were polyethylene wear (25%), aseptic loosening (24.1%), instability (21.1%), infection (17.5%), arthrofibrosis (14.6%), malalignment or malpositioning (11.8%), a deficient extensor mechanism (6.6%), patellar osteonecrosis (4.2%), periprosthetic fracture (2.8%), and isolated patellar resurfacing (0.9%). More than one cause of failure was found in 32% of the patients. Undiagnosed pain⁶ and implant breakage can be added to this list.⁵

Multiple factors need to be considered regarding surgical exposure to a revision TKA.

There is usually scarred skin and subcutaneous tissue due to multiple surgical procedures, a fibrotic quadri-

ceps mechanism and a shortened patellar tendon. In a non-obese patient with none of the above mentioned problems a standard knee exposure might work.

A mid line skin incision if possible is the best. Previous surgical incisions should be in use, and in case of multiple incisions the most lateral incision should be chosen.

Thick subfacial flaps should be raised. In case of obese patients and extensive scarring a lateral flap may have to be raised in order to evert the patella. In the presence of adherent scar tissue, multiple incisions, chronic periprosthetic infection or poor skin quality on the anterior aspect of the knee, preemptive procedures⁷ can reduce the risk of post operative wound complications. They are pre-revision test of skin healing capacity by giving incision in the skin and seeing its healing (Sham incision), tissue expansion, local rotational flaps, gastrocnemius muscle flaps and free flaps.

The medial para patellar approach (Capsular) is the first choice. The extensile exposures might be prevented in few cases by doing a resection of scar tissue from the suprapatellar pouch and Para patellar gutters, a medial subperiosteal release and at times doing the lateral patellar release and not everting the patella initially till the femoral and tibial components are removed. If all these maneuvers do not allow eversion of the patella than a rectus snip or a V-Y Quadriceps plasty, tibial tubercle osteotomy or a femoral peel technique may be used.

Quadriceps Snip technique causes minimal damage to the extensor mechanism and no postoperative immobilization is required for it though it might not give extensile exposure in very stiff knees. V-Y quadricepsplasty has the advantage of an extensile knee exposure and allows con-

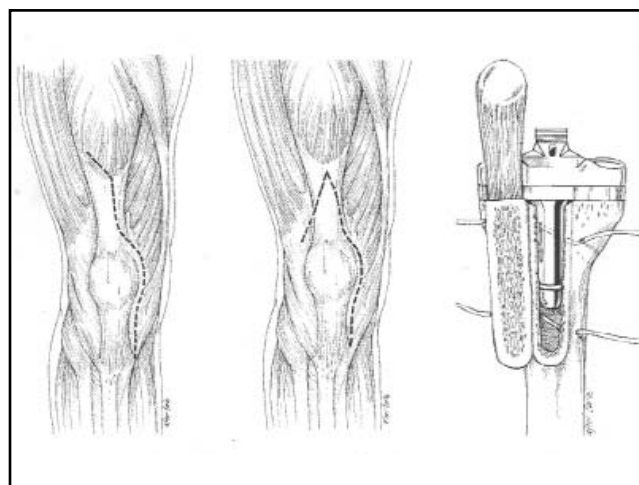


Figure 2 (A). Quadriceps Snip, (B) V-Y Quadricepsplasty and (C) Tibial Tubercle Osteotomy. (© 1998 American Academy of Orthopaedic Surgeons. Reprinted from the Journal of the American Academy of Orthopaedic Surgeons, Younger ASE, Duncan C.P, Masri B.A, J Am Acad Orthop Surg 1998;6: 55-64, with permission).

trolled lengthening of the extensor mechanism improving the range of motion. The disadvantages are compromised healing of the extensor mechanism at the apex of the incision, an extensor lag, quadriceps weakness^{8,9} and the need to protect the knee from active extension postoperatively.

An extended tibial tubercle osteotomy is useful for removal of well fixed stemmed tibial components and adjusting the position of the patella in patella Baja. The disadvantages are risk of fracture of tibia below the distal margin of the osteotomy and an extensor lag. Various methods of fixation of osteotomy fragment have been described including wires and screws with good healing rates.

The femoral peel consists of entire subperiosteal dissection of the distal femur and can include the peeling off the collateral ligaments or an epicondylar osteotomy. This gives the most extensile exposure and is useful in patients with stiff or ankylosed knees. Significant bone loss is commonly encountered in revision total knee arthroplasty and the extent of bone loss is usually more than predicted by the preoperative X-rays. The main causes of bone loss are osteolysis due to wear and tear debris and loss encountered during component removal. Assessment of bone defect is best done intraoperatively after removal of the components and debridement of all osteolytic areas. Bone loss is mainly classified according to the size, location and depth of the defect and the presence and absence of an intact peripheral rim for placement of the prosthesis and containment of the bone defect.¹⁰ The Anderson Orthopaedic Research Institute (AORI) bone defect classification provides some guidelines for management of bone defects. In type I defect the metaphyseal bone is intact and only minor bone defects are present which do not compromise component stability. In type II defects there is metaphyseal bone damage and cancellous bone loss which leads to requirement for cement reinforcement, bone grafting and metal augments to restore joint line. Type II bone defects can occur in one femoral or tibial condyle (Type II A) or both femoral / Tibial condyles (Type II B). In type III defects the metaphyseal region is deficient and therefore a structural allograft or a custom made, hinged or revision prosthesis with an extended intramedullary stem is required.¹⁰

Multiple options are available for reconstruction of bone defects which are cement augmentation, modular or custom implants and allograft and autograft reconstruction. Bone cement usually is used for small, preferably contained bone defects up to 5 mm in depth.¹⁰ The advantages are low cost, easy to use and readily availability. Cement does have a modulus of elasticity which is much lower than bone. It performs poorly when subjected to shear forces and performs well under compression. So the wedges need to con-

vert to flat cut shaped defects to make it a mechanically strong construct. In vitro biomechanical studies have shown that addition of screws in cement can lead to increased strength.

Autogenous bone graft is usually used for defects deeper than 5mm in thickness and involving more than 50% of the tibial hemisphere.¹² The autografts heals readily, has no chance for disease transmission and has osteoinductive properties but is also associated with a limited available amount and donor site morbidity. The usual bone loss in revision TKA is over distal and posterior aspect of the femur.

Modular augmentation blocks can be used to restore the correct position of the joint line, balance flexion and extension gaps and improve the rotation of the femoral component.

Distal bone loss can lead to elevation of joint line which can be dealt with using distal femoral augmentation blocks. Posterior bone deficiency can lead to a mismatch between flexion and extension gap and instability which can be dealt with using posterior femoral augmentation. The rotation of the femoral component can be improved by selectively increasing the augmentation over the posterior lateral femoral condyle in comparison to the posterior medial femoral condyle. Over the tibial side metallic wedges or block augmentations can be used. No significant differences for the maximum strains using metal wedges and blocks were noted by Fehring.

The advantages of allografts are easy availability, low cost (compared to custom implant), bone stock restoration, opportunity for attachment of collateral ligaments and intraoperative flexibility.¹³ The disadvantages can be disease transmission, malunion, nonunion, collapse and fracture of the graft, graft resorption and a high infection rate.

Allografts can be used in morselized form or particulate bone graft and as structural allografts. The particulate bone grafting is usually used in contained bone defects (AORI I and II) in which the immediate stability of the prosthesis is not dependant on the support provided by the graft. It requires tight packing of appropriate sized particulate graft into a contained vascularized defect and a rigid implant fixation.

Knees with massive segmental bone loss are usually candidates for either rotating hinge prosthesis or an allograft-prosthesis composite. The technique of structural allograft-prosthesis composite is defined by Engh and Parks using femoral head allografts and Clatworthy¹⁴ using distal femoral or proximal tibial allografts. It is usually done in the settings of a AORI type III defect. Stemmed components are recommended for structural allograft use.

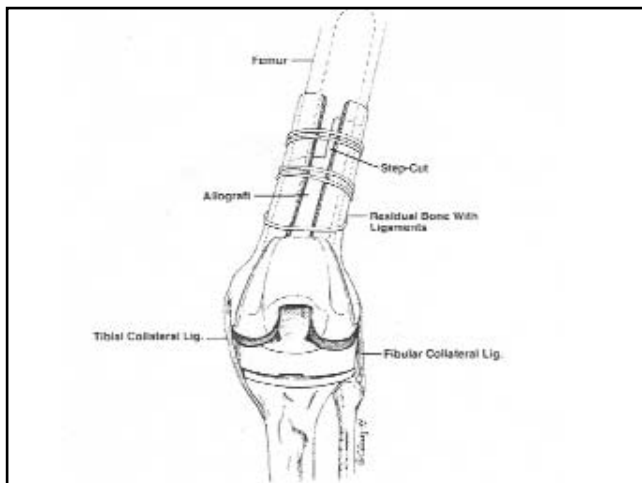


Figure 3. Distal Femoral allograft- Implant construct with wrap around of native bone with collateral Ligaments. (Figure reproduced with permission by JBJS (Am) from Clatworthy MG, Ballance J, Brick GW, Chandler HP, Gross AE, The use of structural allograft for uncontained defects in revision total knee arthroplasty. A minimum five-year review. J Bone Joint Surg Am. 2001 Mar; 83-A (3):404-11).

During revision arthroplasties considerable patellar bone loss may be encountered which may be due to loosening of component, osteolysis or removal of a well fixed patellar component.¹³ This extensive bone loss may preclude placement of the patellar prosthesis. There are multiple ways to deal with this problem i.e. patellar component resection arthroplasty, Patellar bone grafting and Patellectomy.

Patients with isolated patellar resection arthroplasty without revision of the femoral and tibial component are more likely to have continued pain and require reoperation compared with patients who had concomitant revision of the femoral and tibial component.¹⁴ The underlying cause of failure might be malalignment of the extensor mechanism or the femoral and tibial components. Patellar resection arthroplasty has been used as an option by various authors. This option was associated with multiple complications like patellar fracture, persistent patellofemoral pain, patellar subluxation, recurvatum deformity and extensors lag. Patellectomy performed as a part of a revision knee replacement has been associated with markedly inferior functional results as well as difficulties with weakness or delayed disruption of the extensor mechanism. Hansen¹⁴ has recently shown good clinical results and reconstitution of patellar bone stock with a new technique of patellar bone grafting.

Massive bone loss of the distal femur or proximal tibia may cause extensive damage to the knee collateral ligaments leading to instability. Therefore a constrained prosthesis might be required to provide stability in valgus -varus and anteroposterior planes. The implant options, range from the least constrained to the most constrained, including posterior stabilized, nonlinked constrained, rotating-hinge, and modular segmental replacement designs.

It is desirable to keep least degree of component constraint to decrease stresses at the implant bone interface and increase participation of the soft tissues in load sharing.¹⁶ If the flexion-extension gaps are well balanced and the collateral ligaments are competent the posterior stabilized implant can be used. However, if there is functional loss of the medial or lateral collateral ligament, inability to balance the flexion and extension spaces, or a severe valgus deformity, then constrained condylar prosthesis is necessary. It has increased width and height of the tibial post with corresponding increased depth of the femoral box. This resists valgus-varus instability, mediolateral displacement and prevents the dislocation of tibial component in knees with lax flexion gap. Constrained implants allow limited rotation so components must be placed in accurate rotational alignment.

The I-B II constrained condylar knee implant allows 2° of internal and external rotation and 1.25° of varus and valgus movement.¹⁷ The constrained condylar component alone does not constitute a requirement for the use of an intramedullary stem. Nazarian¹⁷ showed that there was no significantly increased loosening rate in unstemmed components as compared to stemmed components using unlinked constrained implants as long as there was no significant bone loss. Stemmed components were only used in knees graded as II or III by the AORI bone defect classification.

The indications for use of hinged knee prosthesis, excluding the resection of malignant neoplasms about the knee, include anteroposterior instability with a very large flexion gap, complete absence of the collateral ligaments, and complete absence of a functioning extensor mechanism.

The early (first and second generation) hinged implants^{19,20} were associated with increased complications and loosening. The third generation of hinged prosthesis²⁰ which include the S-ROM Modular, Mobile-Bearing Hinge Prosthesis and the Finn knee, incorporated few improvements in design like increased congruency at patellofemoral articulation, modular canal filling by slotted fluted stems and metaphyseal sleeves, rotating hinge that accommodates axial rotation and broad, congruent contact areas between femoral and tibial components to best distribute surface and subsurface stresses in the polyethylene. There are only a few medium term studies showing good results of hinged knee prosthesis.^{21,22}

There is general agreement that modular stemmed femoral and tibial components be used whenever there is substantial damage to the condylar surface and a graft or wedge is used. Modular stemmed femoral and tibial components tend to decrease the stresses over the graft. The stems can be cemented or uncemented. The cementless stems provide enhanced fixation by engaging the diaphyseal bone

distal to the area of metaphyseal bone loss and revision and are basically used as a canal filling stems. Jazrawi²³ reported that pressfit stems provided equivalent stability to shorter cemented stems and did not increase proximal stress shielding. Hass et al²³ reported 84% good to excellent results in at 42 months follow up. The reported failure rate with modern prosthetic designs and cementless stems is about 10%.^{25,26} In case a re revision is required the cementless stems are comparatively easier to remove compared with their cemented counterparts.

Cementless stems cause less stress shielding compared with cemented stems.²⁴ Cementless stems avoid cement interdigitation at the host allograft junction in case a massive structural allograft is used. The regular cementless stems because of their canal filling properties might create displacement of the femoral / tibial component from the desired location because of any deformity in the bone like one created by any previous osteotomy. In such a case an offset stem is useful. The incidence of pain at the end of stem in case of cementless stem is almost same as in case of cemented stem.²⁷

The proponents of the cemented stems cite advantages like easier achievement of positioning of components with narrower cemented stems obviating the need of offset stems especially when the translation or malalignment would result from canal filling stems. Another indication of using cemented stems is in osteopenic bone. Vince²⁸ noted a 23% failure rate in cementless stems used in constrained condylar knees. The problems with the cemented stems is the extreme difficulty in removing these stems once revision becomes necessary since the condylar surface of the implant blocks the access to the canal. The proximal stress shielding of cemented stems is another reason not to use them. Alternatively using short cemented stems is associated with less consistent results.²⁹ The current trend is to cement the condylar surface and use the stem in the cementless pressfit fashion.²⁴

Selective component revision can be of the Tibial Polyethylene, Tibial tray, femoral component or the patellar component. Studies³⁰ have shown that revising only the Tibial Polyethylene liner usually does not address the problem and it is only recommended in unbalanced knees with competent ligaments and equal flexion and extension gaps with well fixed components and no patellar maltracking. Babis³¹ found that isolated tibial insert exchange led to a high rate of early failure. Engh³² also found a high failure rate (27%) within five years of the isolated revision of the tibial insert and advised against isolated revision of the tibial insert if there is accelerated wear of the tibial poly with in 10 years of the primary procedure.

Not revising a well fixed femoral component can be

associated with a high wear rate of the Polyethylene due to abrasion of the femoral component leading to increased rerevision rate. Mackay³² retrospectively examined the results of two groups of patients: those treated with complete revision and those treated with tibial tray revision but retention of a well-fixed femoral component. The group with the retained femoral component had a significantly higher re-revision rate (28% compared with 7% in both component revised group). In a companion study³³, the authors attributed the high failure rate (6 /14 knees, 42%) to abrasion of the retained femoral component, which leads to continued polyethylene wear and debris and eventual osteolysis and loosening. On the contrary Cameron found satisfactory results in 98 revisions in which a well fixed femoral component was retained. Isolated revision of Patellar component is also associated with a high failure rate.

Leopold³⁴ examined results of 40 knees with Miller-Galante 1 prosthesis with cemented or uncemented metal backed Patella. They found a high 38% failure rate (15/40 knees) at a mean followup of 62 months. It was concluded from the study that elements of the implant design and component alignment contributed to the patellar component failure. On the other hand, retaining a well-positioned, stable all-polyethylene patellar component at the time of revision tibiofemoral arthroplasty can be successful, provided that the polyethylene is not sterilized in air³⁵. Manufacturing mismatch is acceptable with most contemporary designs provided that the patellar component articulates appropriately with the femoral implant.

Conclusion

The increasing number of primary total knee arthroplasties, ever expanding indications, and younger patients have led to an increased number of revision knee arthroplasties being performed today. All efforts should be made to find the cause of failure of the primary arthroplasty before embarking upon the revision procedure. The principles of a successful arthroplasty are maintenance of limb alignment, ligamentous balance, stability and range of motion. Thorough consideration should be given to the vascular supply of the skin flaps in planning skin incisions. Revision procedures may require reconstruction with stemmed, reinforced or constrained implants and variety of reconstruction materials including but not limited to bone grafts. The outcome of revision knee arthroplasty are not as good as the primary procedure. Selective revision is usually not a good option.

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