Original Article

Total Knee Replacement for Extreme Valgus Deformity: Early Outcome in six Consecutive Cases

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Abstract

Introduction: About 10%–15% of patients who present for total knee replacement (TKR) present with valgus knee deformity. Valgus angulation above 20° is regarded as severe deformity. The aim of this study is to present our initial experience of the surgical management of six consecutive cases with extreme valgus deformity, highlighting surgical techniques and level of constraint required as well as clinical outcome. **Patients and Methods:** Six consecutive patients with end-stage osteoarthritis and extreme valgus underwent TKR between 2016 and 2020. Demographic information, radiographic assessment and operative details were documented. Difficulties encountered and techniques used to achieve correction of deformity during surgery were detailed. Post-operative assessment includes Oxford Knee Score (OKS) and patient satisfaction score. **Results:** All patients were females. The mean age was 71.8 (range: 67–82). Four patients had pie-crusting release and valgus-varus constraint (VVC), one had posterior stabilised implant and one a rotating-hinge (RH) implant. Complications include one recurrent valgus instability, one partial peroneal nerve palsy treated with drop foot splint and one early post-operative infection which resolved with treatment. The mean post-operative follow-up was 14.2 months (range: 3–48 months). OKS improved from a mean pre-operative score of 18 (range: 15–21) to post-operative mean score of 44 (range: 41–46) at a mean 14.8-month follow-up. All patients rated their results as satisfactory. **Conclusion:** Our results show that satisfactory correction of deformity and balance can be achieved, but higher levels of implant constraint were required. Long-term follow-up is necessary to ensure that function remains satisfactory.

Keywords: Level IV study, levels of constraint, pie-crusting release, severe valgus, total knee replacement

Introduction

About 10%–15% of patients who present for total knee replacement (TKR) present with valgus knee deformity, of which 5% or less present with severe valgus of more than 20° as classified by Ranawat *et al*.[1]

In our environment, we occasionally see patients who present with end-stage knee osteoarthritis with valgus deformity of 35° or more. We classify these as extreme valgus deformities.

Extreme valgus knee deformity presents significant bony and soft-tissue challenges that must be properly addressed if good long-term results are to be obtained.[2] The lateral femoral condyle is invariably dysplastic and worn both distally and posteriorly. A consistent finding noted in extreme valgus deformity is a severe punch defect involving the lateral tibia condyle. This may be due to previous lateral tibia plateau fracture with secondary osteoarthritis or it may result from depression caused by the sclerotic lateral femoral condyle. This bony defect on the lateral tibia condyle causes the lateral femoral condyle to dip into it during weight-bearing, thereby exaggerating the valgus deformity and further stretching the medial collateral ligament (MCL). The lateral soft-tissue contracture in both severe and extreme valgus is almost invariably fixed. The contracted lateral soft tissues include, from anterior to posterior, the iliotibial band, lateral collateral ligament (LCL), popliteus, posterolateral corner with or without contracture of the lateral head of the gastrocnemius

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and long head of the biceps tendon. This degree of valgus deformity, particularly if accompanied by fixed flexion deformity, can lead to a significant risk of stretch injury to the common peroneal nerve (CPN) following correction of the malalignment. In addition, the MCL is incompetent with Grade II to Grade III laxity.

The extreme valgus knee therefore poses formidable challenges to successful reconstruction. Restoration of limb alignment and soft-tissue balance is essential for durable and successful TKR.[2] This involves addressing the lateral femoral condylar wear often by block augmentation. It also involves releasing the posterolateral soft tissues sufficiently as to be of equal length with the attenuated MCL to achieve equal and balanced flexion and extension gaps. The limits of elongation of lateral structures by posterolateral release may be easily reached in these extreme deformities. Furthermore, the accompanying lateral tibial condylar defect needs to be addressed to provide a stable weight-bearing surface for tibial component fixation.

We present our experience of TKR for osteoarthritis and extreme valgus deformity describing the techniques used to achieve the correction of deformity and the level of constraint required. We also present clinical and functional outcomes at short-term follow-up.

Patients and Methods

Demographic and clinical data

Between 2015 and 2020, six patients presented with end-stage knee osteoarthritis and extreme fixed valgus deformities of 35° or more. They all underwent TKR following a full informed consent. Limb alignment was assessed, and the valgus angle was measured both clinically and radiologically [Table 1]. The patellar may mal-track in severe knee valgus and patella position and tracking were fully assessed pre-operatively. Four patients had Grade II laxity of the MCL with lax ligament but with an endpoint, while the other two had Grade III laxity with no endpoint. Careful assessment and documentation of the limb's distal neurovascular status was undertaken, especially in patients with a history of low back pain.

Surgical technique

All patients underwent TKR via medial parapatellar arthrotomy. The posterior cruciate ligament was sacrificed early as we believe that this will help in balancing the flexion–extension gaps in these severe cases. The medial capsule was not elevated at all so as not to further compromise an already stretched MCL. A distal femoral cut was obtained via intramedullary alignment at 3° valgus to prevent under-correcting the deformity. The distal cut was usually limited to about 8 mm so as not to raise the joint line and to reduce the anticipated size of the extension gap. The femoral rotation was determined by completely ignoring the posterior femoral condyles as reference and preferentially using trans-epicondylar axis and Whiteside lines as reference. This was to ensure that the femoral component was not prejudiced into internal rotation. Any deficit in the distal and posterior lateral femoral condyle was addressed with planned block augmentation. Next, tibia cut was made with intramedullary alignment in five patients and extramedullary alignment in one patient. Only 6 mm tibia cut was made to reduce the size of the final flexion–extension gaps. Next, using laminar spreaders in extension, the shape of the gap and tightness of the posterolateral tissues were assessed. The posterolateral capsule was divided at the level of the tibia cut from just lateral to the midline and carried laterally using either monopolar diathermy or size 15 blade. The tight posterolateral structures including the iliotibial band were next pie crusted using a sharp 15 mm blade being careful not to plunge to avoid damaging the CPN. The posterolateral release and lengthening should be enough to achieve equal flexion and extension gaps and balance. It is necessary to have large tibial plastic inserts available as the gaps in these extreme cases were large. In three patients, between 17 mm and 20 mm, plastic inserts were required. We addressed the lateral tibia defects by use of a metaphyseal sleeve in two cases with major defects [Figures 1 and 2]. In a further three patients, we utilised screws in the tibia defect as scaffolds to reinforce the cement and support weight-bearing [Figures 3-5]. In one patient with contained defect, autograft was impacted into the defect [Figure 6]. All patellae tracked normally, and

Table 1: Demographic and clinical data on the six cases

Case number	Age (years)	Valgus angle	Technique	Tibial bone defect	Constraint	Outcome	Pre-operative OKS	Post-operative OKS
1	67	35	Pie-crusting	Metaphyseal sleeve	Posterior stabilised	2 years. satisfactory	15	**
2	72	50	Pie-crusting	Screw scaffold	VVC	4 years recurrent valgus instability	18	46
3	67	40	Pie-crusting	Screw scaffold	VVC	16 weeks. Early post-operative infection. resolved	19	41
4	75	35	Pie-crusting	Screw scaffold	VVC	20 weeks. Satisfactory	21	45
5	68	40	Pie-crusting	Metaphyseal sleeve	VVC	16 weeks. Partial peroneal nerve palsy	17	45
6	82	45	Release lateral femoral condyle	Autograft impaction	RH	16 weeks. Satisfactory	19	Subjective assessment satisfactory. Yet to come for follow-up OKS

**Patient suffers with neurodegenerative condition. VVC: Valgus-varus constraint, RH: Rotating hinge, OKS: Oxford Knee Score

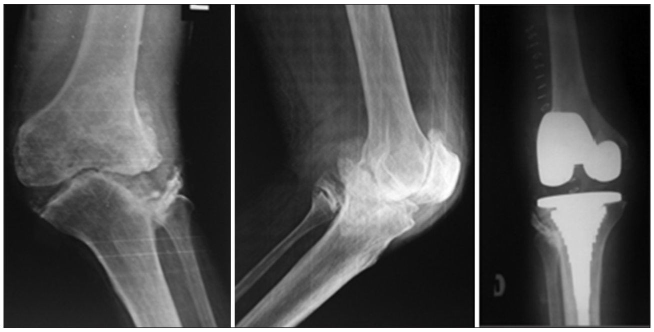

Figure 1: Case number 1

Figure 3: Case number 2

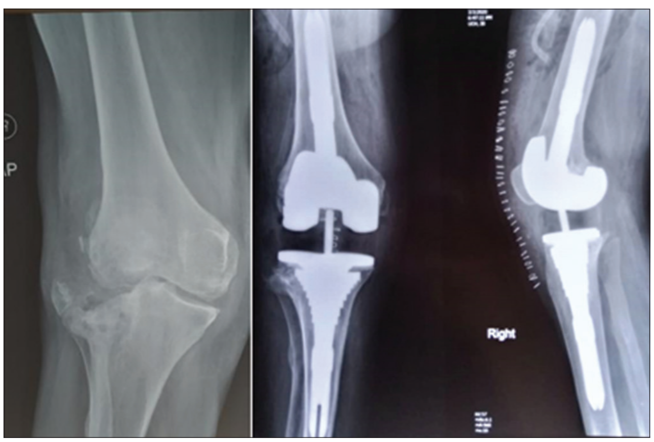

Figure 5: Case number 4

we did not need to resort to lateral retinacular release in any case. One patient had a posterior stabilised knee, with four other patients having a VVC knee implant. In one elderly patient with severe Grade III MCL laxity, we elected to release the posterolateral structures directly from the lateral femoral condyle and implanted a RH knee replacement [Figure 6]. If we use augments larger than 4 mm, we stem the implant on the side of the augment. The RH was stemmed on both the sides. In all pie-crusted knees, we released the tourniquet to ensure that there were no major bleeders that could cause skin and wound problems, and haemostasis was secured by diathermy coagulation. Implants were cemented after appropriate bone preparation. We do not routinely drain our knees. Quadriceps tendon was securely repaired, and wounds were closed in layers. Post-operative knee replacement protocol including deep vein thrombosis (DVT) prophylaxis and early full weight-bearing protocol was followed. Pre-operative and

Figure 2: Case number 5

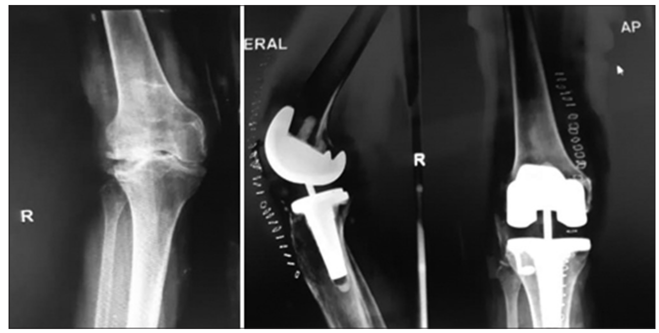

Figure 4: Case number 3

Figure 6: Case number 6

post-operative function was assessed with the Oxford Knee Score (OKS).

Results

The mean follow-up was 14.8 months (range: 4–48 months). All patients were females. The mean age was 71.8 (range: 67–82). Two patients demonstrated a valgus angle of 35°, 2 had 40°, 1 had 45° and another had 50°.

Radiographs revealed severe punch-type bone loss affecting the lateral tibia condyle in three patients (Anderson 3)[3] [Figures 1-3] and three patients with a lesser degree of bone loss (Anderson 2a) [Figures 4-6]. All radiographs revealed wear of both distal and posterior aspects of the lateral femoral condyle.

All patients had medial parapatellar arthrotomy with five having pie-crusting release of contracted posterolateral structures and one had direct subperiosteal release from the posterolateral aspect of the posterior lateral condyle. We undertook screw scaffold in three patients, metaphyseal sleeve in 2 and autograft impaction in one patient. We used posterior stabilised implant in one patient with 35° valgus and varus-valgus constraint in four patients and RH in one patient. These are summarised in Table 1.

Complications

The complications noted were in knees that were 40° valgus and above and include one partial peroneal nerve palsy and one early post-operative infection that resolved with debridement, antibiotics and implant retention. One patient developed asymptomatic recurrent valgus deformity. One patient with pre-operative valgus of 50° treated with VVC developed recurrent valgus instability with opening of the medial aspect of the knee on weight-bearing radiographic views. She does not however complain of subjective instability symptoms. All patients rated their post-operative results as satisfactory. The patient with partial peroneal nerve palsy is mobilising with a drop-foot splint.

Radiology

All cases were corrected to between 3° and 7° of valgus on post-operative X-ray. One case on the most recent follow-up has recurrent valgus instability >10°. Implants in all cases are well cemented with no evidence of loosening of the cement–bone and cement–implant interfaces. Pre-operative and post-operative X-rays of cases 1–6 [Figures 1-6] show satisfactory correction of valgus deformity and intact interfaces.

Clinical outcome

Apart from the patient with recurrent valgus instability, all patients are satisfied with their outcome and can use the knee without any problems. The dissatisfaction of the patient with radiographic recurrent valgus is from the other knee which is severely arthritic and preventing her from mobilising satisfactorily. She is awaiting the replacement of that knee. No patient has reported any subjective instability symptoms. There are no problems with getting up from sitting, getting in and out of a car or stair climbing (going up or coming down the stairs), all of which may suggest mid-flexion instability. All patients report subjective good to excellent satisfaction with their knee replacements. OKS assessment is still on-going as many of the patients are early post-operation. The mean pre-operative OKS was 18 (range: 15–21). The mean post-operative OKS was 44 (range: 41–46). One patient could not be assessed post-operatively as she suffers from a neurodegenerative condition limiting mobility, but she is pain-free.

Discussion

The outcome of TKR for valgus deformity has been noted to be worse than that for varus osteoarthritis and this remains the case when TKR for severe valgus deformity is compared with that for severe varus knee deformity.[4] This is partly due to the failure to adequately correct lower limb alignment within optimal mechanical alignment. Satisfactory lateral soft-tissue release, equal and balanced flexion–extension gaps as well as restored mechanical limb alignment have been shown to be important for durable, long-term well-functioning TKR.[2]

Decision on the type of constraint required for TKR for severe and extreme valgus knee deformity involves careful consideration of many factors. These include the age of the patient, their health and activity demands, the underlying cause of the arthritic deformity, competence of the ligaments, presence of capsular contracture, degree of bone loss and neurovascular function of the extremity.[5]

We do not feel that the posterior stabilised implant is adequate for these extreme deformities as it cannot control varus-valgus forces. Studies have shown that some soft-tissue competence is required for VVC implant to restore stability to the joint, whereas the stability of an RH knee derives from the implant itself with no reliance on the soft tissues.[6] First-generation hinges had poor results due to poor design and high interface stresses with resultant loosening and implant failure.[7] More recent hinge designs with better knee kinematics, particularly from the rotating platform, have resulted in better clinical outcomes.[8-10] There are however other papers that show complication rates for primary RH knee replacement of up to 30% with high rates of infection and loosening.[11-13] Furthermore, depending on the type of RH implant and the orientation of the hinge axle, significant bone resection may be required to accommodate the hinge mechanism. This can make both the implantation and revision of an RH implant very difficult.

There are two main incisional approaches for addressing the pathological changes in valgus deformity when undertaking TKR. Both the medial and lateral parapatellar approaches can be used to undertake the posterolateral releases needed to correct limb alignment as well as balance the flexion extension gaps. Ranawat *et al*.[1] utilising a medial parapatellar arthrotomy undertook a 3-step release of the posterolateral tissues including transverse capsulotomy of the posterolateral capsule and pie-crusting of the iliotibial band and LCL with sparing of the popliteus tendon. The recommendation was to preserve one of the lateral stabilising structures. The results achieved using the pie-crusting technique has been excellent.[1,14] Keblish[15] utilising a lateral parapatellar arthrotomy and release of the iliotibial band, lateral capsule, LCL and popliteus also achieved excellent outcomes. The lateral approach combined with tibia tubercle osteotomy to achieve wide exposure was reported by Whitesides[16] with excellent outcome and this has been replicated by others.[17] Claimed advantages and disadvantages of either approach are summarised in Table 2.

We undertook all the reconstructions using the medial parapatellar arthrotomy. It is the most commonly used approach for TKR, and therefore, an approach with which we are very familiar. It is an approach that lends itself to the indirect pie-crusting technique for release of the posterolateral soft tissues as described by Ranawat *et al*.[1] Furthermore, we felt that the controlled gradual release obtained by the pie-crusting technique was less likely to result in post-operative tibiofemoral instability. We noted that the amount of elongation of the lateral soft tissues required to adequately equalise and balance the flexion–extension gaps was substantial and

Table 2: Considerations in choice of surgical approaches in total knee replacement for valgus deformity[15]

Considerations	Approaches	
	Medial parapatellar	**Lateral parapatellar**
Technical skill required	Low	High
Familiarity with approach	Yes	No
Patella release	Not addressed by approach	Approach is a full lateral release
Patella eversion	Relatively easy	Difficult
Release of posterolateral structures	Indirect	Direct
Adequacy of release	Yes	Yes
Patella bone vascularity	Poor if additional lateral release	Not affected
Wound closure	Secure multilayered closure	Implant subcutaneous
Lateral skin numbness (saphenous nerve injury)	Yes	No

this has some consequences. First, if there is still instability, conversion to a RH knee implant should be considered. Second, thick plastic inserts of 17 mm and above may be required to adequately fill the large gaps and these should be available at surgery. Failure to plan for this will result in iatrogenic global instability from using undersized inserts. Third, as our study has borne out and as described in literature, attempts to balance the gaps in cases of severe valgus are attended with risks of complications. These include wound problems (superficial or deep infection) (4%–13%), recurrent valgus deformity (4%–38%), post-operative stiffness (1%–20%), tibiofemoral instability (2%–70%), patellar osteonecrosis (1%–12%), patella mal-tracking (2%–10%) and CPN palsy (1%–4%).[18-23]

In our small series of cases, soft-tissue releases and use of VVC implant were satisfactory for deformities up to about 35° valgus. Releases needed to balance a 40° valgus deformity resulted in higher complication rates including one partial CPN palsy and one early prosthetic infection. Beyond 40° valgus, a varus-valgus knee failed with recurrent valgus instability in one case, and in the other case, we elected to use an RH knee. The limits of soft-tissue release and varus-valgus constrained implant in our series appeared to be between 35° and 40° valgus deformity.

Cadaveric studies by Bruzzone *et al*.[22] showed that the CPN was at the highest risk of injury during release of the posterolateral capsule. Our recommendation is to fully tension the posterolateral soft tissues with laminar spreader and use a monopolar diathermy or size 15 scalpel to carefully divide the tight posterolateral capsule only without going beyond 5 mm depth into the posterior tissues. Pie-crusting of the more lateral iliotibial band and LCL is relatively safe with low risk of CPN palsy.[22]

In all the cases where we used VVC implant, we could obtain equal and balanced quadrilateral flexion and extension gaps and restored mechanical limb alignment as confirmed by intraoperative assessment. We felt that particularly in the younger patients with higher activity demands and partial competence of the MCL, VVC implant with lesser constraint than a hinge was preferable. This was found to be the case only if the requirements of balanced and equal flexion-extension gaps and corrected limb mechanical alignment were fulfilled. It was less complicated to implant and was associated with less complications at both early and mid-term follow-up.[11-13]

Severe tibia bone defects noted in this series were dealt with using metaphyseal sleeve, a technique that has been shown to be effective for major bone defects at mid-term follow-up.[24] For smaller defects, we used screw and cement scaffold for uncontained defects[25] and bone autograft for contained defects.[26] If the bone defect on either the tibia or femoral condyle is enough to compromise collateral attachment, consideration should be given to an RH implant.

The early post-operative wound infection we experienced resolved following debridement, antibiotics, irrigation and implant retention,[27] with full resolution of infection and recovery of function. Prosthetic joint infection is the most common complication following use of either type of constrained implant but appears to be more frequent with RH implant use. Risk factors include premorbid medical problems, surgery involving extensive tissue releases with an attendant risk of hematoma, the often-long duration of surgery and the technical difficulty of placing large complex implants. Paying attention to good aseptic precautions is important. A full understanding of the technical details in the use of these complex implants can result in expeditious reconstruction with consequent reduced risk of prosthetic infection.

The patient who developed partial peroneal nerve injury has a drop foot splint and is mobilising satisfactorily and is being monitored for recovery of nerve function. The patient with recurrent valgus deformity will likely require revision to an RH replacement if symptomatic. This case was done before RH knee implant became available to us. It would probably have required a primary RH knee replacement from the outset given the severity of the deformity, the presence of windswept deformity which can impose valgus strain on the reconstruction and the presence of significant bony tibia defect.

We undertook direct release of the posterolateral structures from the lateral and posterior femoral condyle and implanted an RH knee replacement in the 82-year-old lady (case 6). The age of the patient, the severity of the valgus deformity and the severe incompetence of the MCL were all factors that contributed to this decision. The soft-tissue release from the lateral condyle is much easier as it is more direct and less risky when compared to the pie-crusting technique. It is only undertaken when an RH knee replacement is planned.

All patients continue to undergo regular follow-up clinical and functional assessments as per our hospital arthroplasty protocol.

Conclusion

This study shows that satisfactory restoration of lower limb alignment and knee balance can be achieved, but higher levels of constraint and various techniques to address the associated bone loss were required. It may be associated with high peri-operative complications. This is a short-term follow-up study and long-term follow-up is necessary to ensure that there is no recurrent deformity and functional outcomes remain satisfactory.

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Conflicts of interest

There are no conflicts of interest.

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