International Journal of Research in Orthopaedics
Jaju RG et al. Int J Res Orthop. 2018 Mar;4(2):254-260
http://www.ijoro.org

Original Research Article

DOI: http://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20180512

Sequential two stage release for genu valgum correction in total knee replacement

Rahul Gopikishan Jaju[1], Ansari Muqtadeer Abdul Aziz[2]*, Mahesh R. Kade[3], Sharad K. Salokhe[4]

[1]Assistant Professor, [2]Associate Professor, [4]Resident Doctor, Department of Orthopaedics, Government Medical College, Aurangabad, Maharashtra, India
[3]Aastha Accident Hospital, Parbhani, Maharashtra, India

Received: 25 January 2018
Revised: 14 February 2018
Accepted: 15 February 2018

***Correspondence:**
Dr. Ansari Muqtadeer Abdul Aziz,
E-mail: mukkuortho@gmail.com

ABSTRACT

Background: Valgus deformity presents a major challenge in total knee replacement, especially in moderate or severe cases. Many surgical techniques have been described to balance the soft tissues in correction of a severe valgus deformity during total knee replacement. The structures most commonly released in a valgus knee include the posterolateral aspect of the capsule, iliotibial band (IT band), the lateral collateral ligament (LCL), the popliteus tendon, and the lateral head of the gastrocnemius muscle.
Methods: thirty two patients undergoing unilateral total knee replacement were followed for the evaluation of study. There were 22 female (68%) and 10 males (32%) with an age of 62.7±6.9 years (range 50-75) with valgus deformity of 18.59˚±8.32˚ (range 10-40˚). Preoperative diagnosis was rheumatoid arthritis in 23 patients (72%) and osteoarthritis in 9 patients (28%). Posterior stabilizing cemented implants were used.
Results: Based on total knee score we achieved 21 (63.64%) excellent, 10 (31.82%) good and 1 (4%) fair results. With the total functional score we had 16 (50%) excellent, 15 (45.45%) good and 1 (4%) fair results. In patients with only step1 release (17 patients) we achieved 84% (15 pts) excellent, 8% (1 pt) good, 8% (1 pt) fair with knee score; and 67% (11pts) excellent, 33% (6pts) good with functional score. In step 2 release group (15 pt) we achieved 10% (1 pt) excellent, 90% (14 pts) good with knee score; and 10% (1pt) excellent, 80% (13 pts) good and 10% (1 pt) fair with functional score.
Conclusions: Good to excellent results can be achieved with two step sequential lateral release of posterolateral capsule and IT band pie-crusting which has direct correlation with severity of valgus deformity. The safety, simplicity, and high success rate of the two step sequential lateral release of posterolateral capsule and pie-crusting of IT band justify its routine use to correct every valgus deformity in total knee replacement.

Keywords: Total knee replacement, Lateral release, Valgus deformity, PL capsule, IT band

INTRODUCTION

Valgus deformity presents a major challenge in total knee replacement, especially in moderate or severe cases**.** Valgus deformity is rare in knee arthritis with only 10-15% patients' requiring knee replacement presents with this deformity.[1] There are various causes of valgus deformity of knee like rheumatoid arthritis osteoarthritis, post-traumatic arthritis, or metabolic bone disease.[2] This deformity is more prevalent in females with incidence of (9:1).[3,4] Correction of the valgus deformity has associated with various technical challenges. Ligament balancing and bony changes of the valgus knee may be more difficult to correct than with varus deformity.[4-7] The

valgus deformity correction and normal anatomic alignment restoration should be achieved to maximize the durability of the prosthesis.[2]

Many surgical techniques have been described to balance the soft tissues in correction of a severe valgus deformity during total knee replacement.[1-3,5-22] The structures most commonly released in a valgus knee include the posterolateral aspect of the capsule, iliotibial band(IT band), the lateral collateral ligament(LCL), the popliteus tendon, and the lateral head of the gastrocnemius muscle.[2,7,13,23,24] Lateral parapatellar arthrotomy approach was first described by keblish, later various authors suggested this approach with good to excellent results.[3,8,9,19,,22] The lateral approach was direct approach and more anatomical however more technically demanding.[3,8,9,22] Insall et al described standard medial parapatellar arthrotomy and soft-tissue balancing technique, later various authors recommended this approach with the release of iliotibial band, popliteus, lateral collateral ligament, and lateral head of the gastrocnemius to correct the deformity but these techniques were quite extensive.[510,24,25] In 1984, Ranawat suggested that such extensive soft tissue releases could result in unacceptably high rate of instability and described a limited pie-crusting (multiple puncture) technique of tight lateral structures to deal with correction of valgus deformity.[6] Miyasaka et al, elkus et al and aglietti et al recommended this pie crusting technique as the technique of choice for correction of valgus deformity with good to excellent result without requirement of additional osteotomy.[13,15,23] The "pie-crusting" multiple-puncture technique is routinely being used in various surgeries like cosmetic skin grafting, head and neck surgeries and ligament balancing in total knee replacement.[26,27] It has the benefit of gradual release of the tight structures under maximal extension space distraction using distracter until balanced gap is achieved.[15] This technique is reproducible and is less technically demanding than many other procedures, such as a less familiar lateral approach or medial soft-tissue imbrication.[13] however limited literature is available on the topic and consensus on the extent of release and its correlation with preoperative deformity is yet to be reached.

This prospective study uses a two step sequential release of posterolateral capsule and iliotibial band (IT band) to correct the genu valgus deformities. The results along with difference in characteristics of patients requiring the two steps are studied to better define the indications.

METHODS

The present study was prospective study conducted between January 2007 to December 2010 at Sancheti Hospital Pune. During this period total forty five valgus knees were operated and were screened with inclusion and exclusion criteria. Patients having valgus (≥10º) deformity of knee with Krackow's types I, II undergoing total knee replacement were included and patients who were previously operated for high tibial osteotomy and Krackow type III valgus deformity of knee were excluded from the study.[25] Total 10 valgus knees were excluded from the present study because of valgus angle <10 degree (n=7) and severe preoperative instability requiring constrained prosthesis (n=3). Three patients were lost to follow up. Remaining thirty two patients undergoing unilateral total knee replacement were followed for the evaluation of study. There were 22 female (68%) and 10 males (32%) with an age of 62.7±6.9 years (range 50-75) with valgus deformity of 18.59˚±8.32˚ (range 10-40˚). Preoperative diagnosis was rheumatoid arthritis in 23 patients (72%) and osteoarthritis in 9 patients (28%). Posterior stabilizing cemented implants (Indus, PFC sigma, Nexgen Zimmer, RPF) were used and resurfacing of patella was done in all.[25,28]

Surgical technique

Spinal and epidural anesthesia were given to patients. Standard medial parapatellar approach were used with vertical midline incision and posterior cruciate ligament was resected, the distal femoral cut was taken in 3° of valgus in relation to the anatomical axis of femur as compared to the typical 5° to 7° of valgus used for a varus knee. Knee was then flexed and proximal tibial surface was cut at 90° to its long axis, after the proximal tibial and distal femoral bone cuts were made, the knee was extended and was distracted with a distracter, bringing the lateral structures under tension. Then electrocautery was used to release tight soft-tissue capsular structures in the lateral compartment intra-articularly. The release was performed transversely, from the lateral portion of the resected posterior cruciate ligament to the posterior margin of the iliotibial band, to create a balanced extension gap (step 1). Electrocautery was used to avoid injury to the peroneal nerve. Both medial and lateral soft-tissue sleeves should have an equal gap and 2 to 3 mm opening when a valgus or varus stress is applied with a spacer block in place.

If there remained unbalance in extension gap after the intra-articular release, the iliotibial band was lengthened in a controlled manner as necessary from inside with use of pie-crusting technique (step 2), which consists of multiple stab incisions 1 cm above the joint line.[13] Extension gap is again checked using distracter and stab incision made. This process continued until a balanced extension gap had been achieved. Then balancing in flexion gap was assessed. No soft tissue releases were performed with the knee in flexion; rather, antero-posterior chamfer femoral bone cuts were made adjusting them to attain the correct soft-tissue balance in flexion with verification that the tibial cut was in fact 90° to the long axis of the tibia and that the soft tissues were balanced in extension. None of the patients required release of lateral collateral ligament, popliteus tendon or lateral head of gastrocnemius for balancing. Seven

patients required screw augmentation for placement of tibial components because of bony loss.

Seventeen patients required release of posterolateral capsule (step 1) and fifteen patients required release of both posterolateral capsule and pie-crusting of IT band (step 2).

Method of evaluation

Preoperatively, each valgus knee was evaluated for degree of alignment, flexion contracture, and ligamentous instability. Preoperative radiographic analysis included scanogram of lower limbs, standing anteroposterior, lateral, and skyline views of the affected knee as well as an anteroposterior view of the pelvis. The Knee Society clinical and functional scoring system was used for preoperative and postoperative evaluation, with a slight modification of the knee alignment scoring.[13,23] With the Knee Society score, points are deducted when the anatomic alignment of the knee is <5° or >10° of valgus. However, we aimed to obtain an alignment of 3° to 5°, the scoring system was modified so that deductions were made for an alignment of <2° or >7° of valgus. Clinical and functional scores of more than 85 points were categorized as excellent; 70 to 84 points, as good; 60 to 69 points, as fair; and <60 points, as poor.

Statistical analysis

Paired T test, Mann Whitney, Wilcoxon signed rank test and Pearson correlation test were used for statistical analysis of study.

RESULTS

Thirty two patients were followed for period of 23±10.81 months (range, 13-36 month) with clinical and radiological evaluation. Nineteen patients (59%) had preoperative knee valgus deformity <20˚ and thirteen patients (41%) had valgus deformity ≥20˚. Two patients had windswept deformity. The mean preoperative pain score was 13.63±4.92 (range, 10-20) points, which improved to 41.81±3.63 (range, 30-45) points at the end of the final follow up. The mean preoperative range of motion were 93˚±15.01˚ (range, 70-130), which improved to 112.05°±10.87˚ (range, 95-130) at final follow up (Figure 1). The mean score for walking ability improved from 16.36±6.58 (range, 10-30) points preoperatively to 45±5.12 (range, 40-50) points at final follow up. The score for stair-climbing improved from a mean of 20.45±7.39 (range, 15-30) points preoperatively to 39.54±3.75 (range, 30-50) points at final follow up. The total knee score improved from a mean of 35.9±8.54 (range, 19-53) points preoperatively to 86.27±4.26 (range, 62-94) points at final follow up (Figure 2). The functional score improved from a mean of 30.68±11.78 (range, 15-45) points preoperatively to 82.72±8.55 (range, 65-100) points at final follow up p<0.05 (Figure 3). The mean preoperative valgus deformity was 18.59°±8.32˚ (range, 10-40), which was corrected to 3.66°±0.91˚ (range, -5 to5) at the time of the latest follow-up. Correction between 2° and 7° of valgus were achieved in thirty knees (94%). The mean pre-operative flexion deformity of 8.25°±4.38˚ (range, 5-20) corrected to 0.68°±1.76 (range, 0-5) at final follow up. Two patients required post-operatively slab support for 6 weeks to treat instability, but no patients required constrained prosthesis. There were no cases of late-onset instability. No cases required release of popliteus, lateral collateral ligament or lateral head of gastrocnemius or shortening of medial structures. No radiolucencies were noted adjacent to any of femoral or tibial components at the time of the latest follow-up. No tibial or femoral component was associated with osteolysis or had radiographic evidence of loosening.

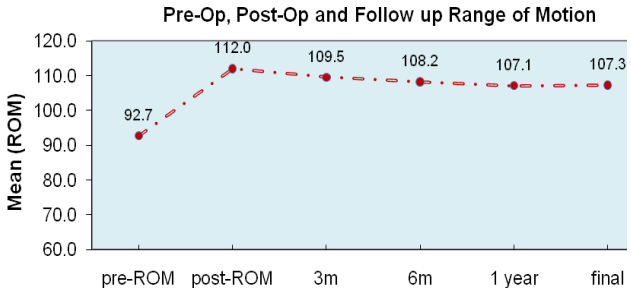

Figure 1: Graph showing improvement in range of motion (ROM).

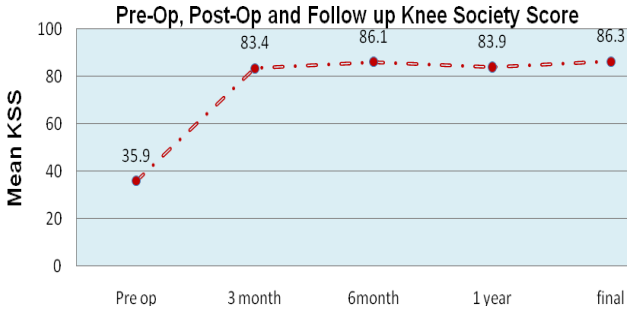

Figure 2: Graph showing improvement in knee society score.

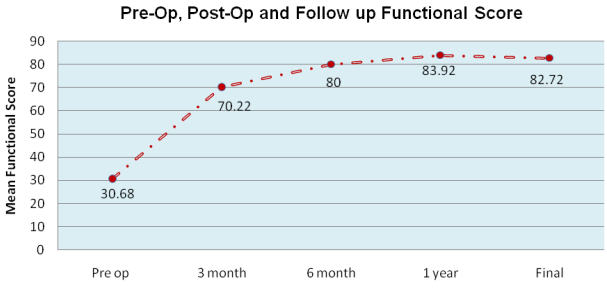

Figure 3: Graph showing improvement in functional score during follow up.

We had two complications in our study, one patient had superficial skin infection which recovered with a course

of intravenous antibiotics with slight delay in post-op rehabilitation and one patient had post-operatively varus alignment of 5 degree because of tibial bony cuts in varus and placement of tibial component in varus alignment, this patient had lowest clinical and functional score among all other patients in our study.

Based on total knee score we achieved 21 (63.64%) excellent, 10 (31.82%) good and 1(4%) fair results. With the total functional score we had 16 (50%) excellent, 15 (45.45%) good and 1 (4%) fair results. With intension to treat analysis (including the 3 drop out patients in analysis) we had 20/35 (57%) excellent, 10/35 (28%) good and 2/35 (5%) fair results with total knee score and 15/35 (44%) excellent, 14/35 (40%) good and 3/35 (8%) fair results with function score.

The patients associated with severe valgus deformity (>20˚) of knee required step 2 release for correction of deformity (p value <0.01). 89% patients (17/19) with pre-op valgus deformity of less than 20˚ required only step 1 release to correct the valgus deformity. Two patients having pre-operative valgus deformity of less than 20° required additional pie crusting of iliotibial band because of tightness in extension. Patients with pre-op valgus deformity of >20˚ had less pre-operative clinical and functional score and so less improvement in outcomes after operated with step 2 release (p<0.01). Patients operated with only step 1 release had significant improvement in knee society both clinical and functional score (p<0.01).

Case 1: 54 yr. Female patient with rheumatoid arthritis of right knee with pre-op valgus angle of 32˚operated with step 2 release.

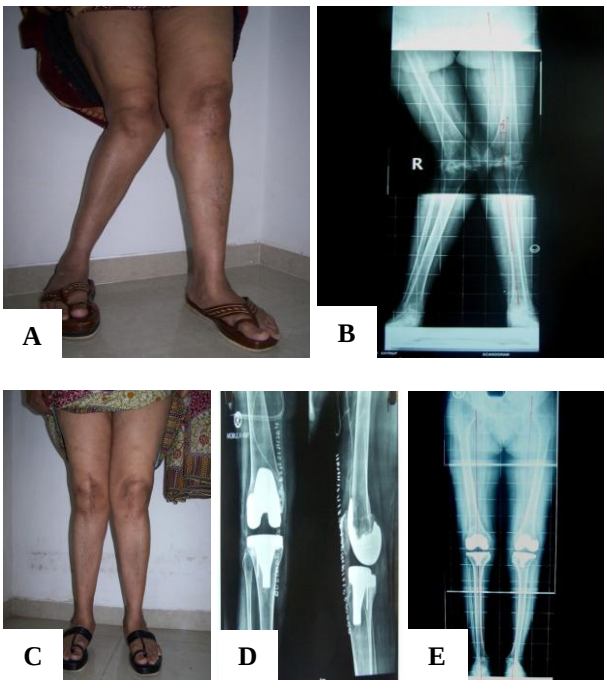

Figure 4: A and B=Pre op clinical photo and x-rays, C-E= Post-op clinical photo and x-rays.

Case 2: 72/ F patient with RA left knee and left knee Pre-op Valgus deformity of 21˚ operated with step 2 release.

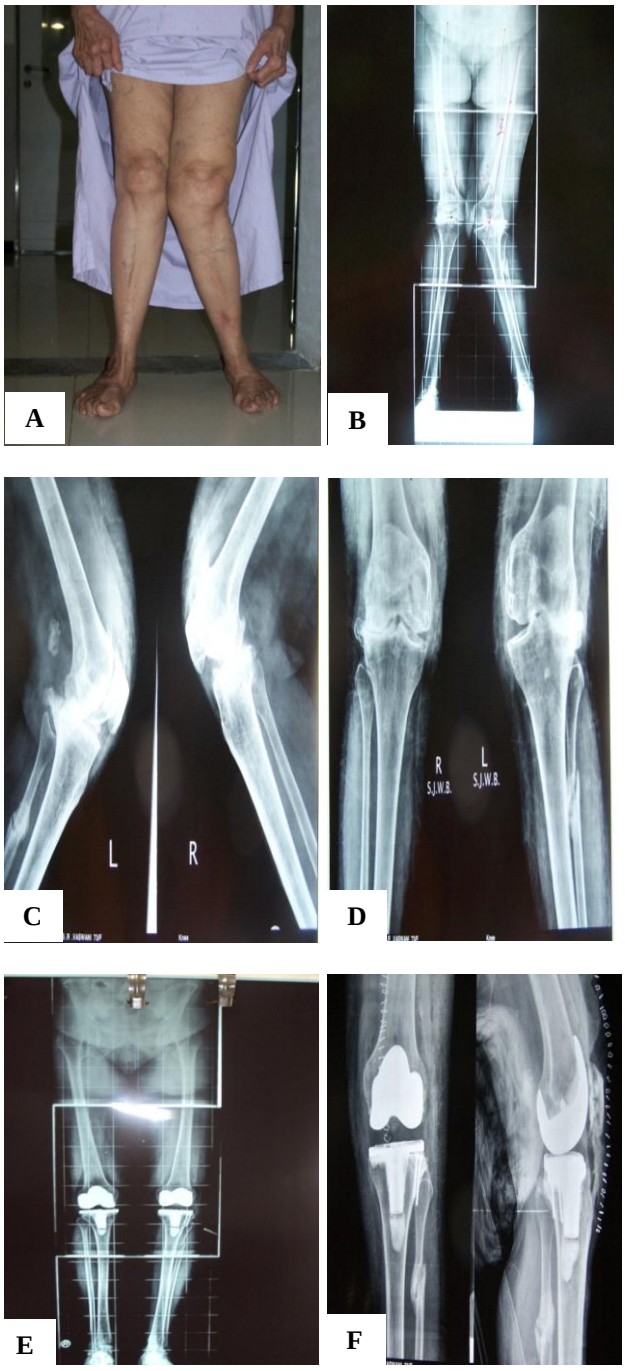

Figure 5: A-D= Pre-op clinical photo and X-rays; E and F= Postoperative x rays with correction achieved.

In patients with only step1 release (17 patients) we achieved 84% (15 pts) excellent, 8% (1 pt) good, 8% (1 pt) fair with knee score; and 67% (11pts) excellent, 33% (6 pts) good with functional score. In step 2 release group (15 pt) we achieved 10% (1 pt) excellent, 90% (14 pts) good with knee score; and 10% (1pt) excellent, 80% (13 pts) good and 10% (1 pt) fair with functional score. Final outcome of results between two groups is shown in Table 1.

Table 1: Effect of lateral release technique on outcome parameters.

Parameters		Posterolateral capsule (n=17)	Posterolateral capsule + IT Band (n=15)	P value
Age		61.91±7.7	63.7±6.1	0.559
Male : Female ratio		7 : 5	10 female	0.003
Valgus angle	Pre-op	12.58±2.07	25.08±7.11	0.000
	Post-op	3.36±0.8	4±0.94	0.220
Flexion deformity	Pre-op	7.27±3.44	9.44±5.27	0.387
	Post-op	0.41±1.44	1±2.11	0.451
ROM	Pre-op	93.33±11.15	92±19.32	0.842
	Post-op	115±10.8 (95-130)	99.5±7.2 (95-115)	0.003
Pain	Pre-op	16.67±4.92	10	0.000
	Post-op	43.3±2.5 (40-45)	40±4.1 (30-45)	0.025
Walking	Pre-op	21.66±3.89	10	0.000
	Post-op	48.3±3.9 (40-50)	41±3.2 (40-50)	0.001
Total knee score	Pre-op	41.25±6.29	29.5±6.17	0.000
	Post-op	88.8±9 (62-94)	83.3±4.1 (76-92)	0.005
Total functional score	Pre-op	38.75±7.72	21±7.75	0.000
	Post-op	87.9±6.2 (75- 100)	76.5±6.7 (65-90)	0.002

PL capsule group—knee score 84%(15 pts) excellent, 8% (1 pt) good, 8%(1 pt) fair; Function 67% (11pts) excellent, 33%(6pts) good. PL capsule + IT group—Knee score 10% (1 pt) excellent, 90% (14 pts) good; Function score 10% (1pt) excellent, 80% (13 pts) good and 10% (1 pt) fair.

DISCUSSION

The most difficult aspect of primary total knee arthroplasty in a valgus knee is achieving soft-tissue balance. Over the last twenty years, numerous approaches and soft-tissue procedures have been described for correction of soft tissues and bony abnormalities of valgus knee.[1-3,5-22] This study describes a two step soft tissue release through medial parapatellar arthrotomy for treatment of genu valgum deformity. Lateral parapatellar arthrotomy was first used by Keblish and later various authors have used this approach with good to excellent results.[3,8,9,22] They described it as a more direct and anatomical approach and the chances of patellar devascularisation is less. Boyer et al commented that IT band was automatically released by this approach and only 4/63 patients in their series required additional releases.[19] But lateral parapatellar approach is considered to be more technically demanding as orientation is reversed and anatomy is less familiar to most of surgeons' also medial patellar displacement is difficult. The standard medial parapatellar approach for valgus knee replacement also described by various authors and recommended that the iliotibial band, popliteus, lateral collateral ligament, and lateral head of the gastrocnemius and lateral aspect of capsule should be released for correction of deformity.[10,23,24] The problem with such extensive lateral release were chances of disruption of lateral genicular vessels during extensive retinacular release causing devascularisation of patella and unacceptably high rate of instability because of release of lateral collateral ligament, popliteus tendon and gastrocnemius requiring need for constrained prosthesis. Ranawat advocated that such extensive soft tissue release are not required and described the less extensive sequential pie crusting of soft-tissue.[6] This reduced chances of instability thereby reducing the need for a constrained prosthesis. This cohort was further followed up for mean 14 years by Miyasaka et al.[23] They reported 75% knees corrected between 2 -7 degree valgus with no cases of peroneal nerve palsy or patellar dislocation. However the rate of postoperative instability was still 24% with some of them requiring a revision with highly constrained component because of excessive instability. They concluded that reason for such significant instability may be soft tissue release which was performed before bony cuts and recommended bony cuts to be taken before the release. Elkus et al reported an individualised approach soft tissue release in genu valgum deformities.[13] They used inside out lateral release of posterolateral aspect of capsule and if required pie-crusting of IT band after taking distal femoral and proximal tibial cuts in 42 valgus knees with 5 to 14 yrs follow up. They reported mean modified Knee Society clinical score improved from 30 points to 93 points, and the functional score improved from 34 to 81 points. There were no cases of delayed instability but 3 patients required revision surgeries due to delayed infection, implant wear and loosening. Aglietti in 2007 reported pie-crusting of posterolateral capsule, LCL and IT band with the knee society clinical score improved from a mean 38 points 90 points and functional score improved from 43 to 82 points with 1 transient nerve palsy and 1 varus instability but in all these studies there were no consensus regarding extent of lateral soft tissue release with severity of valgus deformity.[15]

The present study used the two step sequential lateral release of posterolateral aspect of capsule and additional pie-crusting of IT band to correct valgus deformity. The results show that only step 1 release (release of posterolateral aspect of capsule) successfully corrected preoperative valgus deformity of less than 20° and step 2 release (release of posterolateral aspect of capsule along with pie crusting of IT band) required for patients who had preoperative valgus deformity of ≥20°. Seventeen patients required step 1 release and fifteen patients required step 2 release. None required additional release thus no cases of late onset instability. Postoperative analysis of the cohorts of both steps of release revealed certain characteristics of both groups, all the patients requiring only capsular release had valgus deformity <20˚ (mean 12.58˚±2.07). These patients had better preoperative pain score, walking score, knee score and function score compared to patients who required release of both posterolateral capsule and IT band pie crusting. The pre-operative ranges of motion were similar in both these groups but patients with step I release had better post-operative range of motion. This may be due to more extensive release and subsequent fibrosis in step 2 release group. Patients operated with step 1 release had significant better results in terms of pain score, walking score, knee score and function score. This data can help in judging the treatment and also progress.

Patients with pre-op valgus deformity of <20˚ will require only step 1 release and there will be better postoperative outcomes and patients with preoperative valgus deformity >20˚ will require step 2 release and postoperative clinical and functional outcomes will be relative low. The most commonly reported complications in patients with valgus deformities in total knee replacement are tibiofemoral instability (2% to 70%), recurrent valgus deformity (4% to 38%), postoperative motion deficits requiring manipulation (1% to 20%), wound problems (4% to 13%), patellar stress fracture or osteonecrosis (1% to 12%), patellar tracking problems (2% to 10%).[2,23,25] Peroneal nerve palsy has been reported as potential complication in knee replacement with valgus deformity with 3% to 4% reported rate, Clearke et al in 2004 reported that there is direct anatomic risk of peroneal nerve injury during pie-crusting technique of lateral release and it should be performed carefully but there were no peroneal nerve palsy, no instability or patellar stress fracture in our study.[29] But longer follow up will be required for assessment of these complications.

Soft tissue balancing in valgus knee during total knee replacement along with correction of deformity can be effectively corrected by sequential two step lateral release of posterolateral aspect of capsule (step 1) and along with pie crusting of IT band (step 2) depending upon preoperative valgus deformity of knees with excellent results and minimal complications. This two step release is less technically demanding compared to lateral parapatellar approach and other extensive release. For severe valgus deformity which is uncorrected with this two step lateral release usually requires constrained prosthesis.

CONCLUSION

Good to excellent results can be achieved with two step sequential lateral release of posterolateral capsule and IT band pie-crusting which has direct correlation with severity of valgus deformity. Patients having pre-operative valgus angle of less than 20˚ can be effectively treated with step 1 release but >20˚ will require step 2 release. The inferior result step 2 release group compared to only step 1 group could be explained to less pre-operative knee clinical and function score in previous group. The multiple punctures allow gradual stretching of the lateral soft tissues and preservation of the popliteus tendon reducing the risk of posterolateral instability. The safety, simplicity, and high success rate of the two step sequential lateral release of posterolateral capsule and pie-crusting of IT band justify its routine use to correct every valgus deformity in total knee replacement.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Ranawat AS, Ranawat CS, Elkus M, Rasquinha VJ, Rossi R, Babhulkar S. Total knee arthroplasty for severe valgus deformity. J Bone Joint Surg Am. 2005;87(Suppl 1)(Pt 2):271-84.
2. Favorito PJ, Mihalko WM, Krackow KA. Total knee arthroplasty in valgus knee. J Am Acad Orthop Surg. 2002 ;10(1):16-24.
3. Keblish PA. Valgus deformity in TKR: The lateral retinacular approach. Orthop Trans 1985;9-28.
4. Keblish PA. The lateral approach to the valgus knee: Surgical technique and analysis of 53 cases with over two-year follow-up evaluation. Clin Orthop 1991;271:52-62.
5. Insall J, Scott WN, Ranawat CS. The total condylar knee prosthesis. A report of two hundred and twenty cases. J Bone Joint Surg Am. 1979;61(2):173-80.
6. Ranawat CS, Rose HA, Rich DS. Total condylar knee arthroplasty for valgus and combined valgus-flexion deformity of the knee. Instr Course Lect. 1984;33:412-6.
7. Karachalios T, Sarangi PP, Newman JH. Severe varus and valgus deformities treated by total knee arthroplasty. J Bone Joint Surg Br. 1994;76(6):938-42.
8. Buechel FF. A sequential three-step lateral release for correcting fixed valgus knee deformities during total knee arthroplasty. Clin Orthop Relat Res. 1990;(260):170-5.
9. Fiddian NJ, Blakeway C, Kumar A. Replacement arthroplasty of the valgus knee. A modified lateral capsular approach with repositioning of vastus lateralis. J Bone Joint Surg Br. 1998;80: 859 -61.

10. Healy WL, Lorio R, Lemos DW. Medial reconstruction during total knee arthroplasty for severe valgus deformity. Clin Orthop.1998;356:161-9.
11. Peters CL, Mohr RA, Bachus KN. Primary total knee arthroplasty in the valgus knee: Creating a balanced soft tissue envelope. J Arthroplasty. 2001;16:721–9.
12. Politi J, Scott R. Balancing severe valgus deformity in total knee arthroplasty using a lateral cruciform retinacular release. J Arthroplasty. 2004;19(5):553-7.
13. Elkus M, Ranawat CS, Rasquinha VJ, Babhulkar S, Rossi R, Ranawat AS. Total knee arthroplasty for severe valgus deformity. Five to fourteen-year follow-up. J Bone Joint Surg Am. 2004;86-A(12):2671-6.
14. Stehlík J, Musil D, Held M, Stárek M. Z-plasty for valgus deformity in total knee arthroplasty [Article in Czech] Acta Chir Orthop Traumatol Cech. 2006;73(3):169-75.
15. Aglietti P, Lup D, Cuomo P, Baldini A, De Luca L. Total knee arthroplasty using a pie-crusting technique for valgus deformity. Clin Orthop Relat Res. 2007;464:73-7.
16. Hadjicostas PT, Soucacos PN, Thielemann FW. Computer-assisted osteotomy of the lateral femoral condyle with non-constrained total knee replacement in severe valgus knees. J Bone Joint Surg Br. 2008;90(11):1441-5.
17. Lüring C, Beckmann J, Haiböck P, Perlick L, Grifka J, Tingart M. Minimal invasive and computer assisted total knee replacement compared with the conventional technique: a prospective, randomised trial. Knee Surg Sports Traumatol Arthrosc. 2008;16(10):928-34.
18. Bellemans J, Vandenneucker H, Vanlauwe J. The total knee arthroplasty in valgus knee using standard medial approach, Interact Surg. 2008;3:2-5.
19. Boyer P, Boublil D, Magrino B, Massin P, Huten D. Group G. Total knee replacement in the fixed valgus deformity using a lateral approach: role of the automatic iliotibial band release for a successful balancing. Int Orthop. 2009;33(6):1577-83
20. Liu J, Sun Z, Zhang Y, Tian M, Tian Z, Wang L, Cao J, Sun Y, Wang P. Treatment of valgus deformity by total knee arthroplasty with modified Ranawat soft tissue balance technique. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2009;23(9):1034-7.
21. Koskinen E, Remes V, Paavolainen P, Harilainen A, Sandelin J, Tallroth K, et al. Results of total knee replacement with a cruciate-retaining model for severe valgus deformity-A study of 48 patients followed for an average of 9years. Knee. 2010.
22. Apostolopoulos AP, Nikolopoulos DD, Polyzois I, Nakos A, Liarokapis S, Stefanakis G, Michos IV. Total knee arthroplasty in severe valgus deformity: Interest of combining a lateral approach with a tibial tubercle osteotomy. Orthop Traumatol Surg Res. 2010.
23. Miyasaka KC, Ranawat CS, Mullaji A. 10-12 Year Followup of Total Knee arthroplasty for valgus deformities. Clin Orthop Relat Res. 1997;(345):29-37.
24. Whiteside LA. Correction of ligament and bone defects in total arthroplasty of the severely valgus knee. Clin Orthop Relat Res. 1993;(288):234-45.
25. Krackow KA, Jones MM, Teeny SM. Primary total knee arthroplasty in patientes with fixed valgus deformity. Clin Orthop. 1991;273:9-18.
26. Dunbar RP, Taitsman LA, Sangeorzan BJ, Hansen Jr. Technique tip: use of " pie crusting of the dorsal skin in severe foot injury. Foot Ankle Int. 2007;28(7):851-3.
27. Helms J. Head and Neck Surgery. Volume 3. Georg Thieme Verlag; 1998.
28. Sancheti KH, Laud NS, Bhende H, Reddy G. The INDUS knee prosthesis - Prospective multicentric trial of a posteriorly stabilized high-flex design: 2 years follow-up. IJO 2009;43:367-74.
29. Clarke HD, Schwartz JB, Math KR, Scuderi GR. Anatomic risk of peroneal nerve injury with the "pie crust" technique for valgus release in total knee arthroplasty. J Arthroplasty. 2004;19(1):40-4.

Cite this article as: Jaju RG, Aziz AMA, Kade MR, Salokhe SK. Sequential two stage release for genu valgum correction in total knee replacement. Int J Res Orthop 2018;4:254-60.