

Multiple Puncturing of Medial Collateral Ligament in Extension with Trial Implants and Valgus Stress: An Excellent Method for Coronal Plane Balancing in Severe Genu Varus

Sharath Kittanakere Ramanath¹, Rahul Hemant Shah^{2*}, Jay Palak³, Sandesh Patil² and Sarayoo Ravishankar Vaidya⁴

¹Associate Professor, Department of Orthopaedics, Ramaiah Medical College and Hospitals, Bengaluru, India

²Junior Resident, Department of Orthopaedics, Ramaiah Medical College and Hospitals, Bengaluru, India

³Arthroplasty Fellow, Department of Orthopaedics, Ramaiah Medical College and Hospitals, Bengaluru, India

⁴Intern, Department of Orthopaedics, Ramaiah Medical College and Hospitals, Bengaluru, India

***Corresponding Author:** Rahul Hemant Shah, Junior Resident, Department of Orthopaedics, Ramaiah Medical College and Hospitals, Bengaluru, India.

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Abstract

Background: Success of total knee arthroplasty (TKA) depends on lower limb alignment and soft tissue balancing. It is unusual to have higher degrees of genu varus deformity in the western countries unlike the Indian subcontinent. Here, we describe a method involving multiple puncturing of medial collateral ligament of the knee in patients with more than 20° varus.

Methods: We included 55 patients in the study (27 males and 28 females). Pre-operative varus deformity on radiographs, knee flexion and Knee Society Score (KSS) were compared with post-operative valgus, knee flexion and KSS in all the patients. Medial parapatellar approach was performed in all the patients. Puncturing of the MCL was performed after taking the bone cuts and inserting trial implants. Intra-operative stability and range of motion was checked.

Results: Minimum follow-up period was 3 years. There was a significant improvement in the deformity (from mean varus of 27.67° to mean valgus of 4.82°), range of motion (from mean flexion of 86.65° to mean flexion of 119.2°) and KSS (from mean score of 25.35 to 97.22) in all the patients. A ratio between the number of punctures to pre-operative varus (3.983) was noted. All the patients were operated using unconstrained and semi-constrained implants.

Conclusion: Multiple puncturing of the MCL is a reliable method to achieve correction and soft tissue balancing in genu varus > 20°. It helps to balance the knee in both flexion and extension so that the level of constrained can be kept to as minimum as possible.

Keywords: Total Knee Arthroplasty; Genu Varus; Osteoarthritis; Medial Collateral Ligament; Multiple Puncturing

Introduction

Correction of lower limb alignment and restoration soft tissue balance are important for the successful outcome of a total knee arthroplasty (TKA) [1]. Severe genu varus is associated with contracted medial structure and lax lateral structures which emphasizes the need for soft tissue balancing.

Osteoarthritis in severe genu varus or valgus can be corrected using fully constrained or hinged prosthesis. The advantage of these implants is that they correct the deformity and act as stabilizers for the lax knee without the need for extensive soft tissue balancing [2]. However, they are expensive and have a higher wear rate which leads to increased chances of revision arthroplasty [3].

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Pie-crusting is a well-established technique for valgus knee [1]. This technique can be used in varus knees as well. However, there is always a risk of iatrogenic transection of medial collateral ligament (MCL). Soft tissue release over the tibial insertion for varus correction is associated with overrelease and excessive medial opening [4].

Several methods have been described for correction of genu varus deformity and soft tissue balancing for arthritic knees. Here, we mention about a novel method of correcting varus deformity of more than 20° in patients with Kellgren-Lawrence grade IV osteoarthritis using multiple puncturing of taut MCL in extension while giving valgus stress to the knee. Our study aimed at measuring the correction of the deformity, increased post-operative knee flexion and post-operative patient-reported outcomes using the Knee Society Score (KSS).

Materials and Methods

This was a prospective study performed at our institution over a period of 2 years from February 2015 to February 2017. Institutional ethics committee approval was taken prior to starting the study. Patients were informed about the study and the need for sharing radiographs, intra-operative images and clinical images for research purpose. All the patients gave consent for the study.

Inclusion criteria:

1. Primary TKA
2. Varus > 20°
3. Grade IV osteoarthritis (as per Kellgren-Lawrence classification)
4. Minimum 2 years of follow-up
5. Patients with varying degrees of fixed flexion deformity of the knee.

Exclusion criteria:

1. Traumatic injury to the knee
2. Congenital lower limb deformity
3. Previous infection
4. A diagnosed case of inflammatory arthritis
5. Patients with generalized ligamentous laxity
6. Previous surgeries on the same knee.

The alignment strategy was to achieve mechanical alignment in the coronal plane. Pre-operative KSS was collected 1 week before the surgery and foci of infection were ruled out in all the cases. Pre-operative range of motion was noted in all the patients using a goniometer. Pre-operative varus was measured in all the patients using the mechanical axis of lower limb, femur and tibia in standing scannograms. This was a single surgeon, single centre study. All the patients received a posterior-stabilizing (PS) implant for TKA (Triathlon by Stryker, Sigma by DePuy) with cementation done on both, femoral and tibial sides.

All the included patients were followed up at 2 weeks, 1, 3, 6 and 12 months post-operatively following which they were followed-up annually. Standing lower limb scannograms and standard knee radiographs were taken for all the patients at every follow-up except at 2 weeks. Patient related outcome was assessed using KSS at every follow-up and KSS at the final follow-up was included in the study.

Surgical technique

Medial parapatellar arthrotomy was performed in all the cases. Patella was subluxated laterally and held by straight pointed Hohmann retractor which was positioned against the patella. We did not perform patellar eversion for exposure in any of our cases. Distal femur resection was performed at 5° valgus and 9 mm thickness from the most distal aspect. Femoral sizing was performed using posterior referencing guide and femoral preparation using four in one cutting block was performed and box cut was done. External rotation of 3° was kept as standard rotation and crosschecked if it is parallel to epicondylar axis.

Tibial resection was performed using extramedullary jig making sure it was perpendicular to mechanical axis with a 3° posterior slope. 8-10 mm from lateral non-involved plateau was resected without considering the amount of bone resection from the medial side.

Following alterations from standard surgical steps are followed for severe varus deformity:

- 1. 5 degree external rotation of femoral component:** In cases where distal femur was remodelled to internal rotation and 3° external rotation was not parallel to epicondylar axis, 5° external rotation was given for femoral component. We had to do this in 6 cases.
- 2. Figure-of four technique:** Release of MCL and posteromedial capsule up to the midline of tibia was performed which was followed by anterior subluxation, hyperflexion and external rotation of tibia using blunt central Hohmann retractor. As knee was kept in figure-of-four position, one of the assistant's hand was flexing and externally rotating the foot end of leg while another assistant subluxated the tibia anteriorly using blunt 45° Hohmann retractor placed from intercondylar notch from the box cut of femur and 90° Hohmann retractor to retract the posteromedial aspect of tibia.

At this stage, all the soft tissue from medial and posteromedial aspect up to the median aspect of tibia was released. We noticed that keeping the knee in figure-of-four and external rotation helps to release posteromedial soft tissues better than knee in extension. Although this technique has been practised by several surgeons, there is no special mention in literature. Keeping limb in this position reduction osteotomy was done by removing overhanging osteophytes using nibbler. However, final reduction osteotomy was performed with trial component of tibia.

- 3. Removal of osteophytes attached to MCL:** In long-standing cases, there is fragmentation of osteophytes from the medial tibial condyle rim (Figure 1). These osteophytes eventually get embedded in the MCL. These osteophytes were removed with a meniscal holder and removed with utmost care in order to avoid inadvertent damage to the MCL.



Figure 1: Osteophyte attached to MCL.

- 4. Multiple puncture of MCL:** Keeping trial implants in position, multiple puncture method was performed. In most cases, trial insert used initially was 8 mm polyethylene liner. While keeping the knee in extension, gentle valgus force was applied to knee. Broad right-angled retractor was used to retract skin and soft tissue to expose MCL. Using a needle holder, 16- or 18-gauge needle was used to puncture the MCL (Figure 2). We could feel a 'pop' while puncturing the most contracted part of MCL. Punctures were done perpendicular to MCL over anterior and medial aspect. The punctures were to make pores in the fibrotic areas of MCL and multiple punctures softened the ligament, and which facilitated progressive stretching.



Figure 2: Puncturing MCL.

Tibial side stem extension was used in cases where defect was more than 5 mm and more than 1/5th of tibial surface area. We used tibia side stem extender with primary unconstrained implants in 10 cases. Medial tibial wedge was used in 3 cases. In 3 cases, we used semi constrained TC3 type of implants (2 cases TC3 Depuy and 1 case Total Stabilizer Stryker) (Figure 3-5). Femoral side stem was used in 1 case. Even with the most severe type 3 varus with defect, most of the cases can be managed with unconstrained knee with or without stem/wedge/bone graft.



Figure 3: Varus instability, prominent Gerdy's tubercle.



Figure 4: Post op, semiconstrained implants.

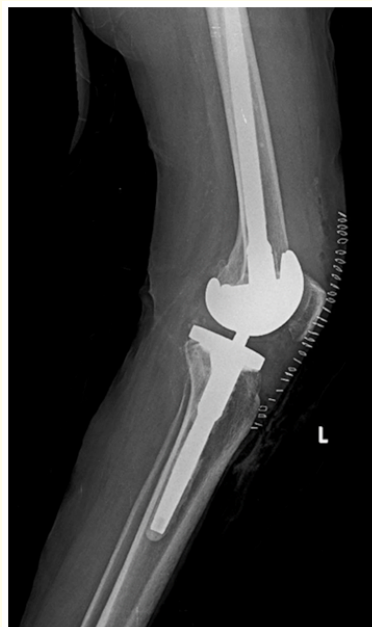


Figure 5: Lateral post op.

Statistical analysis

Data was analysed using SPSS (version 26 for Mac). One-way repeated measures ANOVA test was used to detect differences between the pre-operative and post-operative parameters. P values of less than 0.05 were considered statistically significant.

Results

Minimum follow-up period was 3 years (range of 3 - 5 years). We lost 9 patients to follow-up and eventually 55 patients were included in the study. Our study included 27 male and 28 female patients with an average age of 67.52 years (range of 63 to 75 years). Pre-operative varus ranged from 22 to 33° (average 27.67°). The follow-up period ranged from 36 months to 60 months with an average of 48.21 months. P value of the parameters using one-way repeated measures ANOVA test was found to be 0.039. Table 1 shows the comparison between the pre-operative and post-operative knee flexion, KSS and varus deformity. There was a significant improvement in all the parameters after the surgery. Lower post-op KSS was noted in patients who had greater degrees of varus compared to the other subjects in the study.

	Parameter	N	Lower Limit	Upper Limit	Mean	Standard Deviation	Standard Error of Mean
1	Pre-op Varus (°)	55	22	33	27.67	2.286	0.308
	Post-op Valgus (°)	55	2	7	4.82	1.140	0.154
2	Pre-op KSS	55	0	48	25.35	15.853	2.138
	Post-op KSS	55	83	100	97.22	4.323	0.583
3	Pre-op ROM (°)	55	74	98	86.65	5.761	0.777
	Post-op ROM (°)	55	108	126	119.24	4.562	0.615

Table 1: Comparison between the pre-op and post-op parameters.
KSS: Knee Society Score; ROM: Range of Motion.

We measured the mechanical lower limb, femur and tibia axis for all the patients at the time of follow-up. We were able to achieve valgus alignment in all the patients (range, 2 to 7° with a mean of 4.82°) (Figure 6 and 7).



Figure 6: Varus scannogram.



Figure 7: Post op scannogram.

There was a reliable ratio between the number of punctures to the pre-operative varus deformity. This was noted in all the patients irrespective of the gender, age and pre-operative flexion and varus deformity. This ratio was almost equal to 4 in all the patients (Table 2).

Group	Mean	Lower Limit (95% CI)	Upper Limit (95% CI)	Standard Deviation	Price Related Coefficient	p value	Coefficient of Variation
F	3.993	3.971	4.015	0.057	1.000	0.011	1.4%
M	3.972	3.947	3.998	0.065	1.000	0.013	1.6%
Overall	3.983	3.966	3.999	0.061	1.000	0.013	1.5%

Table 2: Ratio of number of punctures: pre-op varus.

F: Female; M: Male; CI: Confidence Interval.

We had 6 patients with varus stress fracture in proximal tibia noticed intra-operatively. We used tibial stem extension and protected weight bearing for three months. Multiple puncture technique was performed for all these patients. Medial opening was very much appreciated, and we were able to achieve adequate soft tissue balance in all these patients. We had 3 patients with severe varus upon whom we had performed unilateral TKA 6 months to 1 year before we started this study. For the opposite side all three patients we performed multiple puncturing.

Our indication of semi constrained type of implants is when Gerdy’s tubercle is palpable clinically as a bony prominence when varus stress is applied to knee suggesting complete loss of ITB and LCL function. Fully constrained type of implants/hinged knee is almost not required in varus deformity any severity.

Discussion

Severe genu varus is a common occurrence in developing countries like India unlike that seen in the more developed western countries. Factors such as ignorance, apprehension, cost and alternative treatments are responsible for majority of the patients presenting at a later stage. In India especially, many patients opt for surgery after they develop varus stress fracture.

Osteoarthritis with severe genu varus is usually associated with fixed flexion deformity and remodelling of distal femur and proximal tibia. Medial epicondylar osteotomy has the advantage of correcting varus and fixed flexion deformity. This was noted in a study conducted by Mirzatoioei, *et al.* [5] on 14 female patients with bilateral knee osteoarthritis. They performed medial epicondylar osteotomy for one knee and extensive medial soft tissue release for the other knee. The mean varus for the osteotomy group was 22.6 +/- 1.7 degrees and for the soft tissue release group was 21.6 +/- 4.7 degrees. There was no statistically significant difference in the post-operative range of motion, Oxford and WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) scores amongst both the groups. However, an epicondylar osteotomy has a risk of non-union which was noted in one of their patients and this requires non-weight bearing ambulation. This is of particular concern especially in the old osteoporotic patients. Since, all our patients were above the age of 60, an osteotomy would be a risky option as the bone quality in these patients was poor which would preclude non-union and in turn have an effect on the post-operative outcome.

Severe genu varus and valgus with arthritis can be managed surgically by performing a TKA using rotating hinge knee (RHK) implants. RHK implants offer the greatest stability in lax knees and have the significant advantage of correcting the deformity without the need for extensive soft tissue releases [2]. However, these implants are more expensive than the unconstrained or semi-constrained implants and they have a higher rate of loosening which mandates a revision arthroplasty.

Engh [6] published a paper in 2003 mentioning the surgical technique for correction of severe genu varus and valgus. He mentioned that dividing the superficial and deep MCL helps to correct severe varus. However, he stated that the posterior oblique ligament and posterior capsule need to be preserved in these cases. Engh mentioned the possibility of excessive medial opening as a result of overrelease of the superficial and deep MCL. A more recent study conducted by Athwal, *et al.* [7] confirmed that superficial MCL is the primary medial soft tissue stabilizer of the knee in valgus rotation. Their study also confirmed that using a PS TKA increased the load on superficial MCL during valgus load resistance as compared to a cruciate retaining TKA prosthesis. This could lead to early failure warranting a revision arthroplasty. We followed the recommendations of Athwal, *et al.* since all our patients received a PS TKA prosthesis. We performed multiple punctures over the tautest fibre of the MCL and simultaneously gave a valgus stress to access for excessive medial opening and we avoided a subperiosteal release in all our cases. Amundsen, *et al.* [8] performed a cadaveric study on 13 knees. They did intra-operative knee cycling during MCL release to check for inadvertent opening. Their hypothesis was that it is difficult to judge the degree of release without performing cycling and it may lead to excessive MCL elongation. We followed their principles and performed knee cycling after every 10 punctures over the tightest fibres of MCL. None of our cases showed excessive medial opening.

Needle puncture of the MCL in extension has been shown to affect the final flexion and extension gaps equally and has a lower likelihood of over-release than performing needle puncture in flexion. This was first mentioned by Koh, *et al* [9]. A cadaveric study [10] published in 2017 concluded that needle puncture of the MCL in complete extension is a safe and reliable method to achieve medial release and correct the alignment. The study used pressure sensor inserts and mechanical calipers to measure the pressure and distance in the medial compartment. Although accurate, the regular use of such devices is not practically possible in centres of higher volume along with the added cost. This study used cruciate retaining (CR) prostheses unlike our study. Certain studies have shown that CR prostheses are associated with a limited increase in the range of flexion as compared to PS prosthesis [11]. This emphasized on the importance of using PS prostheses in our study for majority of our patients had a fixed flexion deformity of the arthritic knee. Intra-operative soft tissue balancing is more critical while using CR prosthesis as compared to a PS prosthesis. This makes correction of a severe varus knee all the more challenging while using a CR prosthesis.

Ha., *et al.* [12] retrospectively analysed 729 primary TKAs wherein pie-crusting of MCL was performed in extension for medial tightness. However, none of the cases in their study has a varus deformity of more than 15 degrees and pie-crusting was done using No. 11 blade. Although their study concluded that using a No. 11 blade had a reliable opening, there have been cases of excessive opening when using a blade with subsequent instability [13,14]. Hand control of exact release of 5 mm width using No. 11 blade and making equidistant cuts and to observe progressive lengthening of MCL is a difficult exercise. Perpendicular knife as has been advised also doesn't confirm the exact release as described in literature. The chances of iatrogenic MCL damage is very high with the use of blade knife. Using either a 16- or 18-gauge needle is always the better option as it gives a more reliable opening and tension release [8].

Laminar spreader may be used as it helps in medial opening [12] and assessing proper release through improved visualization. However, laminar spreader itself may cause inadvertent damage over the articular surfaces. This is of particular concern especially in osteoporotic bones. We avoided this possible complication by having an assistant give a valgus force to the knee without compromising on the view over the operative area.

The unique aspect of this study was the ratio noted between the number of punctures over the MCL to the pre-operative varus deformity. To the best of our knowledge, this ratio has not been mentioned in literature before. It helps us to predict the number of punctures that may be required to achieve adequate soft tissue release. This was however done with intermittent knee cycling. The ratio was replicable in all the patients irrespective of all the pre-operative parameters suggesting its reliability.

Pie-crusting of lateral structures is a very well accepted method in dealing with valgus deformity balancing. In valgus deformity, there are multiple structures on the lateral aspect for which sequential release is described and being followed universally. Multiple structures are present over the lateral and posterolateral aspect like ITB, popliteus and posterolateral capsule. These structures form a broad surface area unlike MCL which in comparison is thinner. Damage to part of lateral structures during pie-crusting may not create as much as instability to knee so much as damage to MCL during puncturing.

The limitation of our study is that we did not use calipers to measure the medial opening after performing multiple punctures. It was more of an estimation-based technique which may not be completely reliable for the inexperienced surgeon. Another limitation in our study is the fact that the sample size was small, so, it is difficult to extrapolate it to a larger population. We also did not compare our study with other methods of soft tissue release in order to prove which method was more efficacious.

Conclusion

We conclude that multiple puncturing of the MCL is a reliable method of soft tissue balancing for severe genu varus although this has to be done with great precision in order to avoid inadvertent release and excessive medial opening leading to subsequent instability.

Conflict of Interest

None.

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