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Original Research Article

Clinical and radiological outcome of medial proximal tibial vertical (reduction) osteotomy in primary total knee arthroplasty for severe varus deformity of the knee

Prashant Ramesh Agrawal[1], RahulKumar Y Mishra[1], Yash Manish Mehta[1]*, Amey Mahesh Borse[1], Akash Singh Jadon[1]

[1]*Apollo Hospitals, Navi Mumbai, Maharashtra, India*

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ABSTRACT

Background: To obtain balanced knee with severe varus deformity, release of contracted tissues and removal of osteophytes is necessary. MCL release is essential step towards achievement of ligament balancing during total knee arthroplasty (TKA) with varus deformity. This led to over-release of the superficial MCL, hematoma formation, knee joint line elevation and instability. To overcome these, method of bone resection of medial proximal tibia (MPT) with minimal medial soft tissue release called reduction osteotomy (RO). Our study aims to evaluate clinical, radiological benefits of RO over progressive medial soft tissue release during a primary TKA with severe varus deformity, and quantification of method of bone resection of MPT for achieving soft tissue balancing in TKA.

Materials and Methods: This study was conducted at Apollo Hospitals, Navi Mumbai included 24 patients having osteoarthritis with varus deformities more than 10 degrees. All necessary blood investigations with X-ray knee AP(standing), lateral view, scanogram were done and clinically, OKS(Oxford Knee Score) and KSS (Knee Society Score) were assessed pre-operatively & post-operatively. Patients were followed up at 3 months.

Results: There was significant improvement in OKS and KSS at 3 months. For each unit of medial gap deficit, there was corresponding 2.14 units of Proximal tibia vertical osteotomy thickness. For each unit change of Pre-op varus angle, there was a corresponding 0.38 units of Proximal tibia vertical osteotomy thickness.

Conclusion: This prospective RCT on TKA indicated that in patients with severe varus deformity, addition of MPT Vertical Reduction Osteotomy step was better than conventional technique, as it could decrease intraoperative time, by bypassing the step of progressive release of medial soft tissue structures and repeated assessment of medial versus lateral gap balance to achieve a rectangular extension gap. Morbidity and complications due to risk of excessive soft tissue release and need for thicker insert or constraint implant was avoided.

1. Introduction

The goals of TKA surgery include adequate alignment of the prosthesis components and the limb, stability of the knee for functional outcome.[1] In order to obtain a balanced and well-functioning knee, release of contracted tissues and removal of peripheral osteophytes is necessary.

Three challenges must be met to produce an acceptable result from a knee replacement, namely perfect alignment of the components, good soft-tissue balance and compatibility

* *Corresponding author*.
E-mail address: yashmehtapanasonicp81@gmail.com (Y. M. Mehta).

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between the femorotibial articulation and the quadriceps mechanism.

Axial Alignment of lower limb is angle between mechanical axis of femur and tibia. Ideally the mechanical axis of lower limb is 180 +/- 3 degree means the line joining center of femur head to center of ankle should pass through center of distal femur at level of knee joint.[2] On Long leg standing radiograph we can also evaluate other axis which is important for alignment of lower limb like anatomical and mechanical axis of femur and tibia.

The most frequent deformity seen in patients undergoing total knee arthroscopy (TKA) is a varus knee, where a severe deformity entails increasing rigidity of the medial soft tissues and attenuation of the lateral soft tissues.[3]

Medial collateral ligament (MCL) release is one of the essential steps toward the achievement of ligament balancing during the total knee arthroplasty (TKA) in patients with varus deformity. The technique required detachment of the postero-medial capsule from the tibia and partial or complete release of the semi-membranous tendon.[4] In the majority of cases, release of the superficial medial collateral ligament from the proximal medial aspect of the tibia with or without release of the pes anserinus insertion was also required.[5–8]

Unfortunately, this often led to over-release of the superficial medial collateral ligament, hematoma formation, knee joint line elevation and instability; which can in turn require a thicker polyethylene insert or even a constrained implant.[9–11]

Reduction osteotomy (RO), a technique for medial proximal tibia (MPT) bone excision with minimum medial soft tissue release, was developed to address these drawbacks. It is a method that can lessen the degree of medial release and stop the medial soft tissue structures from being overly released.

Our study aims to assess and evaluate intra-op and post-op clinical & radiological benefits of medial proximal tibial vertical osteotomy (Reduction Osteotomy) over progressive medial soft tissue release during a primary total knee arthroplasty in patients with severe varus deformity.

This study sought to determine the effectiveness of the current approach for ML balancing as well as the quantification of the MPT bone resection technique as a potential substitute for attaining soft tissue balancing in total knee arthroplasty.

2. Materials and Methods

This study was conducted at Apollo Hospitals, Navi Mumbai from 2020 to 2021. This study included 24 patients having osteoarthritis admitted in Apollo hospitals with varus deformities more than 10 degrees. Patients with flexion deformity of more than 20 degrees or genu recurvatum more than 20 degrees, patients with pathological fractures and those having neurovascular deficit were excluded from the study. All necessary blood investigations along with X-ray B/L knee AP(standing) and lateral view (Figure 1) and scanogram were done pre-operatively. Pre-operative OKS (Oxford Knee Score) and KSS (Knee Society Score) were calculated. Pre-operative consent for TKR and medial proximal tibial vertical osteotomy (Reduction osteotomy) were taken.

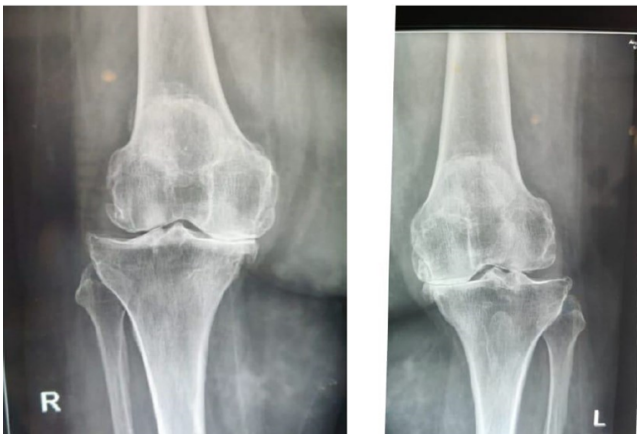

Figure 1: Preoperative x-ray osteoarthritis of bilateral knee

2.1. *Inclusion criteria*

1. Patients with arthritis knee.
2. Patients without neurovascular deficit and compartment syndrome.
3. Patients who have over 10 degree varus deformity.
4. Patients who are medically fit to undergo surgery.
5. Patients who consented for medial proximal tibial vertical osteotomy during surgery and study.

2.2. *Exclusion criteria*

1. Patients with Fixed Flexion Deformity more than 20 degree.
2. Patients with Genu Recurvatum more than 20 degree.
3. Patients with neurovascular deficit and compartment syndrome.
4. Patients with pathological fractures.

2.3. *Surgical technique*

Medial Parapatellar approach done to expose the knee joint and release of deep MCL done less than 2 cm from joint line distally in all cases. After femoral distal and standard tibial cuts, sizing was done, tibial tray of appropriate size matching with femoral counterpart was selected and placed as laterally as possible, after removing lateral osteophytes.

The remnant bone on medial proximal tibia was cut vertically using mechanized saw blade (Figure 2), removal of medical proximal tibia osteotomy fragment (Figure 3) resulted in opening up of medial joint space by bow string

effect caused by lateral shift of the medial soft tissue including medial collateral ligament. Hence, extension gap became rectangular without need of extensive soft tissue release (superficial MCL) on medial side and related complications were avoided.

This was followed by standard femur- anterior, posterior and chamfer cuts for flexion gap balancing.

This intra-operative improvisation can be further advanced by using an appropriate under sized tibial tray compatible with the femoral size selected if more correction is desirable for neutral alignment.

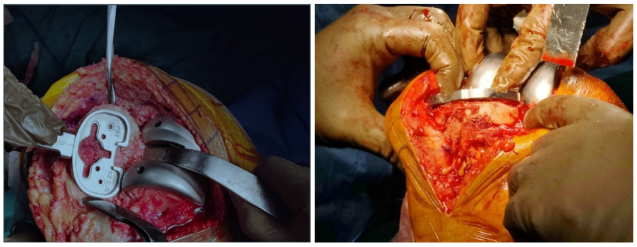

Figure 2: Intraoperative steps as described

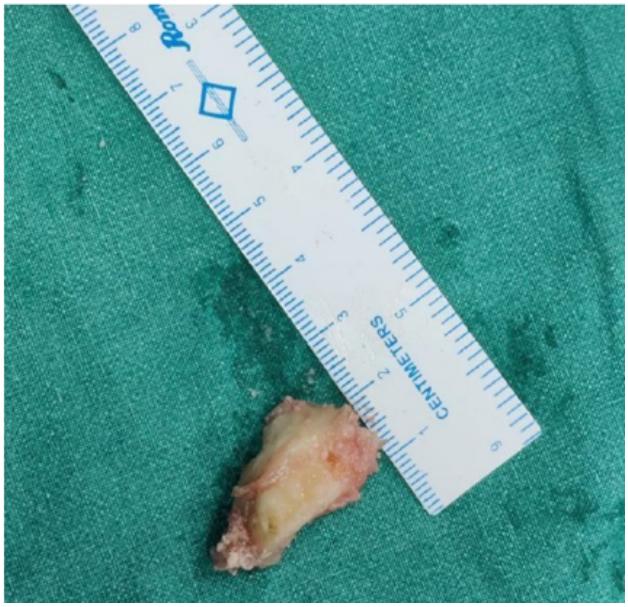

Figure 3: Measurement of Thickness of osteotomy fragment

2.4. *Post-operative*

1. Day 0: Pain management was done using analgesics/ epidural etc. Antibiotics/ antacids and
2. DVT prophylaxis was given till admission.
3. Day 1: Physiotherapy was started. Patient mobilized out of bed.
4. Day 3: Discharge given.
5. Day 14: 1st follow up was taken for suture removal and to evaluate patient.

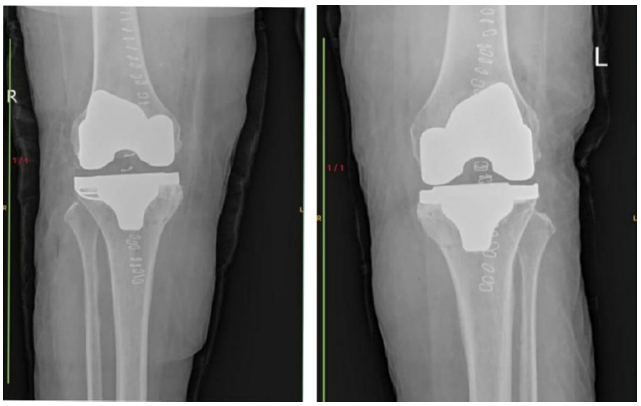

Figure 4: Postoperative X-ray- Bilateral TKA with reduction osteotomy

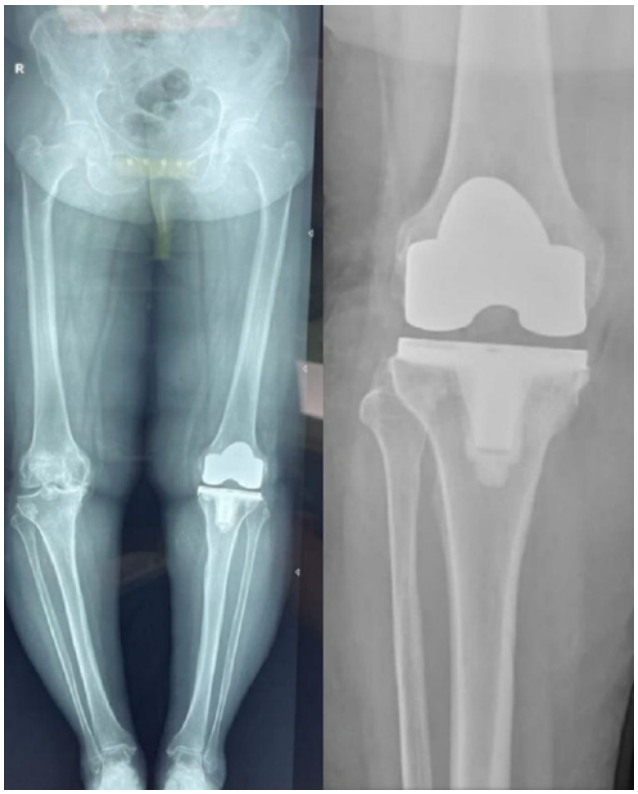

Figure 5: Postoperative x-ray- Bilateral TKA with reduction osteotomy

2.5. *Period of follow up*

Patients were followed up at 3 months post operatively. Post operatively x-ray knee ap lateral and scanogram were done for radiological outcome (Figures 4 and 5). Clinical

outcome was assessed using OKS (Oxford Knee Society) and KSS (Knee Society Score). (Table 1, Table 2)

3. Results

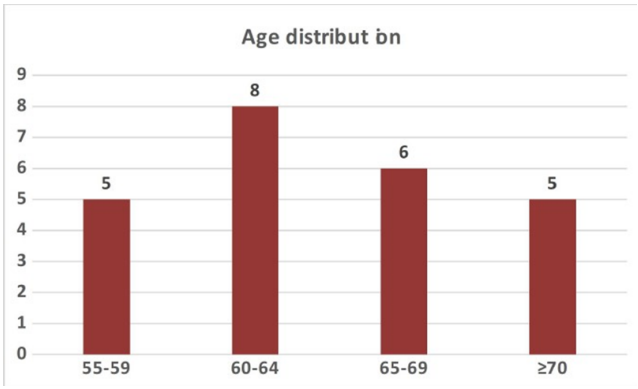

Figure 6: Age distribution

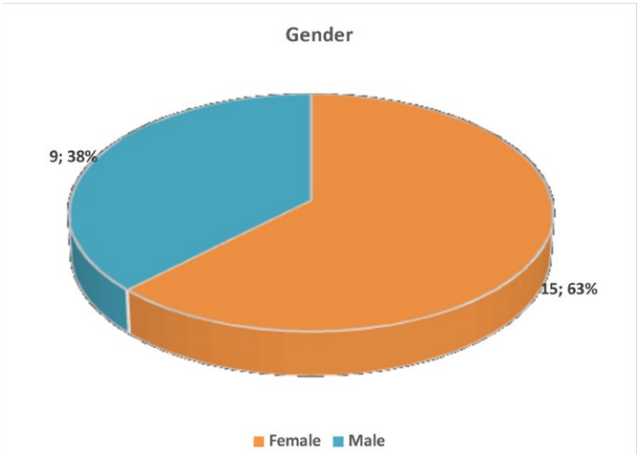

Figure 7: Gender distribution

Table 1: Preop vs postop oxford knee score

OKS (Oxford Knee Score) PRE-OP Score	Number	POST-OP Score (3 month)	Number
0-19 (Severe)	22	0-19 (Severe)	0
20-29 (Moderate to severe)	2	20-29 (Moderate to severe)	0
30-39 (Mild to moderate)	0	30-39 (Mild to moderate)	2
40-48 (Satisfactory)	0	40-48 (Satisfactory)	22
Total	24	Total	24

On linear regression analysis, for each unit of medial gap deficit, there was a corresponding 2.14 units of Proximal tibia vertical osteotomy thickness (mm) [beta coefficient 2.14, 95% CI 1.72-2.56, P value<0.001]. (Figure 8)

Table 2: Preop vs postop knee society score

KSS (Knee Society Score) PRE-OP Score	Number	POST-OP Score (3 month)	Number
80-100 (Excellent)	0	80-100 (Excellent)	17
70-79 (Good)	0	70-79 (Good)	7
60-69 (Fair)	0	60-69 (Fair)	0
<60 (Poor)	24	<60 (Poor)	0
Total	24	Total	24

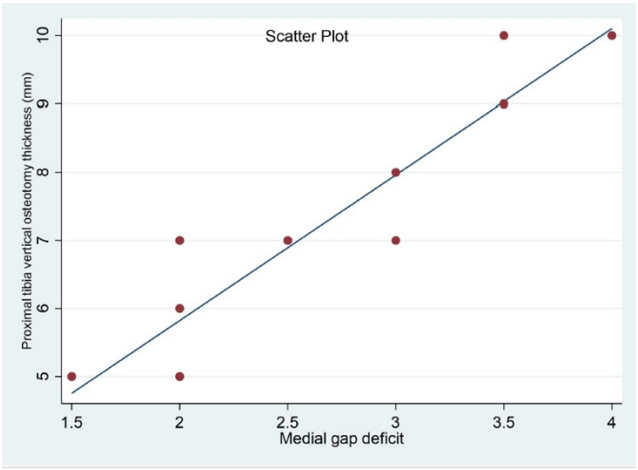

Figure 8: Correlation between medial gap and proximal tibia vertical osteotomy thickness

Ratio of medial gap deficit and Proximal tibia vertical osteotomy thickness: mean ratio was 2.8 (median ratio was 2.7, IQR: 2.5-3.2).

On linear regression analysis, for each unit change of Pre-op varus angle, there was a corresponding 0.38 units of Proximal tibia vertical osteotomy thickness (mm) [beta coefficient 0.38, 95% CI 0.33-0.42, P value<0.001].(Figure 9)

Ratio of Pre-op varus angle and Proximal tibia vertical osteotomy thickness: mean ratio was 0.38 (median ratio was 0.38, IQR: 0.375-0.405).

4. Discussion

In our study, we have attempted to compare conventional intra-operative step of progressive soft tissue release including superficial MCL for gap balancing during primary total knee replacement of knee with severe varus deformity versus our method of medial proximal tibial vertical (Reduction) osteotomy after less than 2 cm release of deep MCL if needed. Thickness of vertical osteotomy fragment was determined after placing tibial tray lateralised,

Table 3: Mean and median of neck shaft angle, preop and postop varus, preop and postop OKS and KSS proximal tibial vertical osteotomy thickness

Parameter	Mean	SD	P25	Median	P75
Neck shaft angle (degree)	124.5	2.9	122.8	124.3	127.2
Pre-op varus (Degree)	17	4.3	13.4	16.1	19.3
Pre-op OKS	15.8	2.6	14	16	17
Pre-op KSS	31.8	6.3	28	34	37
Medial Gap Deficit	2.4	0.7	2	2	3
Proximal Tibia Vertical Osteotomy (Thickness in MM)	6.6	1.7	5	6.5	7.5
Post op varus (Degree)	2.4	0.7	2.1	2.6	2.9
Post op OKS	41.3	1.9	40	42	42
Post OP KSS	81.4	2.9	78	82	84

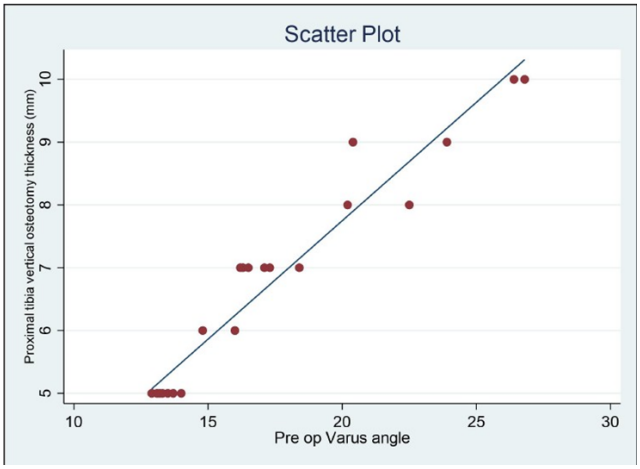

Figure 9: Correlation between Pre op varus angle and proximal tibia vertical osteotomy thickness

after considering the measured deficit in medial gap. Intraoperative advantages, post-operative correction of alignment and relation of pre-operative varus deformity severity with thickness of vertical osteotomy fragment was compared. A total of 24 eligible knees were observed and findings noted for comparison.

It is commonly acknowledged that proper ligament balance is essential for post-TKA survival and optimal function. The lack of agreement on the best practice for achieving an ML balanced knee during an arthroplasty operation is concerning, though. Although a number of medial release principles have been established to help achieve ligament balance during total knee arthroscopy (TKA), they do not provide a clear and universal surgical approach. There were two goals for this investigation. The initial goal was to determine whether the MPT bone excision approach could be used as a viable substitute for ML balance in knee replacements. The second goal was to quantify the bone resection technique by figuring out the coefficient ratio between the resected bone's thickness and the femorotibial gap.[12]

The medial ligamentous structures are indirectly or relatively lengthened as a result of the method that is being described, which involves lateralizing and downsizing the tibial component and eliminating the exposed medial proximal tibial bone, which the medial collateral ligament must pass through. By reducing the distance between the origin and insertion of the medial ligamentous structures, this approach lengthens them without requiring a significant release of medial soft tissue. If the tibia is in between sizes, the same idea might be used. In order to facilitate the resection of the uncapped medial bone, the smaller size is used and moved laterally. By reducing the amount of soft tissue release necessary to balance the knee, this bone resection approach lowers the risk of medial over release.[13]

The traditional method was one of the main foci of Pengfei Zan's 2017 study. In the control group, they carefully released soft tissues one step at a time until ML balance was reached. In the other group, they used a technique of resecting the medial uncapped tibia plateau bone after lateralizing and downsizing the tibia tray in order to correct the varus deformity. The technique's conclusion was that it can lengthen the medial ligamentous structures indirectly by reducing the distance between the origin and insertion without requiring a significant release.[14]

Arun B. Mullaji in 2005 attempted to determine whether there was any correlation between the degree of deformity and the results. There was no statistically significant correlation between the severity of varus preoperatively and femoral component alignment (correlation coefficient, 0.08), tibial component alignment (correlation coefficient, 0.02), and final tibiofemoral alignment (correlation coefficient, 0.03).[15]

The rotation performed by alignment of the medial collateral ligament fibres with the caudal tibial cortex resulted in a significantly greater rotation than the calculated movement required to achieve a postoperative angle of five degrees. The mean over-rotation was 2.1 ± 1.73 mm.[16]

Hyun et al[17] 2016 concluded the MPT bone resection technique is deemed efficacious and yields consistent outcomes in attaining soft tissue balance as measured by

TKA.

Pengfei Zan et al[18] 2017 concluded that compared to knees treated with the traditional ER approach, knees treated with RO were linked to higher improvements in pain and function.

Roberto Rossi et al[19] 2018 concluded that Varus knee is the most common deformity. Good results require deformity repair and adequate soft tissue balance. In particular, soft tissue balancing is a methodical process that need to be initiated just subsequent to the excision of osteophytes. A tibial reduction osteotomy or a medial epicondyle sliding osteotomy may be necessary if consecutive soft tissue balancing is unable to rectify the varus deformity. These treatments ought to be saved for correcting severe deformities.

Arun Mullaji et al[20] 2007 concluded that an incremental selective release of soft tissues should be performed, preserving the pes and the superficial MCL if possible. Reduction osteotomy helps in achieving further correction, and one may use a graft or augments with a stem extension for large defects.

Medial contracture and significant osteophytes are typically linked to varus deformities and proximal tibia remodeling. The removal of osteophytes causes the medial contracture to relax; if this treatment is insufficient to totally correct the deformity, a reduction tibial osteotomy may be necessary. This process aims to balance the gaps on the medial and lateral sides. The degree of the distortion must be taken into consideration when planning the amount of medial tibial resection; Mullaji et al. estimate that a 1 degree correction necessitates a 2 mm reduction in the medial plateau.

Achieving ML soft tissue balance with vertical bone resection of the MPT without releasing the superficial MCL and anticipating the ML gap balancing with vertical bone resection of the MPT are two of the major advantages of vertical bone resection.[12]

5. Conclusion

This prospective randomized controlled trial on TKA indicated that in patients with severe varus deformity, addition of Medial Proximal Tibial Vertical Reduction Osteotomy step was better than the conventional technique for correction of the varus deformity and intraoperative gap balancing, as it could decrease intraoperative time, by bypassing the step of progressive release of medial soft tissue structures and repeated assessment of medial versus lateral gap balance to achieve a rectangular extension gap.

Morbidity and complications associated with possible medial laxity due to risk of excessive soft tissue release and need for thicker insert or constraint implant was avoided. No additional risks were found regarding other clinical outcomes. Other findings noted in the study was predictability of required thickness of medial proximal tibial vertical osteotomy based on preoperative varus angle and intraoperative medial gap deficit. Additionally, more carefully and scientifically designed randomized controlled trials are still required to further support our conclusions.

6. Sources of Funding

None.

7. Conflict of Interest

None.

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Author biography

Prashant Ramesh Agrawal, Senior Consultant

RahulKumar Y Mishra, Secondary DNB Resident

Yash Manish Mehta, Clinical Fellow

Amey Mahesh Borse, Clinical Fellow

Akash Singh Jadon, Primary DNB Resident

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