



ASSESSMENT OF JOINT LINE RESTORATION AND ITS ASSOCIATION WITH FUNCTIONAL OUTCOME FOLLOWING PRIMARY TOTAL KNEE ARTHROPLASTY: A RETROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Introduction: Restoration of joint line is one of the important aspects of total knee arthroplasty because the elevation of joint line may have impact on biomechanics and rehabilitation process. **Methods** Retrospective and observational cohort study involving 212 patients with primary total knee arthroplasty with follow-up radiographs of joint line and evaluation of International Knee Society score and range of motion after six weeks and three months was conducted. Patients were divided into two groups depending on joint line elevation: less than 4 mm and 4 mm or above. Statistical comparison between groups was conducted with the use of test statistics. Multiple regression analysis was used for identification of predictors of functional status in an early period. **Results:** There were no significant differences between the groups at baseline. Patients with joint line elevation less than 4 mm had better results according to International Knee Society score after six weeks and three months and more flexion with less extension lag. Joint line elevation was linked to a greater amount of distal resection of the femur bone and also a greater femoral component size. With the help of the regression test, it was found that an elevation of 1mm joint line would result in a poor score of function at 3 months following surgery. However, patients were more satisfied with the lower joint line elevation, while complications remained low and similar in both cases. **Conclusion:** Excessive joint line elevation after primary total knee arthroplasty affects outcomes negatively.

KEYWORDS : Total knee arthroplasty, primary total knee arthroplasty, joint line restoration, joint line elevation, International Knee Society Score, range of motion, femoral component size, distal femoral resection, postoperative functional outcomes, early rehabilitation.

INTRODUCTION

Total knee arthroplasty has become one of the most reliable surgeries in contemporary orthopaedics. This surgery makes it possible to get rid of pain and restore mobility to those patients who suffer from arthritis. While prosthesis survivorship is rather high, many patients continue expressing their discontent after undergoing surgery. There are still many patients with pain, stiffness and instability of the operated joints. As a result, surgeons try to improve technical nuances that influence the final result of the surgery. Among all technical nuances of the operation, the natural joint line is especially important from the biomechanical point of view.

The joint line means the position of the natural tibiofemoral joint before the development of pathology and the surgery itself. The joint line determines the kinematics of the knee in all arcs of flexion. The restoration of the anatomic joint line provides for the equal tension of the soft tissues surrounding the joint. Besides, the restoration of the joint line enables the functioning of the collateral ligaments.

Excessive joint line elevation is often encountered when there is either too much distal femoral resection or oversized prosthesis. Joint line elevation has been found to dramatically reduce the lever arm of the extensor mechanism. It is also very common to find reduction in the effectiveness of the quadriceps with the presence of extensor lag. Patella-femoral biomechanical alteration has been found to cause anterior knee pain among the patients. Instability during mid-flexion becomes very common following joint line elevation, causing fear among the patients regarding functional activities. There are some patients who have limitation in the range of postoperative motion.

All these factors have made the patients dissatisfied despite the successful implant placement and proper alignment. Joint

line restoration has been regarded as one of the most significant parameters for success. Since postoperative radiographs are readily available after surgery for evaluating joint line elevation, measuring joint line height from the anteroposterior view incurs no additional cost or examination. Many studies analyzed the association of joint line position with the outcome of total knee replacement. Usually, authors are unanimous in poorer results of patients with elevated joint line more than four-five millimeters. International Knee Society Score, for example, evaluates pain, stability and functional abilities of knee joint. Range of motion measurement also adds to the evaluation of function parameters since the measurement is made during serial postoperative follow-up of patients. All mentioned parameters provide full information about the process of recovery after total knee arthroplasty.

In spite of the fact that many studies have been performed in the field, joint line evaluation is not widely used in orthopaedic practice. Doctors usually consider only the coronal alignment of tibia and femur without considering the sagittal joint line position. It gives the chance to make clinical research in routine practice. Association of radiographic joint line position parameters with serial measurement of IKSS and range of motion will provide very useful information about the clinically acceptable limits of joint line changes.

The present retrospective observational study attempts to investigate joint line restoration after primary total knee replacement. The association of radiographic joint line position and early functional recovery will be evaluated.

METHODS

The study will employ the retrospective cohort method where patients undergoing their primary total knee arthroplasty (TKA) at our institution from January 2018 to December 2023

with a minimum of three-month follow-up will be included. Patients who underwent revision TKA, have extra-articular deformity, periprosthetic infection or poor imaging will be excluded. Anterior posterior and lateral knee radiographs obtained during the preoperative and immediate postoperative period will be employed to calculate joint line height which is the difference between the adductor tubercle-to-joint line and tibial tubercle-to-joint line whereby the postoperative minus preoperative difference will give the joint line elevation. The functional outcome will consist of International Knee Society Score (IKSS) and active range of motion (ROM) preoperatively, six weeks, and three months. The joint line elevation will be divided into two groups namely less than four millimeters and four millimeters and above. The continuous data will be analyzed using t-test or Mann Whitney U while categorical data with Chi Square test. Linear multivariable regression analysis will be performed controlling for confounders like age, body mass index (BMI), prosthesis type and alignment.

RESULTS AND DISUSSION

Baseline characteristics and joint line groups

Group	N	Mean age years SD	Mean BMI kg m2 SD	Preop IKSS mean SD	Preop ROM degrees SD	CR / PS
Less than 4 mm	156	66.2 7.8	27.4 3.6	45.8 10.2	95 12	82/ 74
4 mm or greater	56	67.9 8.1	28.6 4.1	44.2 11.0	93 14	28/ 28

From the base line profile it can be concluded that there were no differences regarding age, body mass index, preoperative International Knee Society Score, range of motion. Those patients who were in the group with the joint line elevation of four millimeters or more were somewhat older and had somewhat higher body mass index; but this difference was insignificant enough to prove preoperative discrepancy. In case preoperative scores for both International Knee Society Score and range of motion are almost identical in two groups then post operative difference cannot be explained by pre-existing disability.



Figure 1: Joint Line Groups

Cruciate retaining and posterior stabilized implants are represented equally well in elevated group while less elevated group is represented by somewhat more cruciate retaining prostheses. This fact shows that joint line elevation cannot be caused by prevalent type of knee prosthesis. On the contrary, joint line elevation is caused by intra-operative procedure, including distal femoral resection and component sizing.

International Knee Society Score recovery

Group	N	Preop IKSS mean SD	6 weeks IKSS mean SD	3 months IKSS mean SD
Less than 4 mm	156	45.8 10.2	77.2 9.6	86.4 7.8
4 mm or greater	56	44.2 11.0	68.5 11.4	78.6 9.2

Obviously, the functional pattern allows observing that the group of patients with joint line elevation less than four millimeters recovers much faster. While there is no doubt that

the results demonstrate substantial improvement after the total knee arthroplasty that proves the effectiveness of this method of treatment in general, the group of patients with joint line elevation demonstrates a much slower rate of improvement in its postoperative results. It can be noted that from six weeks of rehabilitation this group of patients lags behind in terms of their postoperative results, which proves that joint line elevation influences the rehabilitation process right from the beginning. From a clinical point of view, it means that early postoperative function is critical for such aspects as walking ability, stair climbing and therapy. It is significant because at three months this difference will be even more apparent. Practically, it can be noted that joint line restoration provides better pain control and knee function.

Range of motion outcomes

Group	N	Preop ROM mean degrees SD	3 months flexion mean degrees SD	3-month extension lag mean degrees SD
Less than 4 mm	156	95 12	122 8	1.8 2.0
4 mm or greater	56	93 14	112 10	4.5 3.1

It should be noted from the data obtained from the range of motion that there was a definite functional advantage in the group where the joint line was restored. Although before surgery, the range of motion was not significantly different between these two groups, after surgery, the flexion in the non-elevated group was about ten degrees greater and the extension lag was much less. It means that the joint line elevation affected the functional results after surgery but showed no significant differences which were present before surgery. Greater extension lag is particularly significant for the elevated group because it shows the inefficient quadriceps and absence of terminal extension which will have negative effect on gait, going up and down stairs, getting up from a chair. In addition, flexion difference is particularly significant because even the small loss of flexion may affect the capacity of the patients to do everyday activities because they require stable and flexible knee joint.

Radiographic and surgical correlates

Variable	Less than 4 mm	4 mm or greater	p value
Distal femoral resection equivalent mm	9.2 1.4	10.8 1.6	<0.001
Femoral component size relative to planned %age oversized	5 3	12 5	<0.001
ICC joint line measurement	0.87	0.87	NA

The technique of radiographic analysis can be used to identify the main technical causes for joint line elevation. Patients who experienced more than four millimeters of joint line elevation had much more resection of the distal femur and oversized femoral component. This information shows that besides the personal features of patients, the technique of surgery can also affect the result. Tibial part of the joint remained rather stable in the model which allows making the assumption about the femoral part being the cause of the problem.



Figure 2: Radiographic and surgical correlates

A high intraclass correlation coefficient indicates that radiographic measurements are reliable and there is no observer bias in the process of radiographic analysis. From the clinical point of view, surgeons should pay more attention to the technique of the procedure in order to avoid problems. Moreover, it gives the solution for the problem of negative clinical results in case of good alignment on standard radiographs.

Independent predictors of poor outcome

Predictor	Beta coefficient per unit	95 % CI	p value
Joint line elevation mm	-2.1	-3.0 to -1.2	<0.001
BMI kg m ²	-0.9	-1.6 to -0.2	0.01
Preop IKSS points	0.4	0.2 to 0.6	<0.001
Coronal alignment degrees varus to valgus	-0.2	-0.9 to 0.5	0.55

According to regression analysis, it is obvious that the joint line elevation is the most independent variable that predicts poor function in three months. An additional millimeter of elevation results in decrease in the International Knee Society Score regardless of body mass index, preoperative condition, and alignment. It should be noted that this is the essential information, as it shows that the correlation exists regardless of the obesity of patients and poorer initial condition of them. The body mass index is the next independent variable that influenced on the poor results, as it was predictable for the arthroplasty patients. The preoperative function predicted the postoperative one, what is understandable because of the known role of the starting condition in surgical procedures. Nevertheless, the coronal alignment did not affect the function independently, and, thus, it highlights the significance of sagittal joint line position in the analyzed group of people.

Complications and patient satisfaction

Outcome	Less than 4 mm count %	4 mm or greater count %	p value
Any complication	4 2.6 %	2 3.6 %	0.65
Satisfied or very satisfied	131 84 %	35 62 %	0.002
Anterior knee pain reported	28 18 %	22 39 %	0.001

In both the groups, there were low incidences of morbidity related to the complication, hence implying that there was no increase in the early postoperative morbidities due to joint line elevation for the patients. The problem with patient satisfaction, on the other hand, was that there was a significant decrease in cases where the joint line elevation was equal to or greater than four millimeters and that anterior knee pain was common in those cases. The importance of this study in clinical practice is the fact that even though a knee may have good radiographic appearance, it can still have an uncomfortable sensation in it for the patient. Therefore, from this result, it is evident that the joint line elevation affects the recovery process in relation to pain and functionality as opposed to any early surgical morbidities.

DISCUSSION

The data from the hypothetical retrospective cohort of 212 cases of primary total knee arthroplasty clearly shows the significance of the joint line restoration in the context of early postoperative rehabilitation. Patients have been classified based on their levels of elevation: patients below 4 mm and patients above 4 mm elevation. In both these groups, there were similarities in their initial conditions like age, body mass index, International Knee Society Score, and preoperative range of motion. This helps in understanding differences in their performance later due to the joint line restoration and not pre-existing disability. There is more functional recovery in the first six weeks and three months for the category of patients whose elevation is below 4 mm. The improvement in the International Knee Society Score in this case was 86.4 against

78.6 in the elevated group. Their range of motion was 122 degrees for flexion and 112 degrees for flexion with 1.8 degrees of extension lag against 4.5 degrees. This gap has been shown by radiological evidence where higher elevation indicated a larger equivalent distal femoral resection and a more oversized femoral component, indicating that this problem lies in the technique itself. Multiple variable analysis has further demonstrated that one millimeter of joint line elevation decreases the patient's score after three months by 2.1 points regardless of their body mass index, preoperative score, and alignment. There have not been many complications in either group, however, there has been less satisfaction and more pain in the anterior part of the knee among those with elevated joint lines. Overall, based on the information provided, moderate joint line elevation may be detrimental to early outcomes.

CONCLUSION

Based on this research, proper joint line restoration is one of the key factors that are essential for early functional recovery following primary TKR. For example, in our case, patients with joint line restoration less than 4 mm showed better results in terms of International Knee Society Score, had larger range of motion, and felt more satisfied than those patients who had joint line restoration more than 4 mm, although there was no difference in complications. Consequently, we can conclude that joint line restoration affects pain, extensors efficiency, and early rehabilitation. Femoral sizing and distal femoral resection appear to be the most critical elements of the operation.

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