The Association between Preoperative Radiographic Parameters and Medial Soft Tissue Release in Total Knee Arthroplasty

Abstract

Introduction: Varus deformity is the most common deformity in patients undergoing knee replacement. Varus correction is based on the release of the medial soft tissue of the knee. But there is no exact measure of its extent. The present study aimed to investigate radiographic parameters that can predict the need for the release of medial elements.

Materials & Methods: In this retrospective cohort study all patients who underwent primary knee replacement surgery performed in a university hospital by a single surgeon during a 2-years period were included in the study. Preoperative and post-operative knee radiographs were collected. Patients were divided into three groups based on the stage of medial release. The radiographic criteria including Mechanical Femoro-tibial angle (mFTA), Lateral distal femoral angle (LDFA), Proximal medial tibial angle (MPTA), valgus cut angle (VCA) and joint line convergence angle (JLCA) before and after surgery were compared between the groups.

Results & Discussion: A total of 115 knee radiographs, related to 103 patients were examined. There was a significant association between LDFA , MPTA , mFTA , VCA and degree of varus correction with the medial release. The degree of varus correction significantly predicts the need for a high grade of medial release (OR=1.49, P=0.01)

Conclusion: higher LDFA, mFTA, VCA, and the degree of correction of the femoral and tibial mechanical angle and lower MPTA were associated with a higher degree of medial release. And the amount of varus correction significantly predicts the need for more medial release.

Keywords: Total knee arthroplasty, Genu varum, Radiography.

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Introduction

Total knee arthroplasty (TKA) is one of the most common orthopedic surgeries. In 2017, about 990,000 knee replacement surgeries in the United States were performed[(1)]. The rate of knee arthroplasty in Organization for Co-operation and Development (OECD) countries is 150 per 100,000 population and will quadruple by 2030[(1)].

Genu varum is the most common deformity in patients with knee replacement. The varus of the knee is defined based on the mechanical femorotibial angle less than 180 degrees in the standing radiograph and narrowing of the medial joint space[(2)]. The goal of knee arthroplasty is to maintain medial and lateral balance and knee function[(3)].

Many techniques are used to correct varus with release of the medial soft tissue of knee. Although many cases are corrected with the standard approach, others require the extensive release of the medial so[(4)]. In severe cases of varus, deep Medial collateral ligament (MCL) is released and osteophytes are removed, then posterior medial capsule, superficial MCL, posterior oblique ligament (POL), Semimembranosus tendon, and Pes anserinus are released, respectively[(5)]. These extensive releases may lead to over-correction and even the need to use constrain prostheses, increasing surgical complications and costs[(6,7)] Inadequate release on the other hand may result in pain, knee stiffness, instability, polyethylene wear, osteolysis, aseptic loosening and need for revision[(8,9)].

Therefore, predicting the amount of medial release based on kinematic alignment to correct varus before surgery is very effective, especially in the absence of a navigation system[10].

So far, few papers have studied the relationship between the parameters of radiography before surgery and need for medial release. Some studies have estimated the need for medial release using varus-valgus stress view x-rays[2,11]. It was found that the total of valgus and varus stress mechanical angles, as well as the varus of the mechanical axis of the knee, are risk factors for more medial release and the need for medial reduction osteotomy[3]. One study also showed that lateral opening of the joint space and the medial tibial articular surface angle predict the need for a medial reduction osteotomy[12] Sajjadi et al. explained that increasing the varus deformity on the radiographs before surgery will need a more soft tissue release and Medial proximal tibial angle (MPTA) and Mechanical Femur-Tibia angle(mFTA) could predict the extend of medial soft tissue release during TKA[9].

The aim of our study was to investigate the radiographic parameters relationship before surgery and the need and amount of medial release.

Materials & Methods

In this retrospective cohort study, cases with genu varum deformity who had underwent primary TKA in two hospitals in Sari city from 2018 to 2020 by a single surgeon were included. Any previous history of knee surgery and ligament laxity were the exclusion criteria.

A pre-operative evaluation in x-rays was performed utilizing standing antero-posterior radiographs of the knee, lateral view, bilateral alignment and patella axial view. The radiographs were evaluated for measuring the mFTA, MPTA, Lateral Distal Femoral Angle (LDFA), Valgus Cut Angle (VCA) and Joint Line Convergence Angle (JLCA) (Figure 1).

All radiographic parameters were measured by two blinded researchers to the groups in two times.

Figure 1: Measurement of preoperative and postoperative radiological parameters

All cases was operated by one surgeon under tourniquet with medial parapatellar approach and gap technique was used for balancing the valgus and varus deformity on proximal tibial and distal femoral cut, and double checked the flexion and extension gap based on the stages of the medial release[13] recorded in the operation description, patients were divided into groups: 1- MCL and medial capsule release 2- Including the first stage and posterior medial capsule and semimembranosus release3- release same as the Second stage and superficial MCL in the form of pie-crusting or Needling and4-Release the elements of the previous step and Pes anserinus. The same standard radiographs as pre-operative was taken at the patients' first postoperative visit with the same measurements (Figure 1).

The amount of correction of varus deformity (ΔmFTA) was measured. The parameters of radiography before and after surgery were compared in different study groups based on stages of medial release:

Quantitative variables were assessed by Kolmogorov-Smirnov test. One-way ANOVA test and Kruskal–Wallis test was used to compare the quantitative variables in the groups.

Paired t-test and Wilcoxon signed-rank test for comparing the variables and the test of chi-square for examination the association between qualitative variables were used. Odds ratios (OR) and 95% confidence intervals (CI) were determined using multivariable logistic regression. All tests were performed at a significance level of 0.05 using SPSS version 21.

Results

103 patients and 115 knees were included with mean age of 64.35 ±7.57. 92 female (89.3%) and 11(10.7%) male, while 58 (50.4%) were right and 57 (49.6%) were left knee.

Based on the medial release stage, the patients were divided to three groups (None of the patients required stage IV release). No statistically significant difference between three groups of medial release in terms of sex and age was found (p>0.05).

All patients underwent primary total knee replacement by PCL substitute (PS) prosthesis. The type of prosthesis used in different groups was not statistically significant (Table 1).

The results of the analysis of preoperative radiographic variables with the non-parametric test of Kruskal Wallis showed that stage of medial release was significantly associated with LDFA, MPTA, and mFTA, But the JLCA had no statistically significant association with the medial release (p=0.189) (Table2).

Table 1: Comparison of age, sex, and prosthesis Manufacturer between groups

variable		Group 1 (Release Stage 1)	Group 2 (Release Stage 2)	Group 3 (Release Stage 3)	P-value
age	Mean(SD)	66.18(7)	64.37(6.96)	63.95(7.93)	0.57
sex	Male	0(0%)	1(3.1%)	8(12.3%)	0.13
	Female	16(100%)	31(96.9%)	57(87.7%)	
prosthesis	ZIMMER	6(37.5%)	9(28.1%)	28(43.8%)	0.57
	SMITH & NEPHEW	7(48.3%)	13(40.6%)	20(31.3%)	
	DEPUY SYNTHES	3(18.8%)	10(31.3%)	16(25%)	

Table 2: Comparison of preoperative radiographic parameters between groups

Variable		Group1	Group2	Group3	P-value
LDFA	Mean (SD) Median	89.73(2.76) 90	90.48(2.55) 90	91.90(2.19) 92	0.006
MPTA	Mean (SD) Median	87.26(3.30) 87	85.58(3.18) 86	84.69(3) 85	0.014
mFTA	Mean (SD) Median	8.93(4.63) 9	12.32(5.64) 12	15.90(5.6) 15	0.0001
JLCA	Mean (SD) Median	5.93(3.15) 5	5.67(2.41) 6	7.18(4.06) 6	0.189

There was a statistically significant association between VCA and stage of medial release and VCA was higher in stage 3, but there was no significant association between the amount of bone cuts and the medial release stages (Table3).

The results of postoperative radiographic parameters analysis were shown in (Table 4). There was a statistically significant association between the total amount of correction of the mechanical femorotibial angle with the greater stage of medial release($p<0.05$).

Comparison of the median of radiographic parameters before and after surgery with non-parametric Wilcoxon signed-rank test showed that in group one, JLCA and mFTA, in group two, MPTA, JLCA, and mFTA, and group three, all 4 angles of MPTA, JLCA, mFTA, and LDFA have been significantly improved ($P<0.05$) (Figure 2).

ROC curve analysis showed that the area under the curve for varus correction (mFTA correction) was 0.768 ($P = 0.0001$), and had 78% sensitivity and 64% specificity for values greater than and equal to 11.5 degrees correction. The area under the curve for the LDFA variable was 0.671 ($P = 0.002$) and for above 90 degrees, it had 74% sensitivity and a 60% specificity. The area under curve for mFTA variable was 0.720 ($P = 0.0001$) and it had a sensitivity of 70% and specificity of 60% for values above 12.5 degrees. The area under curve for the VCA variable was 0.651 ($P = 0.006$) and for values above 6.5 degrees, it had a sensitivity of 50% and a specificity of 88% (Figure3).

Logistic regression analysis including of all radiographic parameters showed that the total amount of correction of varus deformity significantly predicts the need for third stage release (P=0.01, OR=1.49, 95%CI (1.09-2.02)).

Table 3: Comparison of operative parameters between groups

Variable		Group1	Group2	Group3	P-value
VCA	Mean (SD) Median	5.93(2.01) 6	5.93(1.13) 6	6.66(1.41) 7	0.01
External Rotation cut angle	Mean (SD) Median	3(0) 3	3(0) 3	2.87(0.5) 3	0.219
Distal femur cut	Mean (SD) Median	9.43(0.96) 9	9.5(1.25) 9	9.43(1.27) 9	0.779
Posterior femoral condyle cut	Mean (SD) Median	8.46(1.78) 9	9.09(1.45) 9	8.92(1.63) 9	0.709
Proximal tibia cut	Mean (SD) Median	6(1.86) 5	6.64(1.81) 7	6.48(1.74) 6.5	0.343

Table 4 Comparison of post-operative radiographic parameters between groups

Variable		Group1	Group2	Group3	P-value
LDFA	Mean (SD) Median	90.78(1.71) 90	90.39(1.70) 90	89.73(1.81) 89.5	0.08
MPTA	Mean (SD) Median	88.64(2.16) 88	90.1(1.98) 90	89.96(1.86) 90	0.052
mFTA	Mean (SD) Median	1.28(2.24) 1	0.32(3.01) 1	-0.07(2.78) 0	0.271
JLCA	Mean (SD) Median	0.28(0.72) 0	0.28(0.71) 0	0.16(0.59) 0	0.366
Total correction	Mean (SD) Median	8.35(4.06) 7.5	11.51(4.93) 11	15.69(5.21) 16	0.0001

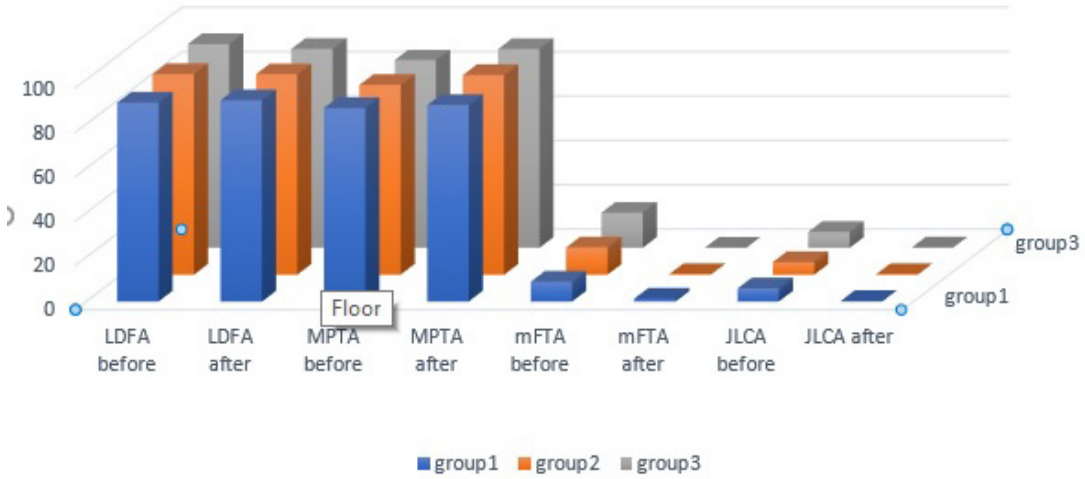

Figure 2: Comparison of radiographic parameters before and after surgery in groups

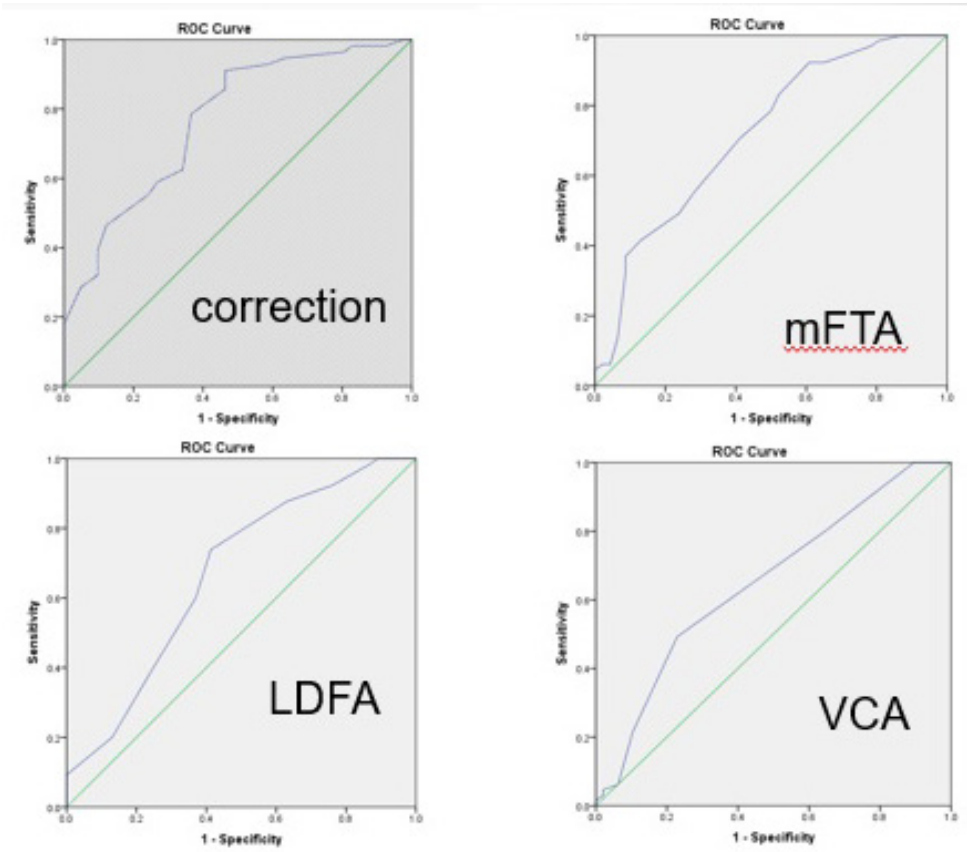

Figure 3: ROC curve of radiographic parameters for stage 3 medial release

Discussion

A small number of studies have examined the association between medial release and preoperative radiographic parameters and also a difference in the sequence of medial release[14]. An estimate of the amount of release for correction of varus deformity before surgery prevents insufficient or excessive release during surgery. Although some studies have used valgus/varus stress radiography for this purpose[3,11], it is not possible to do it for all patients, so bilateral full-length standing lower-limb radiography (alignment view) seems more appropriate. In the present study, it was found that higher LDFA, mFTA, VCA, ΔmFTA and lower MPTA

were associated with a higher stage of medial release. Similar studies have reported similar results, although the order of release of medial elements has not been the same in different studies.

Verdonk et al., as in our study, showed that the amount of varus angle before surgery, was significantly correlated with the medial release[2]. In the study of Sajjadi et al., Medial release had a statistically significant association with increasing knee varus and JLCA and decreasing MPTA as well[9].

Martin et al. Reported similar results and showed that the tibiofemoral varus deformity angle, tibial articular surface angle, the medial tibial articular surface angle, the size of lateral joint space and tibial offset were higher in the osteotomy reduction group. Among these cases, the angle of the medial proximal tibia (MPTA) and the lateral joint space significantly predict the need for reduction osteotomy. In the present study it was found that the total amount of varus correction is a significant predictor of the need for third stage release which is consistent with the results of the study of Sajjadi et al in which femorotibial varus angle and MPTA were mentioned as the predictor factors of the need for medial release[9].

In the Verdonak study, in the group with deep MCL release of varus 6 degrees, in the group with crustal foot MCL, the surface of varus was 8 degrees, and in the group with MCL release, the surface of tibia varus was 10.5 degrees. In the current study, these values were 9 ° for the MCL release group, 12 ° in the posterior capsule release group, and 16 ° in the superficial MCL needling group.

In our study, the amount of varus correction (ΔMFT) to determine severe medial release (stage 3) for values equal and greater than 11.5 degrees had a sensitivity of 78% and a specificity of 64%. The lateral distal femoral angle LDFA had a sensitivity of 74% and a specificity of 60% for values above 90 °. This value was 70% and 60% for mFTA for values greater than 12.5, respectively. Valgus cut VCA for values above 6.5 degrees had 50% sensitivity and 88% specificity in defining the higher stage of medial release. In the study of Sajjadi et al., Varus more than 19 degrees, more than 6 degrees, and less than 81 degrees MPTA required 3rd and 4th stage release[9].

Non-considering the duration of genu varum deformity, stress view radiography, checking the BMI of patients, complications of TKA and patient performance, are the limitations of the present study. We recommend the multicenter studies with higher sample size.

Conclusion

In our study, all patients underwent TKA with PS prosthesis. The lower MPTAand higher LDFA, mFTA, VCA, and the degree of correction of mFTA were associated with a higher degree of medial release. The amount of correction of varus deformity predicts more need for medial release and so the contrasted prostheses may be needed.

Ethical Approval

Code: IR.MAZUMS.IMAMHOSPITAL.REC.1399.079. by the Research Ethics Committee of Imam Khomeini Hospital

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References

1 Pabinger C, Lothaller H, Geissler A. Utilization rates of knee-arthroplasty in OECD countries. Osteoarthritis and Cartilage. 2015;23(10):1664-1673. https://doi.org/10.1016/j.joca.2015.05.008
2 Verdonk PC, Pernin J, Pinaroli A, Selmi TAS, Neyret P. Soft tissue balancing in varus total knee arthroplasty: an algorithmic approach. Knee Surgery, Sports Traumatology, Arthroscopy. 2009;17(6):660-666. https://doi.org/10.1007/s00167-009-0755-7
3 Ahn JH, Lee SH, Yang TY. Varus-valgus stress radiograph as a predictor for extensive medial release in total knee arthroplasty. International orthopedics. 2016;40(8):1639-1646. https://doi.org/10.1007/s00264-015-3018-x
4 Kim MW, Koh IJ, Kim JH, Jung JJ, In Y. Efficacy and safety of a novel three-step medial release technique in varus total knee arthroplasty. The Journal of arthroplasty. 2015;30(9):1542-1547. https://doi.org/10.1016/j.arth.2015.03.037
5 D'Lima DD, Patil S, Steklov N, Colwell Jr CW. An ABJS Best Paper: Dynamic intraoperative ligament balancing for total knee arthroplasty. Clinical Orthopedics and related research. 2007;463:208-122. https://doi.org/10.1097/blo.0b013e318150dc2c
6 Mullaji A, Marawar S, Sharma A. Correcting varus deformity. The Journal of arthroplasty. 2007;22(4):15-19. https://doi.org/10.1016/j.arth.2007.01.017
7 Rossi R, Cottino U, Bruzzone M, Dettoni F, Bonasia DE, Rosso F. Total knee arthroplasty in the varus knee: tips and tricks. International orthopedics. 2019;43(1):151-158. https://doi.org/10.1007/s00264-018-4116-3

8 Mullaji A, Shetty GJTb, journal j. Correcting deformity in total knee arthroplasty: techniques to avoid the release of collateral ligaments in severely deformed knees. 2016;98(1_Supple_A):101-104. https://doi.org/10.1302/0301-620x.98b1.36207
9 Sajjadi MM, Okhovatpour MA, Safaei Y, Faramarzi B, Zandi RJTJoKS. Is Standing Coronal Long-Leg Alignment View Effective in Predicting the Extent of Medial Soft Tissue Release in Varus Deformity during Total Knee Arthroplasty? 2021;35(11): 1192-1198. https://doi.org/10.1055/s-0040-1721787
10 Hunt NC, Ghosh KM, Athwal KK, Longstaff LM, Amis AA, Deehan DJJKS, Sports Traumatology, Arthroscopy. Lack of evidence to support present medial release methods in total knee arthroplasty. 2014;22(12):3100-3112. https://doi.org/10.1007/s00167-014-3148-5
11 Moon YW, Kim JG, Woo KJ, Lim SJ, Seo JG. Analysis of medial flexion gap after medial release for varus deformity by navigation-guided TKA. Orthopedics. 2011;34(5):e37-e42. https://doi.org/10.3928/01477447-20110317-10
12 Martin JR, Jennings JM, Levy DL, Watters TS, Miner TM, Dennis DA. What preoperative radiographic parameters are associated with increased medial release in total knee arthroplasty? The Journal of arthroplasty. 2017;32(3):771-776. https://doi.org/10.1016/j.arth.2016.08.018
13 Thimmegowda RB, Purushotham V, Patel SJIJoO. Sequential soft tissue release and unconstrained TKA implants in severe varus deformity-Prospective study in 75 knees. 2017;3(3):15-20. https://doi.org/10.22271/ortho.2017.v3.i3a.04
14 Aunan E, Röhrl SMJAo. No detrimental effect of ligament balancing on functional outcome after total knee arthroplasty: a prospective cohort study on 129 mechanically aligned knees with 3 years' follow-up. 2018;89(5):548-554. https://doi.org/10.1080/17453674.2018.1485283