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Original Article

Radiological and clinical effect of prosthesis design in varus knees?

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ABSTRACT

Purpose: The aim of the study is to investigate the efficacy of the prosthesis design used in total knee arthroplasty in patients with varus malalignment.

Methods: After exclusion criteria we classified 90 patients underwent total knee arthroplasty according to prosthesis used into two groups: posterior cruciate ligament substituting and retaining. Mean follow up period was 25–98 months. We evaluated preoperative and postoperative radiological and as well as clinical parameters such as pain, knee function, flexion deformity.

Results: We found statistically significant difference in both groups in terms of deformity correction ($p = 0.000$).

Conclusion: Prosthesis design affects radiological outcomes in varus knees.

1. Introduction

As known, total knee arthroplasty (TKA) is a successful treatment of gonarthrosis. It configures the joint and also corrects the deformities. Varus malalignment is one of the most deformity that is seen in gonarthrosis. Patients generally postpone the surgery for social reasons or sometimes with no reason.[1,2] Therefore, severe varus knee deformity can be seen easily and this may cause problems for orthopaedic surgeons.[2–6] In order to correct bone deformities, femoral and tibial components should be properly aligned in coronal and sagittal planes. Unfortunately, there are few and old studies about this subject, particularly affecting elderly population and has an increasingly high importance.[4–7] The aim of this study is to investigate correction rates of varus malalignment in patients whom had total knee arthroplasty and the effect of prosthesis design.

2. Materials and method

This study was approved by Local Ethical Committee of Istanbul Medipol University (No: 10840098-106- 06.06.2014). We obtained enlightened consent form from all cases

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included in this study. In order to minimize errors; clinical scores and radiographic assessments were performed by same surgeons, who are not aware of the type of design. The researcher who tested the case was blinded to the study. Clinical scores and assessments were repeated minimum twice by two different researchers.

2.1. Materials

Coronal and sagittal radiographs were obtained by Diagnost VN1/VM2 (Philips®, USA).

2.2. Method

We included 163 cases, who underwent total knee arthroplasty between August 2010 and December 2013.

2.3. Case selection

Cases which could cause bias in terms of radiographic or clinical scoring were excluded (Fig. 1). One hundred and forty-six of the cases were operated in a single hospital by same surgeon using midline incision and medial parapatellar approach. In order to standardize the cuts, femoral cutting block was fixed at 6° of valgus angle and 3° of external rotation, tibial cutting block was fixed at 0° in coronal plane and 7° in sagittal plane. 17 cases who didn't meet these criteria were excluded from the study.

After exclusion criteria 129 cases were left. We could contact 111 of these cases. However, only 90 cases completed the study.

2.4. Study design

Cases were classified into two groups according to prosthesis design. Group I (n = 49) in which a single type of posterior cruciate ligament (PCL) substituting prosthesis (Biomet, Warsaw) with mobile insert (Biomet, Warsaw) was used by the same surgeon and Group II (n = 41) in which a single type of PCL retaining prosthesis (Biomet, Warsaw) with fixed insert was used (Biomet, Warsaw) by a single surgeon. Demographic data was recorded of these cases as well.

Cases in both groups were evaluated in terms of preoperative and post operative radiographs and scoring systems as well as pain, function, range of motion, flexion deformity and instability.

2.5. Radiological assessment

Postoperative radiological evaluation was performed according to TKA radiological assessment criteria.[8,9] We evaluated joint space narrowing, osteophyte formation, bone quality and alignment using both preoperative graphs and postoperative graphs with the mean follow-up period of 26 months. We compared preoperative varus and postoperative valgus angles between groups by assessing tibiofemoral axis (Fig. 2).

We recorded the presence of osteophytes located posteriorly and may cause flexion contractures which were detected on plain radiographs. In order to evaluate component compatibility we used coronal and sagittal radiographs. On coronal radiographs we evaluated femoral component compatibility alpha (α) angle by assessing the angle between anatomical axis of femur and transfemoral line which was drawn between inferior tips of both femoral condyles. In order to evaluate tibial component compatibility beta (β) angle, we assessed angle between anatomical axis of tibia and transtibial line which was drawn parallel to tibial plateau (Fig. 3). On sagittal view we evaluated femoral component compatibility with gamma (γ) angle by assessing angle between mid medullary axis of femur and the line perpendicular to the distal tip of prosthesis, and tibial component compatibility by sagittal-tibial θ (teta) angle by assessing angle between mid medullary axis of tibia and the line parallel to tibial componentone sagittal tibial view.[10–12]

2.6. Physical examination and clinical scoring process

We checked flexion and extension ranges on transverse axis which passes from inferior tips of both condyles as well as presence of rotation, abduction and adduction at when the knee is flexed at 30° both preoperatively and postoperatively from all cases. In order to evaluate movements in three planes we controlled flexion and extension for sagittal plane, internal

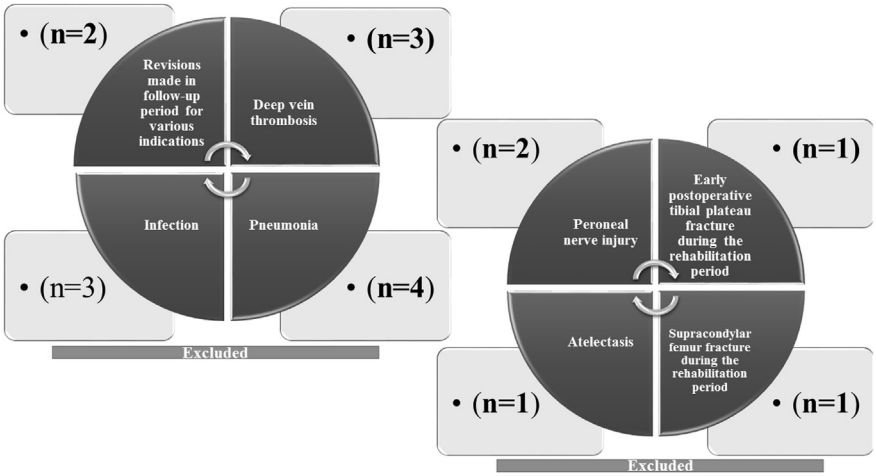

Fig. 1 – Eligible criteria.

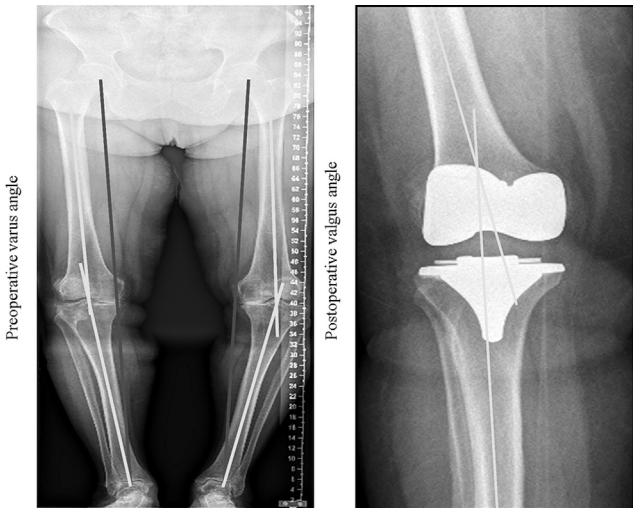

Fig. 2 – Pre- and post operative radiological imaging.

and external rotation for axial plane, and abduction and adduction for coronal plane. We also checked active internal and external rotation when the knee is flexed at 90°.

Knee range of motion (ROM), Hospital for Special Surgery (HSS) scoring system, Knee Society Scoring System (KSS) and Knee Society Functional Scoring System (KSFS) tests, which are based on physical examination and provides information about prosthesis dynamics were performed. HSS and KSS were evaluated over 100 points. At final rating, cases whose score was below 60 were recorded as "poor", between 60 and 69 as "moderate", between 70 and 84 as "good" and between "85–100" as "excellent". In order to compare preoperative and postoperative pain, visual analogue scale (VAS) and The Western Ontario and Mc Masters Universities Osteoarthritis Index (WOMAC) were applied over stiffness and functionality of knee. In this system pain, knee joint stiffness and function is questioned and the lower point represents the better outcome. So, the classification is as follows: 0–14 excellent, 15–28 good, 19–38 moderate, >39 insufficient.[13–15]

2.7. *Statistical analysis*

In statistical analysis our purpose was to investigate whether results of two distinct studies were different. Study data was evaluated using Statistical Package for the Social Sciences v16. Mean statistics were mentioned as "*mean ± standard deviation*". Evaluations were performed at % 95 confidence interval. In order to find out whether data is normally evenly distributed we used Kolmogorov–Smirnov test which predicts over mean difference values. We used analysis of variance (ANOVA) in order to compare preoperatively and postoperatively, followed by turkey HSD test. The comparison of mean radiological data of cases, for whom different prosthesis designs were used, was performed using independent-samples t-tests and paired-samples t test. Moreover, we checked whether Results of variance analysis was homogenous. In order to evaluate presence of homogenous distribution for even variance values we used Levene's test. Following that, p values of all groups were evaluated with independent samples t test.

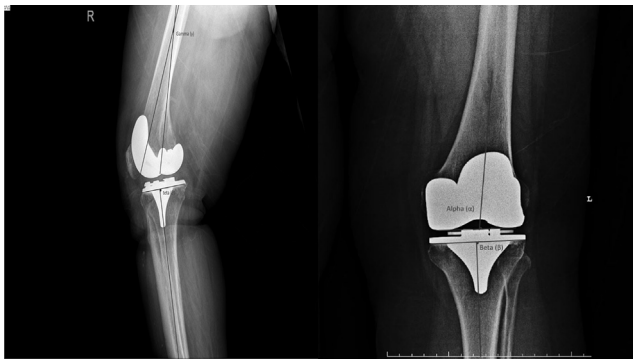

Fig. 3 – Component compatibility measurement.

3. Results

The percentage of men in this study was 13.3%, while in the second group it was 15.38%. The mean age of women and men were 66.74 ± 6.59 and 66.08 ± 6.79, respectively. The mean age of women and men in the first group were 66.30 ± 6.35 (54–80), and 67.83 ± 7.06 (59–79) respectively. In the second group the mean age of women and men were 67.23 ± 6.90 (53–81), and 64.33 ± 6.65 (63–73), respectively. The mean follow up period for all patients were 25.98 ± 8.71 months, while in group I and group II it was 26.12 ± 9.65 and 24.98 ± 7.19, respectively. The mean BMI index of women in this study was 33.12 ± 5.97 kg/m2, which refers to Class II obesity; while the mean BMI index of men was 31.98 ± 5.11 kg/m2, which refers to Class I obesity. The mean BMI indices for men and women in Group II were 42.5 ± 5.52 (Class III obesity) kg/m2 and 34.01 ± 3.16 (class II obesity), respectively. There was no significant difference in gender, age, body mass index, between 2 groups ($p > 0.001$).

We performed 49 PCL substituting and 41 PCL retaining prosthesis for 90 knees and applied tourniquet in all cases. In Group I mean HSS knee score increased from 57.01 ± 11.24 preoperatively to 92.03 ± 10.42 postoperatively. Preoperative KSS range was between 38° and 79°, while in Group I and Group II mean KSS were 61.2 and 61.8, respectively. Postoperative KSS range was between 57 and 100, while in Group I and II mean KSS was 89.9 and 90.01, respectively.

Evaluation of all cases showed that 81 (13.68%) knees had excellent, 13 (13.68%) had good, and 1 (1.05%) had bad results. Preoperative functional knee score range was between 15 and 60 and mean scores in Group I and II were 35.6 and 34.99, respectively. Postoperative range was between 45° and 95° and mean scores of Group I and Group II were 71.5° and 71.97°, respectively.

Preoperative ROM ranges of cases were between 30° and 110°, while it was between 90° and 130°, and with the mean of 116.9°. ROM has increased in all cases independent from design of the prosthesis used and it was over 90° in all cases.

In terms of patient satisfaction and complications there was no significant difference between groups in preoperative ROM, KSS, HSS, WOMAC and VAS ($p > 0.001$). In Group I, active external rotation when knee was flexed at 90° was 27.6°, while in Group II it was 26.8°. There was no statistically significant difference between two groups. Preoperative knee flexion

Table 1 – Measurement of component alignment.

Angle	PCL retaining	PCL substituting
(α)	89°–103°	88°–104°
(β)	83°–92°	82°–92°
(γ)	0°–14°	0°–15°
Sagittal-tibial θ (teta)	77°–95°	76°–93°

contracture range was between 0° and 30°, with the mean of 12.6°. However, we didn't detect flexion contracture in the postoperative period. In order to evaluate component compatibility we obtained coronal and sagittal radiographs. We assessed alpha (α), beta (β), gamma (γ), sagittal-tibial θ (teta) angles. There was no statistically significant difference between groups (Table 1).

Mean preoperative varus angle in the first and second group were 7.24° and 6.62°, respectively. Mean postoperative valgus angle in the first and second group were 5.68° and 4.68°, respectively. Postoperative correction was 12.92° in the first group, while it was 11.30°in the second group. Both groups were found to be statistically effective in terms of deformity correction. However, there was still a statistically significant difference between PCL substituting group and PCL retaining group. Both prosthesis designs were found to be statistically effective in correcting varus deformity of the knee ($p < 0.001$). We compared preoperative and postoperative values with Levene's test. Since we found significant difference, we concluded with the fact that variances of both groups were not homogenous (Table 2). For this reason, group I, which has 0.044 for p value, was more effective for correction of varus deformity. Mean varus correction angle of the first group was 13.60 ± 0.80°, while it was 11.68°±0.49 in the second group. Group I was significantly different from Group II (Table 3).

4. Discussion

Varus is the most common type of deformity in knees with osteoarthritis and many different techniques have been described to correct it.[16] It should be remembered that varus deformity may recur following surgery.[17,18] This study was conducted in knees with varus deformity, which is rather common. We compared operated knees for which two different prosthesis designs were used. Our purpose was to investigate whether substituting or retaining of PCL would differ in correction of varus malalignment. This is the first study in the literature that compared PCL retaining and substitute semi constrained prosthesis design with not only radiologically, but also with clinically by WOMAC, VAS, ROM, HSS, KSS, KSFS.

A successful surgery is not only using the proper incision and replacing the knee with a good surgical technique. In addition to the factors mentioned above, the most important factor is the preoperative preparation and planning. Preoperative planning is known to be the most important factor and also is important in prosthesis choice. As clearly known, in total knee arthoplasty indicated for gonartrosis which is unresposive to medical treatment and is performed to provide normal biomechanics, the retention or substitution of cruciate ligaments are still controversial.[11]

Alexedias et al suggested that PCL caused contracture in the knee joint without presence of anterior cruciate ligament.[19] Laskin et al recommended to choose PCL substituting prosthesis for the correction of the knees with greater than 15° of varus.[20] Although we didn't only include knees with greater than 15° of varus we detected statistically significant difference in varus correction between PCL substituting and retaining groups both varus degree of over 15 or less. First, both groups were found to be effective in correction of varus deformity. Considering tendency to realign into varus in knees with gonarthrosis, both method was successful. However, PCL substituting group was statistically different than PCL retaining group considering varus realignment.

Studies suggesting retention of PCL are extremely high in current literature. Ritter et al published a study of a large series in which they corrected knees with varus deformity over 20° with PCL retaining prosthesis and compared with knees with relatively less varus angle and didn't find any statistically differences.[21] As in our study, in studies with PCL retaining group generally preoperative varus correction was not statistically significant.

In the literature, one of the important factors leading to choose PCL retaining knee prosthesis is its contribution to roll-back mechanism. However, in a cadaver study published by Ormonde et al, it's showed that roll-back mechanism decreased by 36% after PCL retaining prosthesis. Moreover, they also found that there was 15% loss in extensor efficiency.[22] Nevertheless, they found 12% loss in femoral roll-back and 11% in extension, when PCL substituting prosthesis was used. The fact that femoral roll-back mechanism couldn't be maintained after PCL retaining total knee arthroplasty would raise questions about how much could PCL retaining prosthesis protect PCL. Feyen et al published an interesting article addressing this issue.[23] In a cadaver study they showed that during tibial cut, the insertion point of PCL on tibia was highly damaged. Jawhar et al suggested that the level of head of fibula could be used as foot print of insertion point of PCL on tibia to prevent PCL.[24] It's believed that PCL didn't have any function either due to degeneration with age or injury or cut during tibial cut, thus it's believed that in PCL retaining this may cause problems such as insufficient varus deformity correction, insufficient maintaining the roll back mechanism, and loss in extensor efficiency.[23,24]

Table 2 – Comparison of varus correction rates between groups.

	Paired differences			95% CI			
	Mean	SD	SEM	Lower	Upper	t	p^*
Group I	13.61	5.85	0.80	15.22	11.99	16.94	0.0000
Group II	11.13	4.09	0.60	12.33	9.93	18.63	0.0000

p^*: paired samples test sig. (2-tailed). SD: standard deviation; SEM: standard error mean, CI: confidence interval of the difference.

Table 3 – Levene's test for equality of variances t-test for equality of means.

	F	Sig.	t	p^*	Mean difference	SD error difference	95% CI	
							Lower	Upper
Equal variances assumed	10.73	0.001	1.986	0.05	1.932	0.969	0.0014	3.854
Equal variances not assumed			2.048	0.044	1.922	0.9389	0.055	3.789

p^*: independent samples test.

There are three main trends among orthopedic surgeons; those who always use PCL substituting prosthesis, those who always use PCL retaining prosthesis, and those who decides intraoperatively. Surgeons who use PCL retaining prosthesis suggest that PCL, being one of the strongest ligaments in the knee joint, provides stability to prosthesis. However, surgeons who use PCL substituting prosthesis claim that PCL contributed to gonarthrosis it self.

General consideration is to retain if there is no varus or valgus deformity.[25] In this study we ended up with the idea of substituting PCL in the presence of moderate and severe varus deformity. During flexion lateral ligaments become lax, thus knee internally rotates. However, as the knee is extended knee is externally rotated and locked. During initial flexion, knee internally rotates about 0.5° for each 1° degree of flexion until knee is flexed at 20°. When the knee is flexed at 90°, femorotibial contact points are rolled back as much as 14 mm. In the absence of cruciate ligaments "screw-home" mechanism of the knee doesn't happen. It's clearly noted in literature that PCL is highly important for this mechanism.[11,12] Moreover, since knee is locked at extension, active rotation is only allowed at flexion. Maximum rotation is achieved at 90° of flexion and the more the flexion continues the more soft tissue tightness will occur. Thus, rotation will decrease. When knee is flexed at 90°, maximum active internal rotation is expected to be 30° and external rotation would be 40°.[26]

In this study, cases in Group I and II had 39.6° and 37.3° mean external rotation angle when the knee was flexed at 90°, respectively. However, they had 27.6° and 26.8° of internal rotation, respectively. There was no statistical difference between groups.

In literature, it is suggested that knee flexion at postoperative 15th day should be minimum 90°.[26,27]

In this study, mean knee ROM was 116.9° at postoperative 15th day, and varus malalignment was corrected better in PCL substituting group than PCL retaining group. As a result, in this randomized study, we used preoperative values as control group and considering the ultimate aim to be 5–7° valgus postoperatively, we may come up with the idea that knees which have less than 5° of valgus postoperatively could be diagnosed as varus. We found that in Group I the percentage of the knees which have 5° or more valgus alignment postoperatively was 70%, while it was 60% in Group II ($p < 0.001$).

5. Conclusion

There was significant difference in correction deformity in PCL substituting group. In preoperative planning of knees with varus deformity, the effect of PCL on varus malalignment should be considered and PCL substituting prosthesis should be the first choice of treatment.

Conflicts of interest

All authors have none to declare.

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