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Impact of Post-operative Radiological Parameters on Total Knee Arthroplasty Functional Outcome

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Abstract

BACKGROUND: Total knee arthroplasty (TKA) is effective in treating end-stage osteoarthritis. Nevertheless, 20% of patients remain unsatisfied with the outcome at 1 year.

AIM: The aim of our study was to identify the radiological parameters influencing the functional result and patient's quality of life (QOL).

METHODS: We conducted a retrospective observational study of patients who underwent primary TKA between 2015 and 2019. Standard radiographs were used to assess alignment parameters, patellar height, and implant size. Knee function was assessed using the Knee Society Score (KSS) and the QOL through the "Sfax modified Western Ontario and McMaster Universities osteoarthritis index (WOMAC)."

RESULTS: One hundred and twenty cases were analyzed. The results in terms of alignment showed on average: an overall alignment of 2.41° varus, a coronal orientation of the femoral component of 5.49° of valgus, a coronal orientation of the tibial component of 2.16° of varus, a flexion of the femoral component of 0.7°, and a tibial slope of 2.6° with posterior orientation. We identified 19 cases of Patella baja (PB) and seven cases of pseudo PB. We identified 18 cases of oversizing of the femoral implant and six cases of undersizing. The tibial implant was oversized in ten cases and undersized in three cases. Global alignment of the limb and coronal alignment of the tibial component significantly influenced KSS and WOMAC scores. There was also a significant association between patellar height, knee function, and QOL. Femoral component size and overhang of the tibial component showed a significant influence only on WOMAC score.

CONCLUSION: Standard radiography can be effective and reliable to evaluate TKAs. According to our results, we may suggest a checklist aiming to optimize knee function and patient's QOL. It should include mechanical alignment of the limb, coronal alignment of tibial component, prevention of iatrogenic patellar tendon shortening, and precision in implant size choice.

Introduction

Total knee arthroplasty (TKA) is an effective way of treating symptomatic end-stage arthritis of the knee [1]. Despite increasing the number of surgeries and the improvement in implant design as well as surgical technique, 20% of patients remain unsatisfied 1-year postoperatively [2]. Therefore, the ultimate aim of patient and surgeon, namely, to obtain a "forgotten knee," is far from being achieved. To investigate the factors leading to patients' dissatisfaction, it is interesting to refer to conventional radiology, the cornerstone of postoperative follow-up.

This examination, relatively inexpensive and common practice, provides the surgeon with several parameters, which evaluate the anatomical result, reflect the quality of the implantation, and provide information on the probable future of the prosthesis.

The aim of the present study was to investigate the association between radiological parameters with functional results of TKA.

Methods

This study had a retrospective observational design

All consecutive 317 patients who underwent TKA between 2015 and 2019 were considered for inclusion in this study. Inclusion criteria were diagnosis of three-compartmental primary arthritis suitable for the primary standard TKA with a minimum follow-up of 1 year. Exclusion criteria were secondary arthritis (rheumatoid arthritis and hemophilia), previous osteotomy, and revision surgery.

Patients' age, gender, American Society of Anesthesiologists (ASA) classification [3], and the Kellgren–Lawrence grade for severity of knee osteoarthritis [4] were collected and used as baseline parameters.

For radiographic assessment, we analyzed postoperative knee radiographs at last follow-up (minimal follow-up of 12 months). Weight-bearing anteroposterior views, true lateral views (with overlapping images of condyles), and standing scanograms of both lower limbs were performed.

The parameters studied were implant alignment, patellar high, and component sizing.

Overall femorotibial alignment was analyzed by measuring the hip-knee-ankle angle (HKA), commonly defined as the angle between the mechanical axis of the femur (center of the femoral head to center of the knee) and the mechanical axis of the tibia (center of the proximal tibial plateau to the center of talus) [5].

Position of the femoral and tibial components in coronal and sagittal planes was assessed using the angles proposed by the American Knee Society [6] (Figure 1):

- Coronal femoral angle (cFA, α) described the valgus/varus of distal femur and the frontal alignment of the femoral component
- Coronal tibial angle (cTA, β) described the valgus/varus of the proximal tibia and the frontal alignment of the tibial component
- Sagittal femoral angle (sFA, ϒ) described the degrees of flexion/extension of the femoral component
- Sagittal tibial angle (sTA, σ) measured the tibial slope, calculated as 90°-σ.

Patellar height was assessed using the modified Insall-Salvati ratio (mISR) and the Blackburn-Pell ratio (BPR) [7] (Figure 2). While mISR is commonly used to assess true Patella Baja (PB), BPR assessed Pseudo PB (PPB) being independent of the patellar tendon's length. Definitions of PB and PPB relied on arbitrary cutoff values of the radiological indices (PB defined as mISR <1.2; PPB defined as BPR <0.54) derived from the original publications [8], [9].

Posterior condylar offset (PCO) was defined as the maximum thickness of the posterior femoral condyles, calculated measuring the distance between the radius corresponding to the margin of the posterior cortex and its tangent parallel to the condyles posteriorly [10]. This parameter was measured preoperatively and postoperatively. We calculated the differential between the two values.

Femoral component's dimension was assessed by the relationship between the anterior cortex of the femur and the implant (Figure 3). Undersize was manifested by a notch on the anterior cortex, while oversize was manifested by a significant space between the cortex and the edge of the femoral component.

Regarding tibial sizing, we used four lines (Figure 4): Medial tibial overhanging line, lateral tibial overhanging line, anterior coverage line, and posterior coverage line. Distance between those lines and corresponding tibial cortical edges, measured in millimeters, took a negative value in case of undersized implant and a positive value in case of oversizing. Distance of 3 mm or more was significant [11].

Patient outcome measures included knee society score (KSS) to assess knee function at final follow-up and Western Ontario and McMaster Universities osteoarthritis index (WOMAC) to study patient's Quality of Life (QOL) [12]. We used a translated and validated Arabic version of the WOMAC index called "Sfax modified WOMAC" which psychometric properties considers cultural and linguistic specificities of Tunisian people [13].

Results

Of the 317 TKAs performed between 2015 and 2019, 106 patients were selected for the study according to inclusion and exclusion criteria. Fourteen patients were operated on both sides, thus 120 TKAs included.

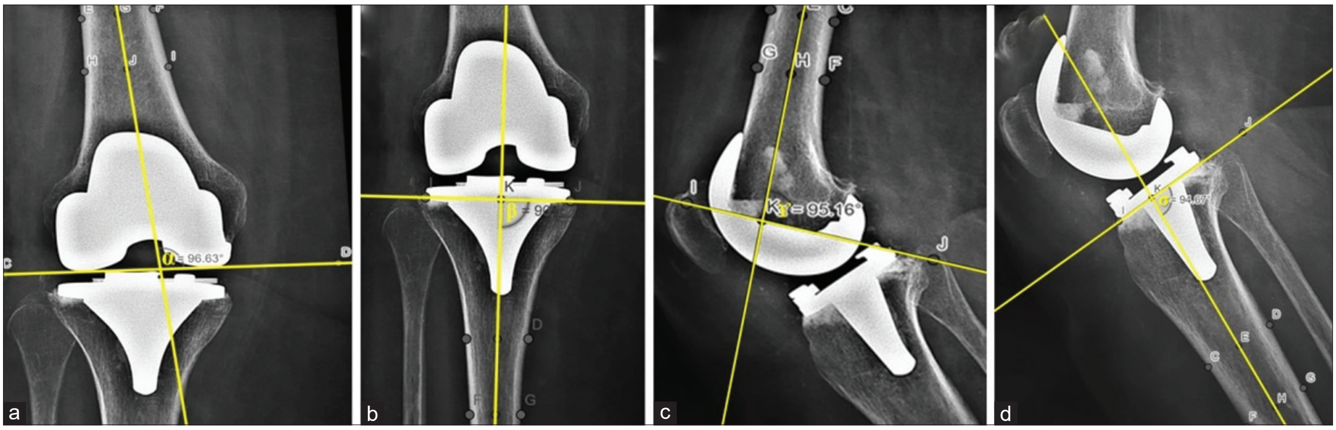

Figure 1: Methods used to assess total knee arthroplasty components position parameters. (a). Coronal femoral angle measured between the femoral anatomical axis and the tangent line to femoral condyles; (b) coronal tibial angle measured between the tibial anatomical axis and the tangent line to the tibial component's plate; (c). sagittal femoral Angle measured between the femoral shaft axis' lateral projection and the femoral component's neutral line; and (d). sagittal tibial angle measured between the tibial shaft axis' lateral projection and the tangent to the tibial tray

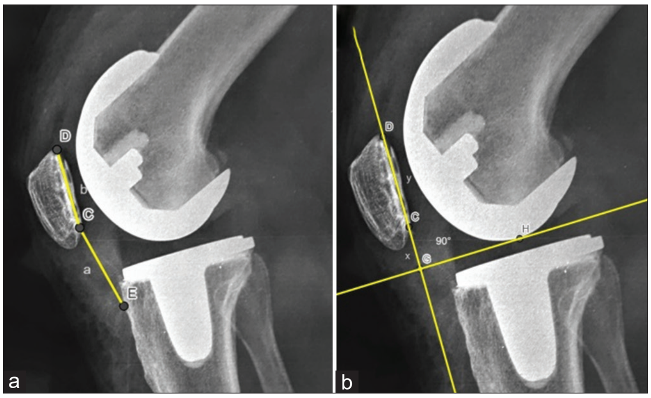

Figure 2: Methods assessing patellar height after total knee arthroplasty. (a) Modified Insall-Salvati ratio: Determined as the distance between the most distal point of the patellar articular surface and the insertion of the patellar tendon (CE) divided by the length of the patellar articular surface (CD); and (b) Blackburne and Peel ratio: Measured as the length of an orthogonal line from the joint line (GH) divided by the patellar joint surface (CD)

Patients' mean age was 70 years old (range 50–87). Gender ratio was 0.25 with a clar female predominance. Fifty patients were rated as ASA I, 32 as ASA II, and 24 as ASA III. According to Kellgren-Lawrence classification, knee osteoarthritis was grade II in 11 cases, grade III in 44 cases, and grade Iv in 65 knees.

Medial parapatellar approach and posterior stabilized knee prosthesis were used for all cases. After surgery, all patients underwent a standard rehabilitation program.

Figure 3: Oversized femoral component of total knee arthroplasty: Abnormal space between the implant and the femoral anterior cortex

Mean follow-up was 3 years ranging from 1 to 5 years.

Mean value of HKA angle was 177.59°, which corresponded to an overall alignment of 2.41° of varus on average. HKA extreme values were 10° of varus and 6° of valgus.

Mean value of cFA angle was 95.49° ± 2.95°, which corresponded to a mean coronal alignment of the femoral component of 5.49° valgus. Extreme values were 7.31° of varus and 14.82° of valgus. cTA angle was 87.83° on average, indicating a 2.16° of tibial component's varus. Extreme values were 9.61° of varus and 4.72° of valgus.

Mean sFA angle was 89.22° ± 4.47°, which corresponded to a mean femoral component's flexum of 0.7°. Average value of sTA angle was 87.37° ± 3.24°, indicating a posterior tibial slope of 2.6°. Extreme values were 5° of anterior orientation and 10° posterior.

Mean mISR was 1.35 and BPR was 0.72 on average. Based on the evaluation of these two indexes, we counted 19 PB and 7 PPB.

Mean pre-operative PCO was 26.4 mm (range 21.1–34.2 mm), while mean post-operative PCO was 24.4 mm (range 16.1–32.8 mm). PCO was increased after the surgery with a mean difference at 2 mm ± 1.6.

Femoral component was oversized in 18 TKAs and undersized in 6. Regarding tibial component's dimension, implants were oversized in ten cases and three were undersized.

Mean WOMAC was 13.25 with a range of 1–38. Mean KSS was 65.35 points for the function score and 80.46 points for the knee score.

There was a statistically significant association of overall femorotibial alignment and tibial coronal alignment with KSS and WOMAC score. Femoral coronal alignment and sagittal alignment of the two components did not affect functional outcome (Table 1).

Patella height according to both methods of assessment was significantly associated with functional outcome (Table 1).

Table 1: Association between the alignment parameters and clinical scores

Parameters	Mean	KSS p	WOMAC p
HKA	11.59°	0.00	0.00
cFA	95.49°	0.516	0.689
cTA	87.83°	0.00	0.00
sFA	89.22°	0.982	0.611
sTA	87.37°	0.889	0.329

KSS: Knee society score, HKA: Hip-knee-ankle angle, cFA: Coronal femoral angle, cTA: Coronal tibial angle, sFA: Sagittal femoral angle, sTA: Sagittal tibial angle, WOMAC: Western ontario and mcmaster universities osteoarthritis index.

Changes in PCO did not affect mean KSS and WOMAC score.

Comparing different groups of component sizing, we found that femoral sizing and tibial oversizing affected only the WOMAC score (Table 2).

Table 2: The relationship between implant size and functional outcomes

	KSS p	WOMAC p
Femoral component		
Undersize	0.11	0.017
Oversize	0.165	0.031
Tibial component		
Undersize	-	-
Oversize	0.229	0.041

KSS: Knee society score, WOMAC: Western ontario and mcmaster universities osteoarthritis index.

Discussion

According to our results, we identified three radiological parameters that influenced functional results: global alignment of the limb, frontal alignment of the tibial component, and patellar height.

As for the patient's QOL, it was influenced by the three parameters mentioned above as well as the size of femoral component and the oversized nature of the tibial component.

Alignment

KSS and WOMAC score were better for neutral alignment (0 ± 3°).

This neutrality has been advocated by several authors including Choong *et al*. [14] who concluded that patients with a frontal alignment of <3° to a neutral axis had higher functional scores at 6 weeks, 3 months, 6 months, and 12 months after surgery.

A systematic review of literature published in 2014 by Gromov *et al*. [15] concluded that neutral frontal alignment remains the gold standard, and it should therefore be targeted for any TKA.

Our study also showed that frontal orientation of the tibial component influenced both clinical assessment scores. This was confirmed by Longstaff *et al*. [16] and Rassir *et al*. [17].

A varus of more than 3° when implanting the tibial component is responsible for an alteration of the load distribution by increasing shear forces at the femoral-tibial interface causing premature wear of the polyethylene on the medial side [15]. Varus >3° has also been implicated by Berend *et al*. [18] in increasing the risk of medial abutment collapse.

Recently, the kinematic alignment concept replaced the need for a neutral HKA angle. He kinematic alignment concept was defended by many authors including Gao *et al*. through a meta-analysis of randomized controlled trials published in 2020 [19]. This meta-analysis showed that kinematic alignment had better results than mechanical alignment for WOMAC score, KSS, and knee range of motion in short-term outcomes.

Young *et al*. [20] in a randomized controlled trial published in 2020 found no difference in clinical and radiological outcomes between mechanically and kinematically aligned TKAs at 5 years postoperatively. He also pointed out that loosening should remain a long-term concern because a high proportion of patients in the kinematic alignment group had their tibial component inserted in varus.

We did not find a relationship between sagittal orientation of the two prosthetic components and postoperative outcome. In a systematic review published in 2016 by Hadi *et al*. [21], no study found any relationship between sagittal misalignment and functional scores.

Murphy *et al*. [22] showed that positioning the femoral implant in 4° flexion improved knee flexion. However, he concluded that this improvement had no functional benefit at 1 year postoperatively.

The role of tibial slope in relation to clinical outcomes has always been a controversial issue. Singh *et al*. [23] studied 209 posteriorly stabilized TKAs and concluded that restoration of the preoperative tibial slope allows for maximum knee flexion. Posterior tibial slope should be between 0 and 7°, excessive posterior slope may decrease implant survival and lead to instability, anterior slope may be responsible for reduced postoperative flexion [15].

Patellar height

PB after TKA is secondary to shortening of the patellar tendon, whereas elevation of the joint space is responsible for PPB [7].

Behrend *et al*. [24] reviewed 282 TKAs and concluded that lowering the BPR can lead to a major restriction in joint range of motion associated with a poor functional outcome.

Our results were also supported by Kazemi *et al*. [25], and Chonko *et al*. [26].

PB is an iatrogenic complication, the excision of Hoffa's fat, the lateral release, and aggressive intraoperative manipulation can lead to tendon ischemia and shortening [25], [27], [28]. Eversion of the patella has also been incriminated by some authors, as the development of minimally invasive approaches without patella eversion has been accompanied by a decrease in the incidence of this complication [29].

Change in joint line level responsible for PPB is the result of an overly generous femoral cut or an insufficient tibial cut with implantation of a baseplate or insert thicker than the resected bone [7].

PCO

Our study showed no influence of PCO restoration on neither flexion amplitude nor clinical evaluation scores.

This can be explained by referring to Arabori *et al*. [30] who studied the difference in flexion amplitude according to the reduction or not of PCO in two groups; the first had posterior cruciate ligament preserving TKA; and the second had posterior stabilized TKA. He concluded that reduction in PCO influences joint flexion only in the posterior cruciate ligament sparing prostheses.

Fluoroscopic study of the two types of prosthesis showed that the posterior-stabilized variant systematically reproduced the femoral roll back during flexion, whereas anterior translation can occur with the posterior cruciate ligament preserving prosthesis [31], [32].

Therefore, the “post-cam mechanism” of the posterior-stabilized prosthesis would have the effect of preventing anterior translation of the femur and posterior subluxation of the tibia opposing posterior impingement regardless of the PCO variation [33].

Femoral implant sizing

We showed that femoral component’s size had a significant influence on the QOL index. Barnes and Scott [34] related the pain from an oversized femoral component to impingement of the popliteus tendon causing painful tenosynovitis. Oversizing of the femoral component is also considered to be one of the factors responsible for post-operative stiffness as reported by Lo *et al*. [35].

Tibial implant sizing

The incidence of tibial component size abnormalities in our study was 11%. 8.5% of the implants were oversized and 2.5% were undersized. This incidence was comparable to that found by McArthur *et al*. [36] in his series of 532 TKAs.

Lateral overhang was more common than medial overhang. This was probably due to the approach used. In fact, medial arthrotomy would allow less exposure of the lateral compartment, especially posteriorly.

Our study showed that patients who had an oversized tibial component had a worse QOL index.

Bonin *et al.* [37] concluded that mediolateral oversizing is responsible for post-operative residual pain, flexion limitation, and poor overall functional outcome.

Liu *et al*. [38] and Nielsen *et al*. [39] showed that medial oversizing is more harmful and one of the major factors in post-operative pain. This has been attributed to irritation of the medial collateral ligament.

Strengths and limitations of the study

The strengths of this study are evidenced by the radiological evaluation, which was based on conventional radiology, a standard technique, low cost, easily accessible to the orthopedic surgeon, and reproductible in daily practice.

Evaluation strategy adopted was based on three main lines: mechanical alignment of the prosthesis, patellar height, and size of the prosthetic parts.

Our approach was based on the use of an objective score and a QOL index.

The latter consists of a self-questionnaire that assesses the impact of a disease and the possible improvement brought about by treatment [40]. We used the “Sfax modified WOMAC” which was more adequate for the study sample [13].

The knee society clinical rating system is concise and easy to use. It represents a clear attempt to separate knee function from overall patient function. A major study of the validity and responsiveness of this rating system has been published [41].

A limitation of this study was that we included 120 prostheses in our study, a relatively small number to assess the impact of certain parameters such as implant size. Axial or rotational alignment of the implants was not studied, as it needs CT scan for evaluation. To be able to project our results on the daily practice, we limited ourselves to the study of the parameters noted on standard radiographs.

Conclusion

While performing TKA, surgeon should consider several parameters to improve functional status of the knee and patient’s QOL. He should aim to limb’s mechanical alignment, verify tibial component’s frontal positioning, choose the perfect size of implant, and avoid approximative measures. Patellar hight should be preserved by avoiding iatrogenic lesions of the patellar tendon and modification of the joint line level.

A study with a better level of proof, prospective, and multicentric with a large representative sample with different evaluation times would allow us to confirm and improve our results and recommendations to optimize TKA outcomes and eventually get closer to the “forgotten knee” concept.

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