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Original Research Article

The role of the femoral anterior offset index on the degree of flexion in total knee arthroplasty

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ABSTRACT

Background: Anterior projection of the femoral condyles is often disregarded as an issue in knee arthroplasty. Overstuffing the patellofemoral joint may limit knee flexion and be a source of patellofemoral complications, thus having an impact in satisfaction rates after total knee arthroplasty (TKA). Our hypothesis is that excessive anterior projection of the femoral condyles as a negative effect in flexion range after TKA, introducing a new concept, the anterior offset index (AOI).
Methods: From a group of 99 consecutive patients who underwent TKA using patient specific instrumentation (PSI), we selected the patients with good pre-operative flexion range (above 90º) and a 6-minute walk test (6 MWT) ≥ 0 meters, evaluating the correlation between the AOI and the flexion range. A total of 23 patients were included in the study.
Results: A moderate and positive correlation (r=0.488; p=0.018) between AOI and flexion range was found.
Conclusions: Our results seem to indicate that the AOI influences postoperative flexion in TKA, in patients with a good pre-operative flexion and good functional outcome. AOI is an important concept to retain when optimizing knee flexion and minimizing patellofemoral complications. However, more studies need to be done in order to clarify the role of all the factors influencing post op flexion after TKA.

Keywords: Total knee arthroplasty, Anterior offset index, Knee flexion, Patellofemoral joint, Patellofemoral kinematics, Anterior knee pain

INTRODUCTION

Total knee arthroplasty (TKA) is a complex surgery where anatomic knowledge is essential for adequate surgery performance. Previous studies demonstrated the need for correct sizing and rotational alignment for good clinical outcomes[1]. The patellofemoral joint anatomy represents a significant challenge when striving to achieve deep knee flexion, while preserving proper patellofemoral tracking [2].

Patellofemoral overstuffing seems to be associated with patellofemoral maltracking[3, 4], increased polyethylene wear, painful TKA, aseptic loosening of the patellar component and decreased knee flexion – on average, for every additional 2 mm of composite patella thickness, knee flexion decreases by 3º, as shown by Bengs et al. [2]. As the knee arthroplasty procedure further develops, better outcomes are expected. Frequent causes for overstuffing are inadequate patellar resection, implanting an oversized patellar component, or anterior translation of the femoral component [5].

It is theorized by the authors that the anterior femoral condyle's length also plays also a role on the patellofemoral dynamics of TKA. The femoral

components do not fully reproduce the patient's anatomy, thus, knees with a less prominent native anterior condyle have a higher risk of patellofemoral overstuffing, which may be reflected in decreased postoperative flexion, stiffness and anterior pain.

The anterior offset index (AOI) was developed by the authors to assess the anterior projection of the native femoral condyles, resorting to the lateral image of the knee. This index relates the distance of 3 parallel lines: (A) tangent to the anterior cortex of the femur, (B) tangent to the most anterior point of the femoral condyles and (C) tangent to the most posterior point of the femoral condyles, where AOI = AB / BC x100 (Figure 1). This index is higher when the anterior condyle projection is highest.

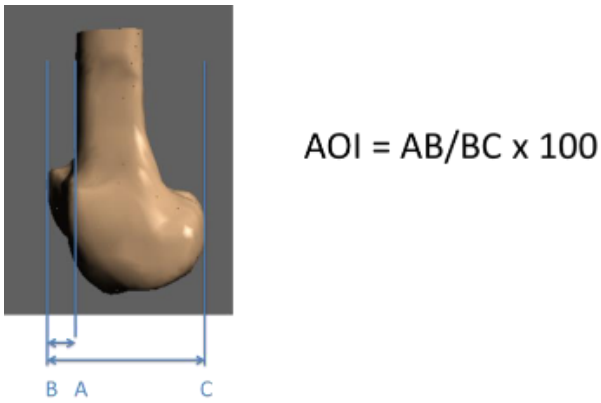

Figure 1: AOI index.

Preoperative determinants of TKA such as function, pain and general health related quality of life (HRQoL), have been previously studied with the results being divergent and in many cases contrary.[6-8] Satisfaction rates after total knee arthroplasty (TKA) are high, although very variable between series, ranging from 75 to 89%.[9-12]

Objective

The objective of the study was to test the hypothesis of a positive association of native anterior femoral condyle length and improved flexion after TKA and, using a non-validated new tool created by the authors - AOI. Secondary objectives included testing the hypothesis of the association of AOI and the functional 6MWT test.

METHODS

A retrospective, single-center, cross-sectional study was performed using a sample of 99 patients submitted to unilateral TKA in a single institution, during the first 6 months of 2016. Procedures were performed through a standard medial parapatellar approach, implanting cemented Legion Primary TKA, without a patellar implant. Instrumentation was performed with Smith & Nephew's Visionnaire™ customized planning by the same surgical team.

Patients were submitted to magnetic resonance imaging (MRI) prior to surgery, with the images being used to create a 3D model of the knee to evaluate their Anterior Offset Index. Other recorded measures were knee flexion and the gait perimeter by the 6 minute walk test (6MWT), preoperatively and 6 months post-operatively.

The defined inclusion criteria were: pre-operative flexion range greater than 90º and gains in the 6MWT during the follow-up period, aiming to minimize other factors that negatively influence the post-op flexion.

Statistical analysis

Analysis was done using the Statistical Package for Social Sciences (SPSS®) v.25. For the descriptive statistics of the categorical variables, we calculated absolute and relative frequencies. Descriptive analysis was conducted on demographic variables, re-operative knee flexion, 90-day knee flexion, knee flexion variation, pre-operative 6MWT, 90-day 6MWT, 6MWT variation, AB, BC and AOI.

Symmetric variables were described with mean, the standard deviation and the maximum and minimum values and asymmetric variables with median values and percentile values at P25 and P75. The gender differences were analyzed with the Mann-Whitney test.

The correlation analysis between the variables (AOI, Pre-operative knee flexion, knee flexion variation, pre-operative 6MWT and 6MWT variation) was performed using the Pearson's correlation coefficient and the criteria for separating low, moderate, good and strong correlation levels used, were 0.3, 0.5 and 0.7, respectively. The significance level considered was 0.05.

RESULTS

Considering the total sample, and the inclusion criteria, 23 patients were analyzed. The sample was formed predominantly by women (n=12; 52.2%) and the mean age, weight and height were 70.5 years (±8.3), 74.5 kg (±12.1) and 1.63m (±9.4), respectively (Table 1). The sample included 13 individuals submitted to right knee surgery (56.5%). Table 1 also shows the descriptive statistics of the variables under study. The value of the postoperative flexion of the sample was 106.7±10.8º with range between 90º and 127º, while the variation of pre and postoperative flexion was -3.6±20.2º with range between – 38º and 30º. As for AOI, its mean value was 13.99±3.0, with limits between 8.48 and 20.39. Gender analysis revealed no significant differences, except for the AB distance (p=0.002), whose lowest value was observed in women (65.83±4.3 mm versus 73.18±4.1 mm) (Table 2).

Table 1: Characteristics of the sample (n=23).

	N (%)
Gender	
Female	12 (52,2)
Male	11 (47,8)
Age (years), mean (SD)	70,5 (8,3)
Height (m), mean (SD)	1,63 (9,4)
Weight (kg), mean (SD)	74,5 (12,1)
Pre-operative Knee Flexion (degrees), mean (SD)	110,4 (14,4)
Pre-operative 6MWT* (meters), mean (SD)	244,5 (72,5)
90-day Knee Flexion, mean (SD)	106,7 (10,8)
90-day 6MWT*, mean (SD)	352,4 (87,9)
Knee flexion variation, median [P25;P75]	-8,0 [-18,0;14,0]
6MWT* variation, mean (SD)	107,8 (87,3)
AB (mm), mean (SD)**	69,34 (5,6)
BC (mm), mean (SD)**	9,73 (2,4)
***AOI, mean (SD)**	13,99 (3,0)

*6MWT–6 meters walk test; **AB and BC–distances in reference to Figure 1; ***AOI – Anterior offset index

Table 2: Sociodemographic descriptive statistics of the sample, by gender (n=23).

	Females n=12 (52.2%)	Males n=11 (47.8%)	P value*
Age (years), mean (SD)	71.8 (7.2)	69.2 (9.5)	0.60
Pre-operative knee flexion (degrees), mean (SD)	107.8 (12.0)	113.1±16.9	0.20
Pre-operative 6MWT (meters), mean (SD)**	226.3±57.7	264.5±84.0	0.27
90 days Knee Flexion, mean (SD)	106.4±12.4	107.1±9.3	0.80
90 days 6MWT, mean (SD)**	324.6±67.8	382.6±100.0	0.15
Knee flexion variation, mean (SD)	-1.4±17.7	-6.0±23.3	0.44
6MWT Variation, mean (SD)**	98.3±83.2	118.2±94.5	0.67
AB* (mm), mean (SD)**	65.83±4.3	73.18±4.1	0.001
BC* (mm), mean (SD)**	9.48±1.8	10.0±3.0	0.95
AOI**, mean (SD)**	14.39±2.5	13.56±3.6	0.58

*p value=0.05; ** 6MWT – 6 meters walk test; *** AB and BC – distances in reference to Figure 1; **** AOI – Anterior Offset Index.

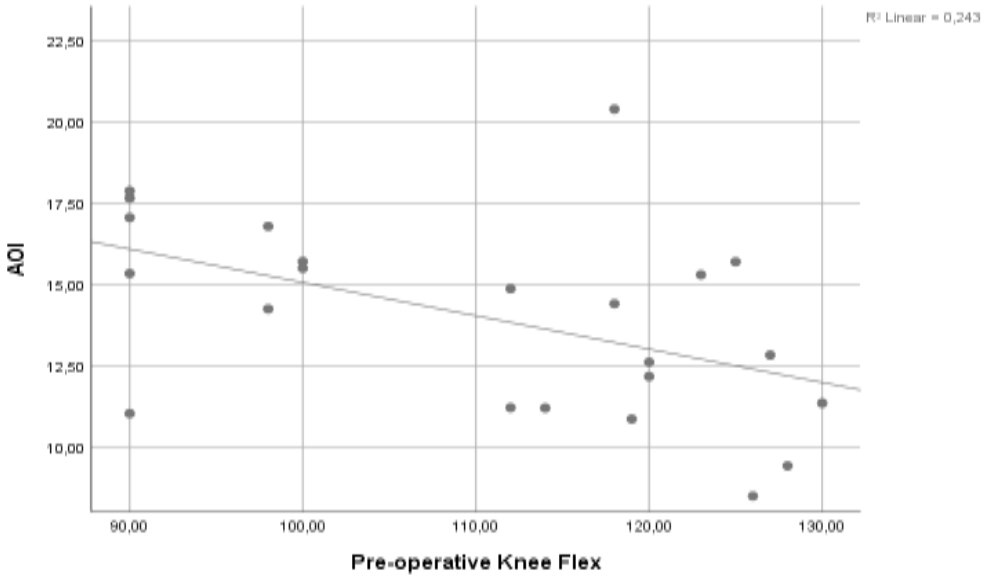

Figure 2: Scatter-plot with AOI and pre-operative knee flexion correlation.

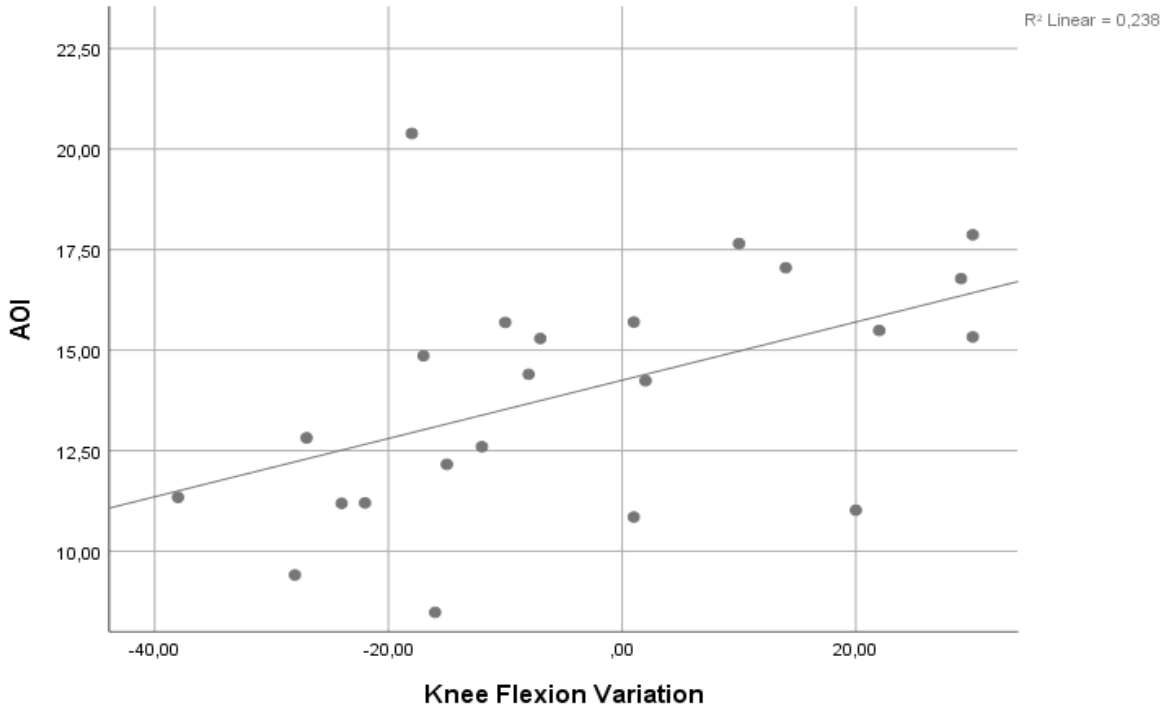

Figure 3: Scatter-plot with AOI and knee flexion variation correlation.

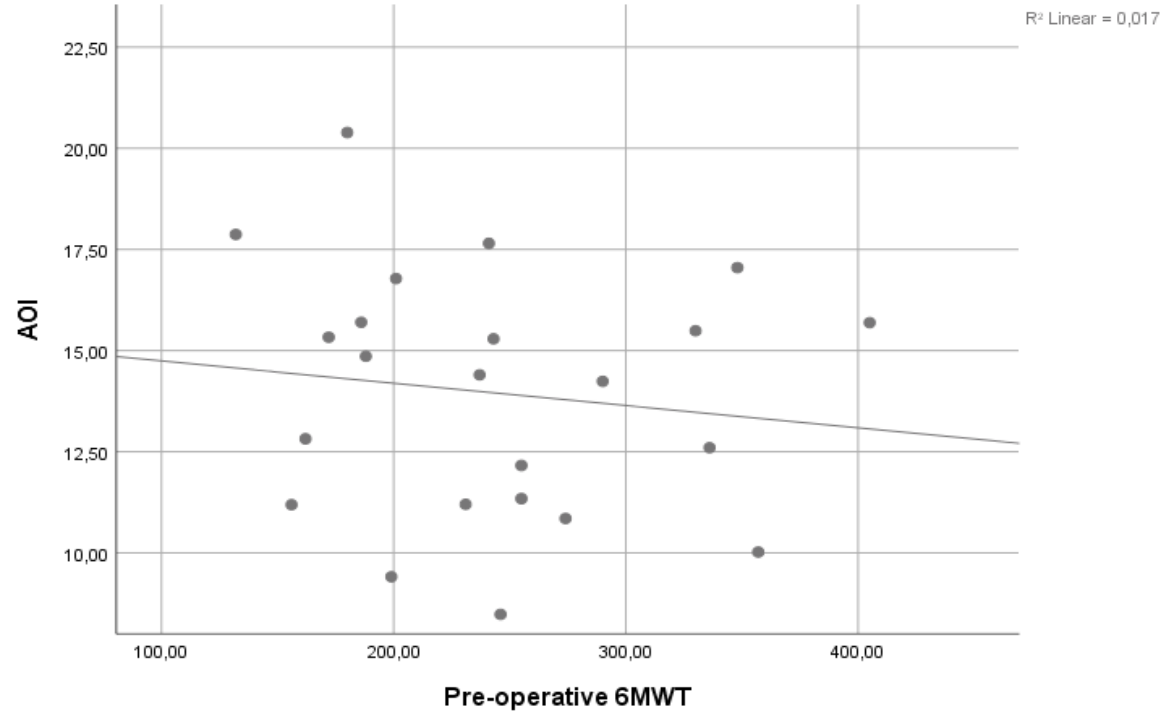

Figure 4: Scatter-plot with AOI and pre-operative 6MWT correlation.

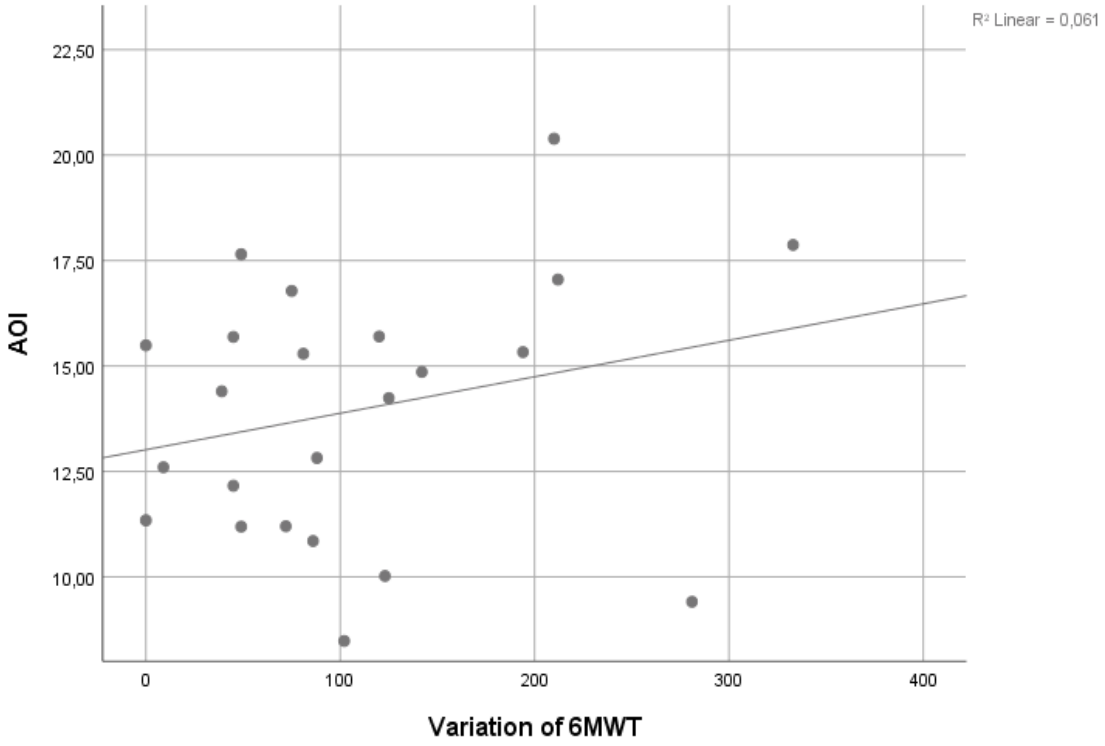

Figure 5: Scatter-plot with AOI and 6MWT variation correlation.

Pearson correlation coefficients demonstrated a moderate and negative correlation (r -0.493; p=0.017) for AOI and pre-operative knee flexion and a moderate and positive correlation (r=0.488; p=0.018) between AOI and postoperative knee flexion variation (Figure 2 and Figure 3 respectively).

AOI and pre-operative 6MWT demonstrated a low and negative correlation (r -0.131; p=0.55) and low and positive correlation (r=0.247; p=0.26) between AOI and postoperative 6MWT variation (Figure 4 and Figure 5 respectively).

DISCUSSION

In TKA there is a concern to reproduce the original anatomy in the implant,[13] reproducing the thickness of the bone removed. This concern is evident in the distal and posterior femur and also the proximal tibia, frequently neglecting the anterior femoral cut. Our results show a correlation of the relative anterior condyle projection with the post-operative flexion range. AOI will not be a major determinant of the mobility outcome in patients undergoing TKA but, as its role as shown by Bracey.[5]

The option to select the cases with pre-operative knee flexion greater than 90º is related to the attempt to reduce the impact of a major determinant of postoperative flexion, which is preoperative flexion. Selecting the patients with a positive gait perimeter differential, tries to exclude cases in which other complications influence the evaluation.

The use of precise TKA planning, such as patient specific instrumentation (PSI), allows detailed fine tuning.[14] If, as the study demonstrates, the AOI interferes with postoperative flexion, it is reasonable to think that in extreme AOIs, planning should take this into consideration, eventually trying to compensate the relative overstuff in the smaller AOIs with a more proximal distal femoral cut, femoral implant flexion or with alterations on the Implant design. We could not totally exclude other factors known to be involved in the post-op flexion, such as the posterior offset, body mass index, among others; a paired evaluation would be more effective. It will be important in the future to design a randomized study with a larger number of patients, in order to clarify the role of AOI in total knee arthroplasty, as well as to define cut-off values for which post-operative flexion may be affected.

CONCLUSION

AOI seems to influence post-operative flexion range in patients undergoing TKA, particularly in patients with a good pre-operative flexion and good functional outcome, thus we recommend considering AOI during TKA planning.

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Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

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