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Adequate joint line restoration and good preliminary clinical outcomes after total knee arthroplasty using the Flexion First Balancer technique

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ABSTRACT

Introduction: Up to 20% of patients are dissatisfied after total knee arthroplasty (TKA). Factors which could possibly contribute to this dissatisfaction are a decreased posterior condylar offset (PCO) and subsequent joint line elevation which leads to mid-flexion instability. The Flexion First Balancer (FFB) technique aims to adequately restore the medial PCO and thereby reconstruct the medial native joint line to its pre-disease height.
Methods: A retrospective cohort of 59 patients operated using the FFB technique was analyzed and matched with a historic measured resection (MR) cohort of 59 patients. Groups were matched for age, gender, BMI and ASA classification. Joint line and PCO changes as well as patient reported outcome measurement scores (PROMs) were evaluated at one year [1.0 – 1.6] postoperatively.
Results: Radiographic evaluation revealed no changes in joint line height in the FFB group, whereas an elevation in joint line was seen in the MR group ($p = 0.002$). The PCO increased after surgery in both group without any statistically significant differences. Evaluation of PROMs found no differences between the two groups for total OKS and KOOS scores, nor in re-operation or complication rates.
Conclusion: The FFB technique seems to be a safe technique to use in TKA and reconstructs the pre-disease joint line in contrast to the MR technique. The clinical outcomes were comparable between both groups.

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1. Introduction

Total knee arthroplasty (TKA) is an effective surgical intervention in patients with end-stage knee joint degeneration [1]. It has proven to alleviate pain, restore function and improve patients' quality of life [2,3]. However, approximately one out of five patients undergoing this type of surgery are dissatisfied at one year postoperatively [4,5]. From a surgeon's perspective, optimal

Abbreviations: (c)ATJL, (corrected) adductor tubercle joint line distance; FFB, Flexion First Balancer; FW, femoral width; MR, measured resection; (c)PCO, (corrected) posterior condylar offset; TKA, total knee arthroplasty.

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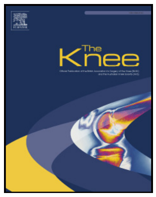

prosthesis placement is key for a good functional outcome. Therefore, restoring the joint line to its pre-disease height might improve post-operative clinical outcomes after TKA [6].

Primary TKA surgery leads to a mean joint line elevation of three millimeters (mm) [6]. In order to maintain a symmetrical flexion and extension gap the posterior condylar offset (PCO) needs to decrease as well. Therefore, the flexion axis of the knee will be positioned more proximally and ventrally and the medial collateral ligament will lose its isometric contraction ability in the mid-flexion range (0–90° flexion). The theory that a raised joint line results in mid-flexion instability has been proven in a cadaver studies [7,8]. Restoring the medial joint line height to its pre-disease height is advocated by experts to achieve a balanced knee [9].

For this reason, the Flexion First Balancer (FFB) has been developed. This new technique was designed to enable the surgeon to reproduce the medial pre-disease joint line and PCO. It restores the medial PCO, which is used to determine the tibial build-up. When the joint line is set in the flexion position (i.e. tibial and posterior femoral cuts are performed), the extension gap is subsequently matched to the flexion gap with the use of a balancer. With the use of balancers, the distal femoral resection level and angle and femoral component rotation are determined. No additional ligament releases are performed.

The aim of this study was to compare the FFB technique to a matched control group, using the conventional measured resection technique (MR), and evaluate the post-operative changes in joint line height and PCO. Furthermore, complication rates, reoperation rates and patient reported outcome measures scores (PROMs) were compared after one year of follow-up. Our hypothesis was that the joint line height is better restored in the FFB group, which leads to superior PROMs.

2. Material and methods

2.1. Study design

The FFB technique was introduced in September 2015. A cohort of patients who underwent TKA that were performed with the use of the FFB technique by two orthopedic surgeons in the period between September 2015 to September 2016 was studied retrospectively. A matched control group was composed from a historic cohort of patients who underwent TKAs that were performed using the MR technique by the same orthopedic surgeons between September 2014 and August 2015 (RvG or LE). In all patients a cruciate retained (CR) type, Vanguard Complete Knee System (Biomet Orthopedics, Warsaw, IN, USA) implant was used. Matching was performed based on age, gender, Body Mass Index (BMI), and American Society of Anesthesiologists (ASA) classification. No Medical Ethical Committee approval was needed for this retrospective chart study, as no addition radiographs or questionnaires were obtained.

2.2. Surgical technique FFB

A standard midline skin incision and medial para-patellar arthrotomy is followed by a perpendicular tibial cut. This is set at six millimeters below the intact medial posterior cartilage. A preliminary five millimeters distal femur cut is made to obtain a flat surface for the following steps. After removal of medial and lateral osteophytes the Flexion Balancer is placed with the knee in 90° of flexion to determine the correct posterior offset. The system references of the intact posterior cartilage of the medial femur condyle to recreate the joint line height and uses ligament tension to set femoral rotation. The flexion gap should read at least 10 mm, if not, an extra tibial cut should be performed to accommodate the implant. This way joint line elevation is prevented. Drill holes are made throught the balancer and a slotted four-in-one cutting guide is placed. The posterior and anterior cuts can be made at this point. After removing posterior osteophytes the extension gap is matched to the flexion gap with the use of balancers. In case of a trapezoid extension gap the medial collateral ligament (MCL) and lateral collateral ligament (LCL) can be tensioned equally with the use of wedges. These come in one, two, three and four degrees of varus or valgus. By using wedged spacer blocks the distal valgus angle of the femur is adjusted to create a rectangular extension gap. When the extension gap is adequately balanced the drill guide is placed to set the final distal resection level. Finally, the chamfers cuts are made through the previously used slotted four-in-one cutting guide. From this point on, the orthopedic surgeon continues with the standard technique to finish preparing the femur, tibia and patella and prosthesis placement.

2.3. Data collection

Patient medical records were reviewed, and data was collected preoperatively and at six weeks and one year postoperative (as standard practice in our hospital). No patients were lost to radiographic follow-up. Collected data consisted of the maximum degree of flexion of the knee, the occurrence of complications, and the need for re-operations. PROMs data were gathered for all included patients preoperatively and at three and 12 months post-operatively. Standard PROMs consisted of the Oxford Knee Score (OKS) [10], the Knee injury and Osteoarthritis Outcome Score (KOOS) [11], and Visual Analogue Scale (VAS) scores regarding pain, disability and satisfaction. VAS scores range from 0 to 100, in which a score of 100 is the worst possible outcome.

2.4. Radiological analysis

For radiographic analysis JiveX software (Visus Technology Transfer GmbH, version 4.7.1.10, Bochem Germany) was used. The researcher was blinded for the operation technique while performing the radiological measurements. Joint line changes were assessed on anteroposterior (AP) weight-bearing X-rays of the knee, in which we used the medial adductor tubercle as reference point. The joint line height was defined as the perpendicular distance between the adductor tubercle and the joint line (ATJL) (Figure 1). This reference point has proven to be accurate and reproducible to evaluate joint line height pre- and postoperatively

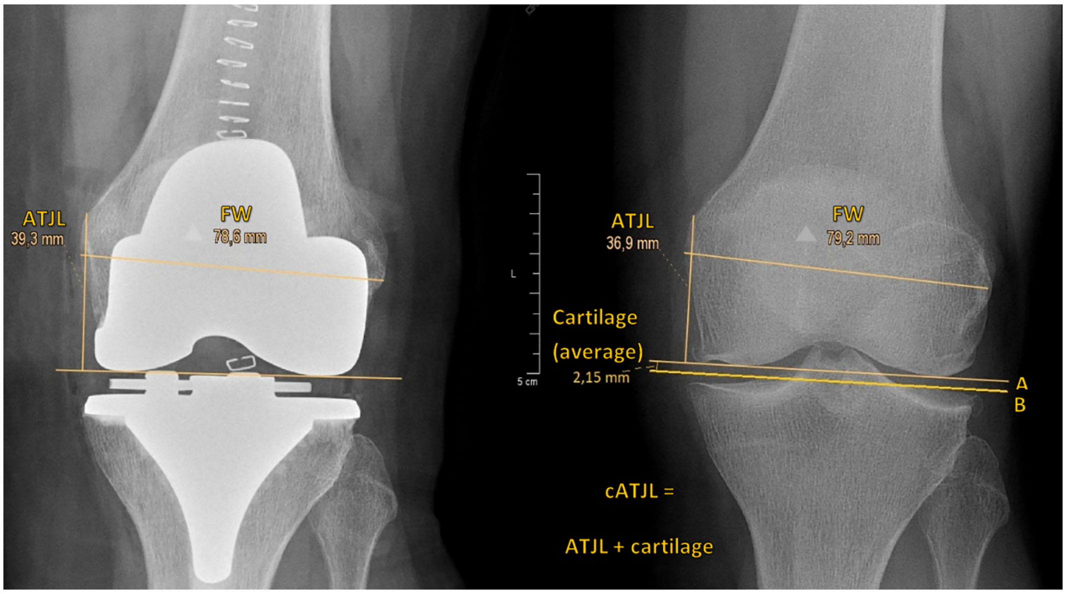

Figure 1. Radiological measurements for joint line changes pre- and postoperative. The right preoperative figure was taken eight years before surgery. At the time of surgery the patient had bone-to-bone osteoarthritis on the medial side. This radiograph was selected to elaborate more clearly the preoperative radiological measurement correction. Abbreviations: ATJL: Adductor tubercle joint line distance; FW: Femoral width; cATJL: corrected adductor tubercle joint line distance; A: joint line bony edge femur; B: actual joint position.

[12]. Hence, a decrease in ATJL indicates a proximalization of the joint line. To minimize the error in the measurement of the ATJL, only patients without bone-loss on the preoperative AP radiographs were included in the analysis. With regard to the preoperative X-rays, a line tangent to both distal femoral condyles was used as the joint line reference. Postoperatively, the distal border of the femoral component was used (i.e. actual joint line) (Figure 1). To estimate the true pre-disease joint line, one must compensate for the standard error in the pre-operative measurement, because the cartilage thickness was not included in this measurement (as it is not seen on X-ray imaging). A corrected ATJL (cATJL) was defined by adding the average cartilage thickness of the distal femoral condyl of 2.15 mm to the preoperative measured ATJL distance [13]. To correct for magnification errors we calculated the adductor ratio, which was defined as the ratio between the adductor height (ATJL) divided by the coronal femoral width (FW). The

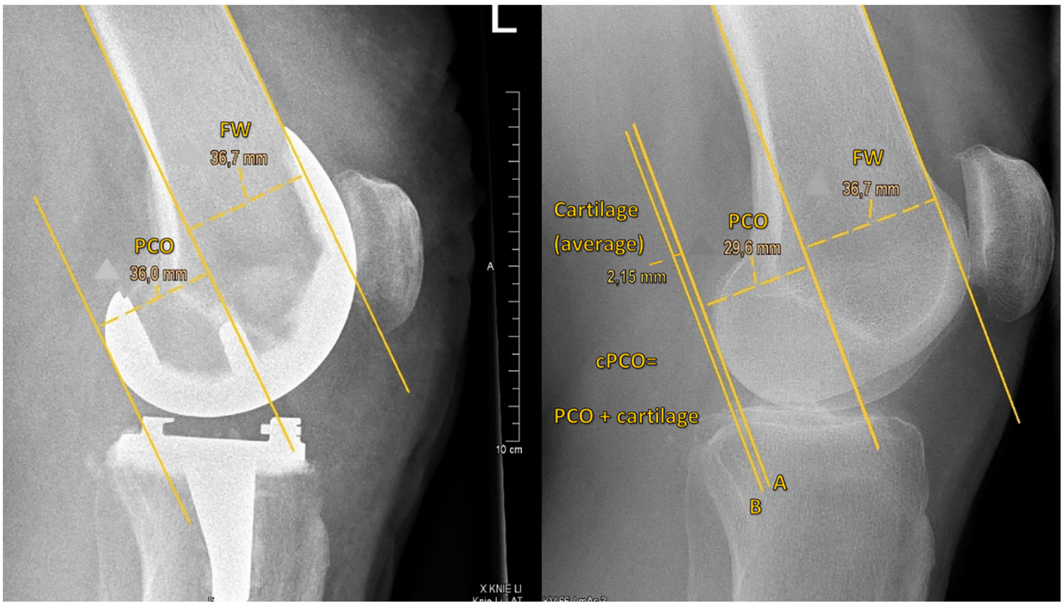

Figure 2. Radiological measurements for posterior conylar offset changes. The right figure shows a preoperative true lateral radiograph with complete overlap of the medial and lateral posterior condyl. The left figure shows a postoperative true lateral radiograph. Abbreviations: PCO: posterior condylar offset line distance; FW: Femoral width; cPCO: corrected posterior condylar offset distance; A: joint line bony edge femur; B: actual joint position.

Table 1
Patient characteristics.

	FFB group N = 59	MR group N = 59	p-Value
Gender (no. male)	21 (36%)	21 (36%)	N.S.
Age (mean ± SD)	66.8 (8.9)	68.1 (9.0)	N.S.
ASA (no. per category)			N.S.
I	10 (17%)	10 (17%)	
II	42 (71%)	42 (71%)	
III–IV	7 (12%)	7 (12%)	
BMI (mean ± SD)	29.5 (4.7)	29.4 (4.5)	N.S.
Fixed varus	1	2	N.S.
Fixed valgus	8	6	N.S.
Surgery time (mean ± SD)	76.6 min (14.6)	64.4 min (11.4)	<0.001
Blood loss (median + IQR)	300 ml (150–350)	120 ml (0–200)	<0.001

N.S. indicates a non-significant difference between the groups
ASA: American Society of Anesthesiologists; BMI:: Body Mass Index; SD: standard deviation; IQR: inter quartile range; FFB: Flexion First Balancer; MR: Measured resection

coronal FW is defined by the distance between the most external points of the medial and lateral epicondyles (Figure 1) [14]. Preoperatively, the cATJL was used and for postoperative calculations the ATJL was used.

Lateral X-rays of the knee were used to measure PCO. To minimize the error in the measurement of PCO, only patients of which true lateral radiographs were performed were included in the analysis. Radiographs in which complete overlap of the medial and lateral femoral condyles were defined as true lateral knee radiographs, as described by Hanratty et al. [15]. The preoperative PCO was measured on the true lateral radiograph, as the tangential distance between the posterior cortex of the femoral diaphysis and the apex of the posterior femoral condyle. The postoperative PCO was measured as the tangential distance between the posterior cortex of the femoral diaphysis and the apex of the posterior femoral component post-operatively. The lateral femoral width (FW) was defined as the tangential distance between two parallel lines through the anterior and posterior cortex of the femoral diaphysis (Figure 2). In the pre-operative PCO distance the cartilage thickness was not included in the measurement. Therefore, the corrected PCO (cPCO) was defined by adding the average cartilage thickness of the posterior femoral condyl of 2.15 mm to the preoperative measured PCO distance [13]. A ratio was then calculated for PCO, the PCO ratio, to adjust for radiographic magnification errors. Preoperative PCO ratio was calculated using the formula: cPCO/(cPCO + lateral FW). Likewise, postoperative PCO ratio was calculated using the formula: PCO/(PCO + lateral FW). A similar method has previously been used by Yang et al. [16].

2.5. Statistical analysis

Baseline characteristics were compared between the groups using Chi-square tests for categorical and independent samples t-tests for continuous data. Flexion and extension data, radiological outcome parameters and PROMs were analyzed with two-way

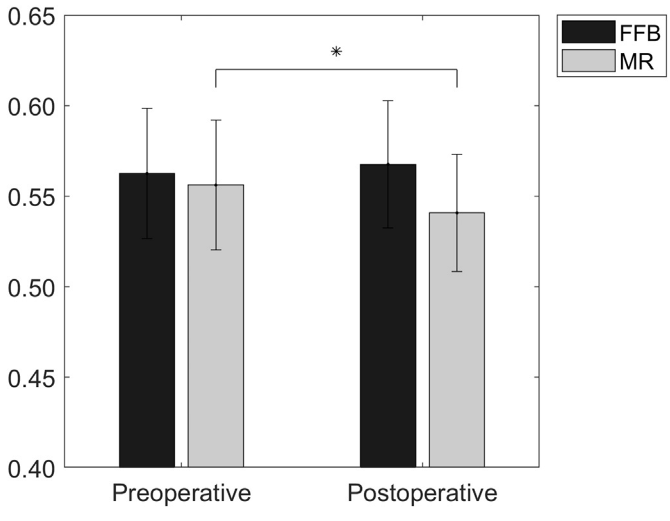

Figure 3. Joint line adductor ratio results for the FFB and MR group. Black bars present the data of the FFB group and the gray bars present the data of the MR group. The left side demonstrates the preoperative data and the right part the postoperative data. Error-bars represent one standard deviation. (Note that a decrease in joint line adductor ratio represents an increase in joint line). FFB: Flexion First Balancer group; MR: Measured Resection group; *: significant effect ($p < 0.05$).

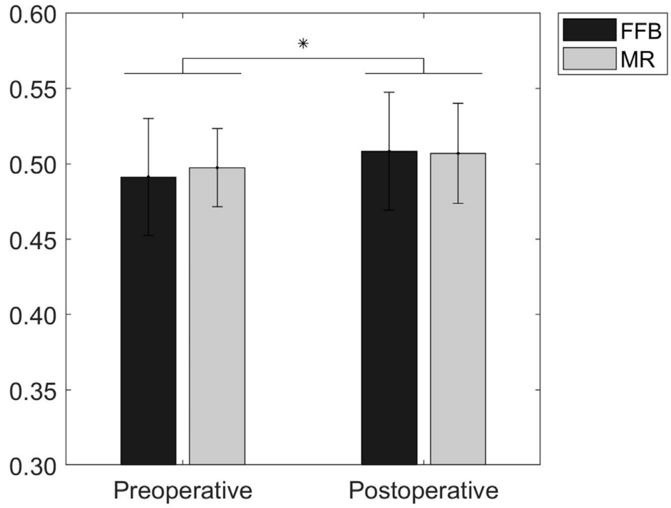

Figure 4. Posterior condylar offset ratio results for the FFB and MR group. Black bars present the data of the FFB group and the gray bars present the data of the MR group. The left side demonstrates the preoperative data and the right part the postoperative data. Error-bars represent one standard deviation. FFB: Flexion First Balancer group; MR: Measured Resection group; * indicates an overall significant increase in PCO ratio after surgery ($p < 0.05$).

repeated measures (RM) ANOVA with time as "within subjects" factor and group (MR vs. FFB) as "between subjects" factor. With regard to missing data, analyses were restricted to individuals with complete data on all variables required for a particular analysis. Fixed varus/valgus, complication rates, reoperation rates were compared between the two groups using Fisher's Exact tests. Significance level was set at $p < 0.05$.

3. Results

A total of 118 patients were included in this study: 59 patients who underwent TKA using the FFB technique and 59 patients who underwent TKAs using the MR technique. There were no statistically significant differences in baseline characteristics between the groups for age, ASA, gender and BMI and fixed varus or valgus deformities (Table 1). Surgery time increased with 10 min with the use of the FFB technique (76.6 min (standard deviation (SD) 14.6) vs 64.4 min (SD 11.4) ($p < 0.001$). Blood loss was significantly higher in the FFB group (300 ml (IQR: 150–350) vs 120 ml (IQR: 0–200) ($p < 0.001$). All patients were evaluated after one year of follow-up (mean: 1.03 SD 0.07 (range 1.0–1.6 year)). One patient had 1.63 years of follow for the PROMs questionnaire. If excluded, the range was one to 1.2 years.

Pre- and postoperative radiographs were available for all patients, however, bone-loss was present in 15 patients (eight FFB; seven MR) resulting in 103 patients who were evaluated for joint line changes. two-way RM ANOVA revealed that the adductor ratio had a significant interaction effect ($p = 0.002$), which permits evaluation of the data per group. While comparing pre- and postoperative radiographs, there were no joint line changes in the FFB group ($p = 0.304$). In the MR control group there was a significant decrease in the adductor ratio of 0.015 ($p = 0.002$), which indicates a significant joint line elevation (Figure 3).

Table 2
OKS, VAS scores and maximum flexion outcome for the FFB and MR technique.

	Groups	Pre-operative	6 weeks/3 months[a]	12 months	Statistics with 2-way repeated ANOVA
OKS	MR (n = 41)	26.0 (±9.6)	36.5 (±7.6)	40.0 (±7.5)	Time effect
	FFB (n = 44)	23.9 (±6.8)	34.4 (±8.3)	39.0 (±8.0)	
VAS pain	MR (n = 40)	51.1 (±28.7)	22.9 (±23.8)	16.4 (±24.6)	Time effect
	FFB (n = 39)	56.1 (±21.8)	25.7 (±21.8)	15.8 (±20.4)	
VAS disability	MR (n = 40)	50.7 (±27.2)	22.6 (±20.3)	15.6 (±21.6)	Time effect
	FFB (n = 39)	52.9 (±25.6)	22.8 (±20.0)	16.3 (±20.2)	
VAS satisfaction	MR (n = 31)	63.6 (±30.2)	29.9 (±26.1)	23.8 (±28.4)	Time effect
	FFB (n = 36)	61.8 (±22.7)	28.1 (±27.9)	18.4 (±25.0)	
Flexion	MR (n = 46)	119° (±16°)	113° (±9°)	118° (±9°)	Time effect
	FFB (n = 47)	121° (±15°)	108° (±12°)	119° (±11°)	

The number of complete filled out questionnaires per group is indicated in the "groups" column.
[a] Flexion data was collected at 6 weeks postoperative. VAS and OKS data were collected at 3 months postoperative; the data is shown as mean with standard deviation. OKS: Oxford Knee Score; VAS: Visual Analogue Scale score.

Table 3
KOOS subscales outcome for the FFB and MR technique.

	Groups	Pre-operative	3 months	12 months	Statistics with 2-way repeated ANOVA
KOOS symptoms	MR (n = 41)	53.1 (±23.1)	73.0 (±17.2)	82.9 (±17.6)	Time effect
	FFB (n = 43)	49.0 (±16.3)	65.6 (±20.0)	78.7 (±18.0)	
KOOS pain	MR (n = 41)	48.2 (±25.6)	76.4 (±21.0)	84.8 (±16.6)	Time effect
	FFB (n = 43)	42.2 (±13.3)	71.1 (±18.7)	81.3 (±22.0)	
KOOS ADL	MR (n = 41)	50.6 (±26.1)	78.5 (±16.2)	85.3 (±14.9)	Time effect
	FFB (n = 39)	47.4 (±14.0)	75.0 (±16.7)	82.3 (±19.9)	
KOOS sport/rec	MR (n = 38)	23.2 (±25.9)	36.5 (±30.1)	46.8 (±31.5)	Group and Time effect
	FFB (n = 34)	10.4 (±19.1)	27.5 (±26.0)	37.2 (±26.2)	
KOOS QoL	MR (n = 41)	26.2 (±19.6)	54.6 (±23.0)	68.6 (±22.5)	Time effect
	FFB (n = 40)	24.1 (±15.6)	52.3 (±19.4)	62.8 (±24.1)	

The number of complete filled out KOOS subscales per group is indicated in the "groups" column.
KOOS: Knee injury and Osteoarthritis Outcome Score; ADL: Activities of Daily Living; Sport/Rec: Sport and Recreation Function; QoL: Quality of Life; MR: measured resection; FFB: Flexion First Balancer

With regard to PCO measurements, only 26 FFB and 17 MR patients had true lateral X-rays pre- and postoperatively and could therefore be analyzed. Two-way RM ANOVA revealed no interaction effect ($p = 0.48$) and no statistically significant difference between the groups ($p = 0.91$), but it did demonstrate an overall increase in PCO ratio of 0.05 comparing pre and post-operative values ($p < 0.01$) (Figure 4).

PROMs data, available for 2/3 of the patients, showed improvements in OKS, VAS and KOOS scores in both the FFB and the MR groups (Tables 2 and 3). With regard to the OKS, VAS and KOOS scores, no interaction effect was found. Only the sport and recreation subscales of the KOOS showed a significant group effect, lower KOOS values were reported for the FFB group across all time points. The KOOS sport and recreation was already significantly different at baseline. For maximum flexion no interaction effect nor differences were found between the two groups, but a statistically significant time effect was found at the six weeks post-operative time interval (Table 2, Figure 5). No differences between the groups were reported regarding complications and re-operations. Documented complications were stiffness (six in the FFB and two in the MR group, $p = 0.14$ (post-hoc power 30.4%)), which resulted in two manipulations under anesthesia (MUA) in each group. Four patients in the FFB group showed an improved result in their maximum flexion range between six and 12 weeks follow-up and therefore did not require a MUA. Furthermore, one infection and one wound problem were recorded, both in the MR group. Documented re-operations were five in total. Two insert changes were performed: one due to a case of stiffness in the FFB group and one case of instability in the MR group. Two additional releases were needed because of (postero)lateral knee pain: one case with fabella resection in the MR group and one extra release of the iliotibial tract in the FFB group. These re-operations were equally divided between the two groups. Furthermore, there was one deep infection which was treated by debridement, insert exchange and antibiotics (in the MR group).

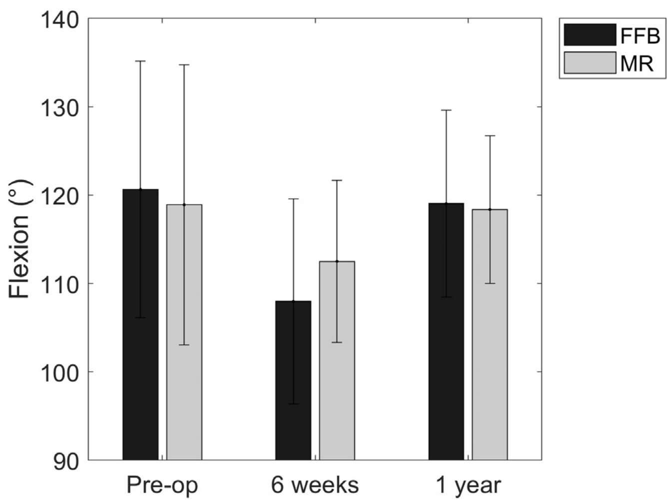

Figure 5. Maximum flexion results for both the FFB and MR group. Black bars present the data of the FFB group and the gray bars present the data of the MR group for the three time intervals. Error-bars represent one standard deviation. FFB: Flexion First Balancer group; MR: Measured Resection group; Overall there is a significant time effect for the 6 weeks' time interval, no differences between the groups.

4. Discussion

The main finding of this study was that with the novel FFB technique the pre-disease joint line height can be restored more accurately in comparison to the standard measured resection technique. While comparing TKA using FFB and MR technique there were no statistically significant differences in complication rates. Hence, the FFB technique is a safe technique for TKA. Despite the expected improvements in clinical outcome and PROMs after adequate joint line reconstruction, no differences in PROMs were observed when compared to the measured resection technique.

Since no calibrated radiographs were available for this study we validated our results to previous reports for joint line measurements performed with calibrated radiographs. Our mean coronal FW of 86.1 mm observed in our cohort is in line previous studies reporting a coronal FW of 85.4 mm and 89.7 mm [14,17]. Our mean ATJL distance is 46.7 mm, in contrast to 44.6 mm and 48.7 mm for respectively the cohort of Luyckx et al. and Iacone et al. [14,17]. Joint line alterations measured with the adductor ratio, to compare our preoperative results with the literature we had to corrected the previous reported adductor ratios with the average cartilage thickness (ATJL +2.15 mm) [13]. Our adductor ratio of 0.56 is comparable with previously reported ratios. The study by Luyckx et al. reported an adductor ratio of 0.52 and after our correction for cartilage thickness this is 0.55 [14]. The study by Iacono et al. reported an adductor ratio of 0.54 and after correction for cartilage thickness this is 0.57 [17]. These results are completely comparable and therefore our absolute measurements are expected to contain no systematic error. The significant decrease of 0.015 in adductor ratio in the MR group therefore corresponds with an elevation in joint line of 1.3 mm. A recent systematic review showed that a joint line elevation of >4 mm results in worse PROMs [6]. This small difference between the groups makes it questionable if this can be detected with PROMs. However, PROMs are not the ideal way to assess mid-flexion instability. An increase in mid-flexion instability has a negative effect on stair climbing abilities and walking speed in contrast to PROMs [18]. The FFB technique enabled us to reconstruct the joint line without any elevation, potentially decreasing mid flexion instability. This could improve the functional ability of the patient. In conclusion, the FFB technique showed better reconstruction of the joint line position compared to the MR technique. This could result in less mid-flexion instability which is previously shown in the literature [7,8].

With regard to the PCO, we documented an increase in PCO for both groups. For the FFB technique the medial PCO is the reference for the posterior femoral resection. This differs to the MR technique, in which the average of the medial and lateral PCO is used as reference for the posterior femoral resection. However, no statistically significant differences in PCO changes were documented between the groups. Our PCO ratio findings are slightly higher than previously reported values by Yang et al. [16]. The significant increase in PCO ratio of 0.05 in both groups was an unexpected finding. This might be explained due to an error in radiological measurement. In the native knee, the lateral PCO is smaller than the medial PCO and therefore, a slight exorotation of the knee is required to obtain a true lateral view. The measured preoperative PCO on a true lateral radiograph is the average distance of the medial and lateral PCO. Postoperatively, the medial and lateral PCO distance is the same for the Vanguard knee prosthesis. Therefore, the actual PCO is measured on the postoperative true lateral radiograph. This radiological error could possibly explain the minor statistically significant increase in PCO in both groups. An increase in 0.05 in the PCO ratio corresponds with an increase of 1.7 mm (mean lateral FW 33.3 mm). Changes in PCO >2 mm are correlated to mid-flexion instability ($p = 0.017$) [19]. At one year postoperatively, one patient in the MR group had instability in the coronal plane with the need for an insert exchange. No relation with an increased PCO was seen in this patient. It is questionable if PCO changes can be accurately documented on plain radiographs. Previously, Ishii et al. studied the changes in PCO after TKA and compared radiographs with CT imaging. They reported no correlation between PCO changes on pre- and postoperative radiographs and the actual changes on CT imaging of the medial and lateral PCO after TKA [20]. However, plain radiographs are used routinely and several studies have been conducted with true lateral radiographs of the knee. Moreover, the patient is less exposed to radiation, which can justify the use of plain radiographs for evaluation of the PCO.

With regard to PROMs outcome only a difference between the two groups was recorded for KOOS sports and recreation. The significant lower KOOS at baseline in the FFB group is however responsible for this group effect. Hence, both groups showed a comparable increase in KOOS sport and recreation. Our postoperative PROMs scores are comparable with outcomes of the registry data regarding outcomes after TKA. At one year postoperatively, the range for OKS in the literature varies between 36.1 at six months to 39.5 at one year postoperatively [21–23]. Our postoperative OKS scores were respectively 38 for the FFB group and 40 for the MR group at one year follow-up. With regard to the KOOS, comparable results to ours are presented in the literature and registry data for the KOOS subscales at one year [24,25]. These results indicates that the new technique, the FFB, is a safe alternative in TKA.

Our hypothesis that a reconstruction of the medial PCO and subsequently the medial joint line would result in better PROMs was not established in this study. It may be that the difference between the two groups is not large enough to be clinical important. Or it may be that the outcome measurements used (i.e. OKS and KOOS) do not represent the functional ability of the patient detailed enough. This is supported by a previous study that showed that the KOOS did not capture the extent of persistent deficits in function at six months postoperative [26]. Moreover, a study by Freisinger et al. showed that there is no correlation between the KOOS and varus-valgus laxity in the osteoarthritic knee, this was in contrast to functional tests like a six-minute walk test [18]. This varus–valgus laxity is to be expected in the mid-flexion range in TKA patients with an elevated joint line [7,8]. Therefore, future research including functional tests are needed to establish a possible benefit of FFB technique. Since the FFB technique restores the joint line more accurate than the MR technique an increase in functional outcome could be expected.

The new technique might have some downsides. The operating time and the accompanied blood loss are significantly higher compared to the standard technique. This might be explained by a learning curve for using this new technique, since even the first FFB patient was included in this study. However, another explanation for the increased blood loss might be the gradually declining use of a tourniquet in our clinic during TKA surgery. Another possible downside of TKA via the new technique is the extra build-up of the lateral PCO due to medial PCO referencing. This might inflict tightness on the lateral side which may lead to pain and a decline in range of motion. Although the difference was not significant as a result of lack of power in the current study, the six stiff knees reported in the outpatient clinic after six weeks of surgery versus two in the MR group might be an indication of this tightness of the knee. At six weeks postoperative, both the FFB and MR group showed a significant lower flexion range angle (107° vs 112°) compared to preoperative and one year postoperative values. The maximum flexion recovered at one year postoperative and no statistical differences in flexion angles were observed between the groups. Moreover, no differences in lateral knee pain were observed and MUA was performed equally between the two groups. This suggests that the build-up of the lateral PCO does not affect patient outcome, but there are some indications that at six weeks postoperative patients in the FFB group may suffer from more flexion contractures.

A limitation of this study is its retrospective design which resulted in an incomplete dataset. PROMs data at all time points was only available in approximately 2/3 of the patients. However, follow-up data including complications and reoperations was available for all patients. The follow-up of one year is rather short for prosthesis replacement surgery, hence these outcomes are classified as preliminary results. However, recent literature has proven that PROMs do not change between 12 and 24 months for TKA and therefore the results of the current study are valid [27]. As radiological analysis could only be performed on cases with minimal bone loss, the findings can only be generalized to this category of cases, not all. Another limitation is the lack of calibrated radiographs. For ratio calculations this is no problem, for absolute measurements this could result in a measurement error. However, when validating our results to the literature this possible error seems ruled out. Furthermore, as mentioned above, CT imaging would have been a more reliable method to determine PCO changes and functional tests might have been more sensitive to detect a change in mid-flexion stability. Therefore, future studies should consider using CT-scan to analyze PCO and functional tests like the six-minute walk test and stairclimbing test to assess functional outcome after TKA surgery.

5. Conclusion

The FFB technique seems to be a safe technique to use in TKA, which can improve reconstruction of the native joint line. Unlike the MR technique, the FFB technique does not lead to elevation of the joint line. The clinical outcomes were comparable in both groups for both PROMs and complication rates.

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Conflict of interest

Dr. R.C.I. van Geenen is a consulting orthopedic surgeon for ZimmerBiomet.

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