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KNEE ARTHROPLASTY

Severity of valgus knee osteoarthritis has no effect on clinical outcomes after total knee arthroplasty

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Abstract

Introduction Advanced valgus osteoarthritis (OA) is one of the most challenging indications for total knee arthroplasty (TKA). There is no information in the literature about the optimal timing of surgery. The current study investigates the impact of the preoperative deformity and degree of arthritis on postoperative outcome after TKA.

Material and methods The study evaluated 133 knees in 107 patients with valgus OA that failed nonoperative treatment with a minimum 2-year follow-up. Mechanical alignment, Kellgren and Lawrence (K/L) score, and minimal joint space width (minJSW) were measured on AP- and hip-to-ankle radiographs. All knees had advanced OA (i.e., K/L grades 3 or 4 and less than 50% minJSW). Pre- and postoperative WOMAC, VR-12, UCLA, VAS, ROM were recorded.

Results There was no difference in clinical outcome (WOMAC, UCLA, VR-12, VAS or ROM) between patients with different degrees of valgus deformities (< 5.0 deg., 5.0–9.9 deg., 10.0–14.9 deg., ≥ 15.0 deg.). There was also no correlation between K/L score or minimal joint space width and any of the outcome parameters.

Conclusions The degree of valgus deformity and the grade of osteoarthritis do not predict the outcome of TKA in patients with valgus OA. Since the risk of complication and the need for implant constraint increases with increasing deformity and instability of the knee, surgery appears to be justified in patients with advanced OA that failed nonoperative treatment, regardless of the degree of deformity.

Keywords Valgus osteoarthritis · Valgus deformity · Knee arthroplasty · Indication · Early surgery · Outcome

Introduction

The indication for total knee arthroplasty (TKA) in osteoarthritis (OA) is based on the multiple factors, including pain, functional limitations, physical examination, and radiographic evidence of OA [1, 2]. It is often assumed that patients with more severe preoperative arthritis have better postoperative results and that early surgery should be avoided [1, 3]. This also is in line with the guidelines of the American health insurance industry (CG-SURG-54). However, it remains controversial whether the degree of joint space narrowing is correlated with postoperative outcomes [3–8].

Progressive valgus deformities are often accompanied with increased medial knee laxity and make balancing the knee during TKA more difficult [9]. In addition, pronounced mechanical malalignment in combination with a flexion contracture (tri-planar deformity) increases the risk of peroneal nerve injury [10, 11].

The current paper analyzes the following research question: Does the degree of the mechanical deformity or the grade of the osteoarthritis at the time of surgery impact the clinical outcome of TKA in patients with valgus OA who failed nonoperative treatment?

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Materials and methods

For the current study, 167 TKA in 135 patients (108 females and 27 males) with a minimum of 2-year follow-up were available. TKA was only indicated for advanced osteoarthritis (Kellgren and Lawrence (K/L) grades 3 or 4 and less than 50% of the remaining minimal joint space width (minJSW)). TKA in patients with mild valgus deformity (< 5 degree (deg.), 48 knees) were only indicated after failed nonoperative treatment (Table 1).

Patients underwent the same standardized soft-tissue release regardless of the extend of the deformity as described by the senior author [9]. Depending on the level of instability after the release of the iliotibial band and the posterolateral corner, either a posterior stabilized (PS, $n = 98$)—or constrained ($n = 35$) insert was used. Hinged knee systems, or additional correction-osteotomies were not needed in any of the cases. Implants used were $n = 123$ (92.5%) Genesis II (Smith & Nephew, Memphis, Tennessee, USA), $n = 7$ (5.3%) BKS (OrthoDevelopment, Draper, Utah, USA) and $n = 3$ (2.3%) Sigma (DePuy Synthes, Warsaw, Indiana, USA).

Of the 167 knees, 2 (1.2%) had to be excluded because not all X-rays were available, 2 (1.2%) because postoperative range of motion (ROM) was not recorded and 30 (18.0%) because not all outcome scores were available. In total 34 knees had to be excluded leaving 133 (79.6%) knees in 107 patients for enrollment in the current study. There were 23 men with 25 TKAs and 84 women with 108 TKAs. The mean age at the time of surgery was 68.3 years (range 44–89). The mean BMI was 30.6 kg/m^2 (range 19.7–58.7 kg/m^2). The minimum follow-up was 2 years (mean: 43.9 months, range 24–120 months).

Clinical evaluation

The data collection included pre- and postoperative range of motion (ROM), degree of flexion contracture, Western Ontario and McMaster University Osteoarthritis index (WOMAC) score (Likert scale 0–96), desired—and actual UCLA activity score (1–10), visual analogue pain scale (VAS) (100 mm) and the VR-12 score (RAND) with the subgroups: "mental component summary" (MCS, 0–100) and "physical component summary" (PCS, 0–100).

Table 1 Criteria to define "failed nonoperative treatment" for knees with mild valgus deformity (< 5 deg.)

Failed nonoperative treatment is defined as inadequate pain relief following 2 out of 3 nonoperative treatment modalities	
A	Series of 3 or more intraarticular hyaluronic acid- or one corticosteroid injections
B	At least 10 physical therapy sessions
C	Six months course of a nonsteroidal anti-inflammatory and/or narcotic medication

Only if at least 2 of 3 treatment modalities were applied without success, TKA was indicated

Radiographic evaluation

All patients underwent a series of preoperative radiographs. The standard bilateral weight-bearing anterior to posterior view of the fully-extended knee (AP view) and the weight-bearing hip-to-ankle (HA) radiograph.

Mechanical and anatomic alignment were determinate using HA radiographs [12]. The knees were divided into groups based on the degree of mechanical malalignment: group 1 (< 5.0 deg.), group 2 (5.0–9.9 deg.), group 3 (10.0–14.9 deg.) and group 4 (≥ 15.0 deg.). The minimal joint space width (minJSW) was defined as the macroscopic smallest distance between the femoral condyle and the articulating tibial plateau in mm. It was measured for the medial and lateral compartment using digital, calibrated AP- and PA-flexed radiographs [13]. Malpositioned radiographs (2, 1.2%) can compromise minJSW measurement and were excluded [14]. OA was graded on AP radiographs based on the Kellgren and Lawrence classification (K/L 1–4) [15]. One investigator repeated measurements on 20 preoperative AP views and HA radiographs for intraobserver reliability (intraclass correlation coefficient, ICC, range 0.79—0.94). Another investigator repeated measurements on 20 preoperative AP view and HA radiographs for inter observer correlation (ICC, range 0.78—0.92). All measurements were obtained in SECTRA PACS software package IDS7 (Sectra AB, Linkoeping, Sweden). The study received IRB approval by the institutional review board at the authors institution (IRB number: 2017—0418).

Statistical analysis

Descriptive statistics were performed to describe means and range and standard deviation for all variables. Kolmogorov–Smirnov was used to identify normal distribution of variables. Levene test was used to test for homogeneity of variances. Paired t test or ANOVA test (for metric and normally distributed variables; ΔWOMAC, minJSW, mechanical and anatomic alignment) or the Wilcoxon Rank Sum or Kruskal–Wallis test (for independent, nonparametric variables; WOMAC, UCLA, desired-UCLA, VAS, VR-12, ROM, gender, age at time of surgery, BMI) were performed to identify significance. Statistical analysis was performed for a 95% confidence interval. The results with p values less than 0.05 were considered statistically significant.

Standard deviation for WOMAC was previously calculated to be 17.6 [9]. Power calculation for an alpha failure of $\alpha = 0.05$, an effect size of 0.57 to detect a difference in 10 points and an aimed power (1–β) of 80% required a sample size of 100 knees. The "intraclass correlation coefficient" (ICC) (minJSW measurements) or Cohen's Kappa (Kellgren and Lawrence score) test were applied to measure inter- and intraobserver reliability. All statistical analyzes were performed using IBM SPSS® Statistics software version 26.0.0.0 (SPSS Inc., Chicago, Il, USA). Power calculation was performed with G*Power, version 3.1.9.2 (University of Duesseldorf, Duesseldorf, Germany) [16].

Results

In 133 knees, the mean preoperative mechanical and anatomical alignment was 8.8 deg. (range 0.3–25.4 deg.) and 14.5 deg. (range − 1.5 to 30.3 deg.) respectively. Based on the severity of the mechanical deformity 35 knees were placed in group 1, 53 knees in group 2, 25 knees in group 3, and 20 knees in group 4. There was no significant difference in demographic data between the 4 groups of valgus deformity, but females tended to have more severe valgus deformity (Table 2). K/L score in the AP view was 1 or 2 in none, 3 in 80 (60.2%) and 4 in 53 (39.8%) knees. 5 knees had revision surgery (two for instability/dislocation, one for infection and two for aseptic loosening of the tibial and the patella component, respectively). One patient, female, 65 years, BMI of 45 kg/m^2, showed a moderate medial instability postoperatively. With a ROM of 120 degrees and no pain whatsoever, we draw no operative consequence. All other patients did not show any postoperative instability.

Comparing knees with posterior stabilized or constrained inlays, the use of the later was more likely with higher valgus ($p < 0.001$) and female patients ($p < 0.001$) but no difference in age ($p = 0.399$) or BMI ($p = 0.164$) was observed. While the type of insert constraint had no impact on functional outcome (UCLA, $p = 0.994$, WOMAC $p = 0.255$, V12 physical, $p = 0.315$, V12 mental, $p = 0.520$, or ROM, $p = 0.498$) it affected postoperative VAS (mean 1.1–1.7, $p = 0.036$).

Clinical outcome scores were not significantly different between the groups (WOMAC, $p = 0.887$, ΔWOMAC, $p = 0.553$, UCLA, $p = 0.662$, desired-UCLA, $p = 0.093$, V-12 mental, $p = 0.819$, V12 physical, $p = 0.796$, ROM, $p = 0.9978$, VAS, $p = 0.998$ and flexion–contracture, $p = 0.383$) (Fig. 1).

In a second step patients with only mild to moderate OA on AP view (K/L ≤ 3, minJSW of at least 2.0 mm) and mild valgus deformity (< 5 deg.) were compared with cases with "bone on bone" OA on the AP view (K/L = 4, minJSW < 0.5 mm) and advanced valgus deformity (≥ 10 deg.). Both groups had no significant difference in the outcome scores WOMAC ($p = 0.935$), ΔWOMAC ($p = 0.510$), V-12 mental ($p = 0.102$), V-12 physical ($p = 0.403$), UCLA score ($p = 0.403$), VAS ($p = 0.243$) or ROM ($p = 0.567$) (Fig. 2). Postoperative desired-UCLA score tended to be ($p = 0.041$) higher in the mild to moderate OA group (desired-UCLA mean: 7.5, range 3–10) compared to the severe OA group (UCLA mean: 5.8, range 2–8). There was no difference in gender ($p = 0.301$), age at time of surgery ($p = 0.203$), BMI ($p = 0.961$) and preoperative ROM ($p = 0.918$) between the groups. Of note, the first subgroup comprises patients with moderate not minimal osteoarthritis.

Discussion

The current data suggest that neither the degree of valgus deformity nor the severity of osteoarthritis have an impact on the clinical outcome (WOMAC, UCLA, VR-12, VAS or ROM) (Fig. 1) in patients with valgus osteoarthritis who have failed nonoperative treatment. Moderate osteoarthritis with a joint space of at least 2 mm on AP radiographs was not a predictor for poor outcome. This suggests that patients who failed nonoperative treatment and have evidence of at least grade 3 K/L valgus osteoarthritis can undergo successful TKA regardless of the joint space on AP radiographs

Table 2 Demographic data of the patient population. Distribution of age at time of surgery ($p = 0.103$) and BMI ($p = 0.758$) were similar for different degrees (deg.) of valgus deformities

		Mechanical valgus [degrees]				Kruskal–Wallis test
		< 5.0	5.0–9.9	10.0–14.9	≥ 15.0	
BMI [kg/m^2]	Mean	30.1	31.0	30.2	31.1	$p = 0.758$
	Range	19.7–56.6	19.7–58.7	21.2–45.2	20.7–45.9	
Age at date of surgery [years]	Mean	69.3	66.4	71.6	67.3	$p = 0.103$
	Range	51–89	44–82	53–84	58–82	
Gender	Women (81.2%)	23 (65.7%)	44 (83.0%)	21 (84.0%)	20 (100%)	$p = 0.016$
	Men (18.8%)	12 (34.3%)	9 (17.0%)	4 (16.0%)	0 (0%)	

Valgus deformity was more severe ($p = 0.041$) in females (mean: 9.5 deg., range 0.3–25.4 deg.) compared to men (mean: 6.1 deg., range 0.5–13.0 deg.) resulting in a difference of distribution of gender between the 4 groups ($p = 0.016$)

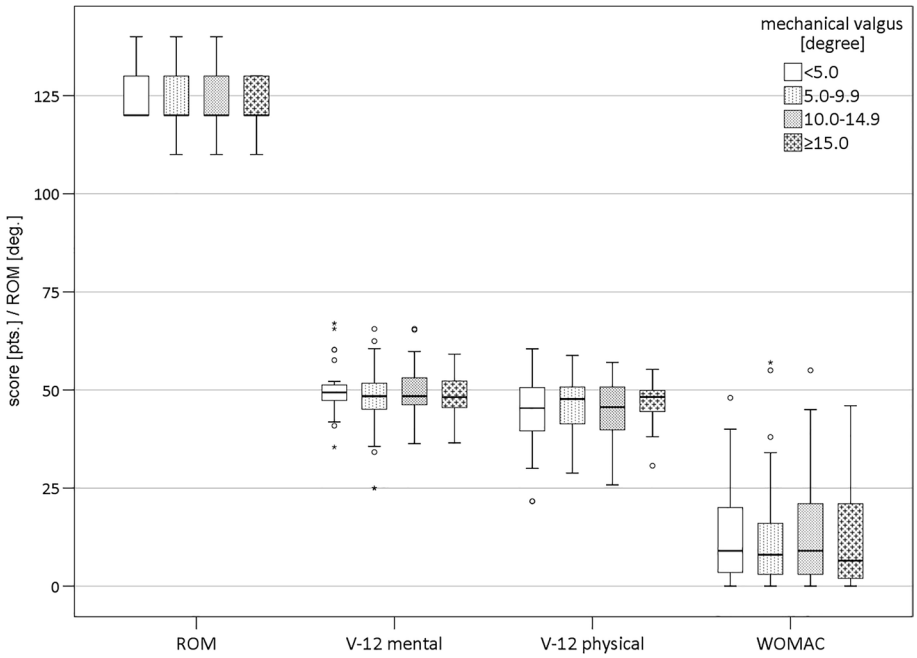

Fig. 1 Boxplot showing postoperative clinical outcome scores (range of motion (ROM), VF-12 mental and physical, WOMAC) for subgroups of different valgus deformity (< 5 deg., 5–9.9 deg., 10–14.9 deg., ≥ 15 deg.). The clinical outcome was not significantly different between these groups

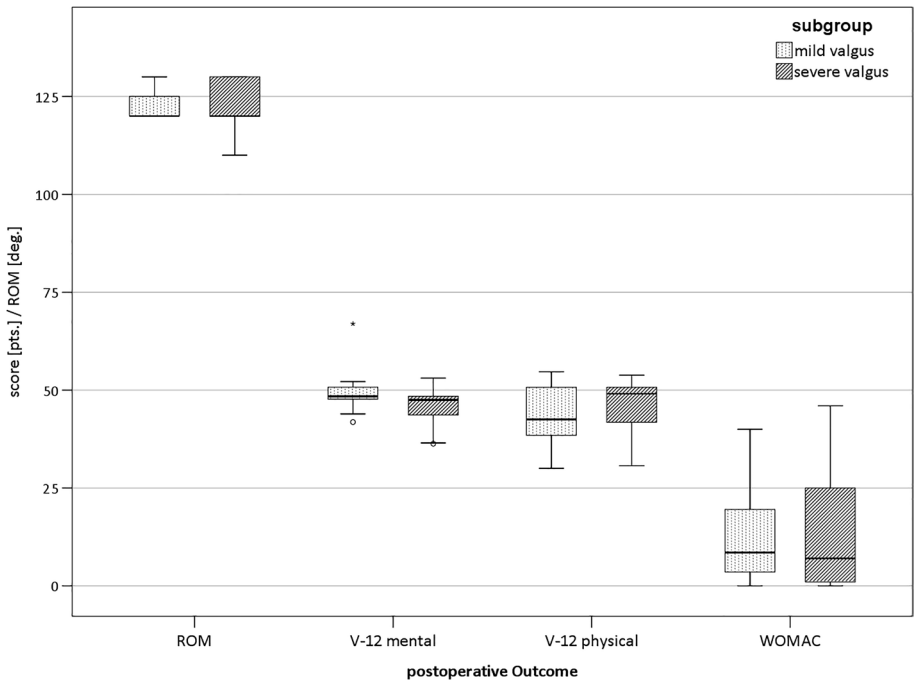

Fig. 2 Boxplot showing postoperative clinical outcome scores (range of motion (ROM), VF-12 mental and physical, WOMAC) for subgroups with mild or moderate OA and minimal valgus deformity (Kellgren and Lawrence (K/L) ≤ 3, minimal joint space width (minJSW) > 3.0 mm, < 5 deg. of valgus) or "bone on bone" OA and an advanced valgus deformity (K/L = 4, minJSW < 0.5 mm, ≥ 10 deg. of valgus). The clinical outcome was not significantly different between the two groups

and that "bone-on-bone" osteoarthritis is not necessary to achieve a significant clinical benefit after TKA.

Patient satisfaction is multifactorial [17]. Today, it is still unclear whether the results of TKA are influenced by the degree of osteoarthritis at the time of surgery [18]. Some authors reported superior results for TKA performed for early OA [4, 5, 7, 19], whereas others reported the opposite [8]. Especially the correlation between the degree of radiographic deformity and postoperative outcome has not been studied. The current data suggest that functional improvements and clinical outcomes are not influenced by the degree of deformity and osteoarthritis at the time of TKA [4, 20]. One of the reasons for this finding might be that AP radiographs underestimate the degree of severity of OA in valgus osteoarthritis and might not be a reliable indicator for cartilage quality in the lateral compartment [21–24]. The presented data suggest that patients

with valgus OA can achieve excellent postoperative results whether they have moderate or severe OA (Fig. 2).

Rationales against early surgery include the greater likelihood of revision surgery in younger patients [25] as well as the potentially higher complication rate [3]. However, these results might not apply to valgus knees. Worsening deformity and increasing instability over the course of valgus osteoarthritis can result in higher short-term complication rates (more complicated surgery, longer surgery duration, increased blood loss, higher percentage of peroneal nerve injuries) [10, 11, 26–28] as well as long-term failure rates (higher loosening rates for constrained implants) [29]. The revision rate was reported to be two times higher at 10 years and three times higher after 20 years for constrained or hinged compared to unconstrained implants [29]. The rate of aseptic loosening may increase in knees with more than 11 deg. valgus deformity [28].

In a registry study with 10,361 TKA preoperative valgus deformity was significantly ($p < 0.001$) associated with peroneal nerve palsy. Of 32 knees with nerve palsy, 10 had 12–25 deg. (mean: 18 deg.) of valgus deformity [30]. The increased risk of peroneal nerve injury could be either the result of direct injury during the lateral release [31, 32] or traction or compromised vascular supply due to stretching of the nerve during the correction of the deformity [33]. Valgus knees with more than 20 deg. valgus and flexion deformity are at increased risk for nerve palsy [33]. Avoiding severe valgus malalignment (> 15 deg.) and more advanced flexion deformities can reduce the risk of peroneal nerve injury according to the literature [9, 34]. The current study suggests that early surgery does not compromise the outcome of TKA in valgus knees.

Delaying surgery in patients with failed nonoperative treatment impacts the patients' quality of life (WOMAC, VR-12). This reduces their quality-adjusted life-years (QALYs), a measurement tool for clinical effectiveness of a specific procedure [35]. Higher age-at-date-of-surgery and decreased preoperative WOMAC may be related to inferior outcome [4]. Our data seem to support this assumption. Other authors reported that patients' satisfaction seems to be more related to the postoperative outcome rather than to preoperative symptoms [36].

The extended release of the posterolateral corner in correction of valgus deformity may significantly decrease stability in the medial compartment [37]. Consequently. Consequently, cruciate retaining (CR) TKA was recently reported to be more likely at risk of postoperative instability compared to posterior stabilized (PS) systems [38]. In addition, most modern PS designs accommodate effortless conversion to a constraint if ligamentous stability is not achieved by the described soft tissue release. Following these findings, we only used PS or constrained inserts depending on the soft tissue release necessary. We found no differences on outcome except postoperative VAS. Only one patient showed minor postoperative instability with no pain and good ROM.

The current study has the following limitations: (1) This is a retrospective study and response to nonoperative treatment was judged based on the preoperative office notes alone. (2) All 133 TKAs were performed by one high volume fellowship trained surgeon who does more than 250 TKAs per year at a specialized orthopedic hospital. (3) Manual measurement of the minJSW is influenced by a number of factors, however, this method has proven to provide reproducible results in the literature and in the current inter- and intraobserver analysis [13, 39, 40]. Some subgroup analyzes only compare small populations and might be underpowered. (4) This paper specifically investigated OA in knees with valgus deformity. The conclusions of the study do not apply to patients with neutral or varus mechanical alignment. (5) This study does not display a knee-specific outcome score. However, WOMAC, UCLA, VR-12, VAS and functional outcomes including ROM and degree of flexion contracture provide adequate information about the clinical outcome. (6) The enrolled patients only had a minimum of 2-year follow up and no long-term conclusions can be drawn from the current data.

Conclusion

The current data suggest that neither the degree of valgus deformity nor the severity of osteoarthritis on AP radiographs have an impact on the clinical outcome of TKA in patients with valgus osteoarthritis. Moderate osteoarthritis with a joint space of at least 2 mm on AP radiographs, with evidence of joint space narrowing on PA-flexed-view was not a predictor for poor outcome. Considering that certain complication and the use of more constrained implants are related to the severity of valgus deformity surgeons might proceed with TKA in patients that failed nonoperative treatment but do not display "bone-on-bone" arthritis on AP radiographs.

Author contributions Study conception and design: FB, KR, MFK; Material preparation, data collection and analysis: KR, AR, AJ, MF; Draft of the manuscript: KR; Scientific supervision: FB.

Compliance with ethical standards

Conflict of interest Author FB has received royalties from Smith and Nephew and OrthoDevelopment and is consultant for Smith and Nephew, OrthoDevelopment, DePuy and Medtronic. He receives research support as a principal investigator for DePuy. All other authors declare they have no conflict of interest.

Ethical approval This study was performed in line with the principles of the Declaration of Helsinki. The study received IRB approval by

the institutional review board at the Hospital for Special Surgery (IRB number: 2017 – 0418).

Consent to participate Informed consent was obtained from all individual participants included in the study.

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