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Review

Effect of individualized distal femoral valgus resection angle in primary total knee arthroplasty: A systematic review and meta-analysis involving 1300 subjects

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ABSTRACT

Background: Proper limb alignment and implant positioning are important for successful total knee arthroplasty (TKA). Whether any differences exist in restoration of limb alignment for valgus knees between fixed and individual femoral valgus correction angle (VCA) for distal femoral resection remains unknown.

Methods: The PubMed, Medline, Embase, and Wangfang databases were searched to identify studies comparing individualized VCA and fixed VCA in the distal femoral valgus resection. The primary outcomes were the mechanical femorotibial angle (MFT angle) and the proportion of postoperative alignment deviation within ± 3°. The secondary outcomes were femoral valgus correction angle (VCA), component angle (α angle and β angle).

Results: Six studies with 1167 TKAs were analyzed quantitatively. The coronal limb alignments in individualized group were closer to neutral than fixed group with a mean 0.77° difference (95% CI, −1.43 to −0.11; $P = .022$; $I^2 = 71.0\%$). Moreover, there were more patients' postoperative alignment deviation within neutral ± 3° in the individualized group (RR, 1.23; 95% CI, 1.09 to 1.38; $P = .00$; $I^2 = 36.4\%$). The α angle were closer to neutral in the individualized group, and there's 1.2° more deviation from neutral in the fixed group (95% CI, 0.99 to 1.41; $P = .00$; $I^2 = 0\%$). No difference was found in the β angle between groups (WMD, 0.85; 95% CI, −0.09 to 1.78; $P = .075$; $I^2 = 88.3\%$).

Conclusions: This systematic review and meta-analysis demonstrated that the individualized VCA for distal femoral resection could enhance the accuracy of postoperative limb alignment and femoral component alignment in the coronal plane. However, further high-quality RCTs and well-designed trials are still needed.

1. Introduction

Proper limb alignment and implant positioning are important to the success of total knee arthroplasty (TKA) [1]. Failing to restore a neutral mechanical axis is correlated to increased loosening and inferior long-term survivorship of the prosthesis [2,3]. Historically, the proposed aim for coronal alignment, as measured at the mechanical femorotibial angle (MFT angle), has to be within ± 3° of 180° [4]. To achieve this goal, the cut of the femur and tibia should be made perpendicular to their respective mechanical axes in the coronal plane [5]. As previous research showed [1], the femoral valgus correction angle (VCA), which is the angle between the anatomical axis and the mechanical axis of the femur, determines the resection of the distal femur in TKA, and affect the axial alignment of the limb.

According to morphologic and gender differences, there is a variation between the mechanical and anatomic axes ranging from 2° to 9° in regard to the femur [4,6]. Most surgeons used a fixed resection angle for patients from the average value in the nonarthritic population in practice [7,8]. However, many studies have compared the difference of fixed and individualized VCA for distal femoral resection in lower limb alignment restoration [1,9–12]. And increasing researchers supported the view that the individualized VCA improve the accuracy of postoperative limb alignment restoration and the same resection angle may lead to malalignment [1,9,11,12]. However, some researchers still argued that a fixed VCA for an uncomplicated primary TKA was safe [13].

The fixed and individualized VCA for distal femoral resection, which one is more accurate in the restoration of limb and implant alignment in primary TKA? To our knowledge, no previous meta-analysis has specifically answered this question. The aim of this meta-

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analysis was to cover all of the available studies to assess whether there was any significant difference in postoperative alignment and component positioning between two methods, one where a fixed VCA was used and one where an individualized VCA was used. We hypothesized that the individualized VCA could enhance the accuracy of postoperative limb alignment and femoral component alignment.

2. Method

The systematic review and meta-analysis was conducted following the guideline of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) statement [14]. This study was registered in the Research Registry.

2.1. Literature search and study selection

A comprehensive literature search was performed in May 2017 by two of the authors independently. The primary sources were the electronic databases of PubMed, Medline, Embase, and Wangfang. Search term included 'arthroplasty, replacement, knee', 'valgus correction angle' or 'valgus cut angle', 'individualized angle' or 'individualized angle' or 'variable angle' or 'tailoring angle', 'fixed angle'. The language was restricted to English and Chinese. The computer search was supplemented with manual searches of the reference lists of all retrieved studies, review articles, and conference abstracts. This process was performed iteratively until no additional articles could be identified. The following inclusive selection criteria were applied: (a) population: patients undergoing primary TKA; (b) intervention and comparison: the individualized VCA (a measured one) and the fixed VCA (an empirical one); (c) outcome: coronal lower limb mechanical alignment and coronal implant alignment; (d) design: randomized controlled trials (RCTs) and observational studies (prospective or retrospective cohort studies). We calculated a kappa statistic to quantify the agreement between the two reviewers on study.

Pre and postoperative radiographic measurements were defined clearly in the articles as following: (a) MFT angle, was defined as the medial angle between femoral mechanical axis and tibial mechanical axis, the neutral value was 180° and deviation with 180° ± 3° was acceptable; (b) VCA, was defined as the angle between the femoral anatomic and mechanical axis; (c) α angle, was defined as the medial angle between the femoral mechanical axis and femoral component on the coronal plane, the neutral value was 90° and deviation with 90° ± 3° was acceptable; (d) β angle, was defined as the medial angle between the tibial mechanical axis and tibial tray on the coronal plane, the neutral value was 90° and deviation with 90° ± 3° was acceptable. On the coronal radiograph, deviation from the neutral value was the alignment error in which the varus alignment was given a negative value, and the valgus alignment was given a positive value. We compared the absolute value of the angle deviation from the neutral value and the proportion of angle which deviation within ± 3° from the neutral value. Articles that reported at least one outcome were included.

2.2. Data extraction and quality assessment

Data extraction was performed. and confirmed independently. The following information were extracted from each study: first author, year of publication, sample size, patient characteristics (age, BMI, gender, side, ethnicity), level of evidence, femoral valgus correction angle (VCA), MFT angle, α angle, β angle and the number of patients which alignment deviation with neutral ± 3°. Disagreements were resolved by discussion. The qualities of the included cohort studies were assessed by the Newcastle-Ottawa Scale (NOS).

2.3. Statistical analysis

Differences were expressed as relative risks (RRs) with 95% CIs for dichotomous outcomes and weighed mean differences (WMDs) with 95% CIs for continuous outcomes. Heterogeneities across studies were tested by using the I^2 statistic. A random-effects model was used for all comparisons because preoperative deformities and other factors were inconsistent across trials. Subgroup and sensitivity analyses were performed to detect the potential source of heterogeneity when significant and to determine the influence of different subgroups, respectively. The subgroup analyses were conducted according to race (Asian versus Caucasian). Publication bias was quantitatively assessed by Egger's and Begg's test. A p value $< .05$ was judged as statistical significant. All statistical analyses were performed using STATA (Version 12.0, Stata corp.: College Station, TX, USA).

3. Results

3.1. Study identification and selection

A total of 162 relevant studies were identified by the initial database search. 57 were excluded because of duplicate studies, and 85 studies were excluded based on the titles and abstracts. The remaining 20 full-text articles were reviewed for more detailed evaluation, and four of them were then excluded because they were designed in radiographic and anatomical study. Another nine studies were excluded for not reporting required outcomes. Finally, seven studies fulfilled the predefined inclusion criteria and were included in the final systematic review and meta-analysis [1,11–13,15–17]. The selection process is shown in Fig. 1. The kappa for the agreement on study inclusion was 0.88.

3.2. Study characteristics

The main characteristics of included studies are described in Table 1. The sample size ranged from 40 to 546 (a total of 1300, 681 in individualized VCA group and 619 in fixed VCA group). Of the included studies, one was RCT and the other six were cohort studies (three retrospective studies, and three prospective studies). Seven studies were analyzed qualitatively, in which six studies were analyzed quantitatively. The races in two studies were Caucasian and five studies were Asian.

3.3. Quality assessment

Risk-of-bias assessment of the included studies is presented in Table 2. When using the Newcastle–Ottawa Scale to assess the risk of bias of the cohort studies, six studies were rated as a total score of more than 6 indicating a low risk of bias.

3.4. Primary outcome

Shi et al. [15] found that patients who received individualized VCAs had a better limb alignment (178.1° vs. 175.9°, $p < .05$) and more patients' alignment deviation within ± 3° from the neutral axis (77.6% vs. 28.2%, $p < .001$) compared with those who received fixed VCAs.

Six cohort studies (1167 TKAs) had reported MFT angle, the individualized group was closer to neutral than the fixed group with a mean 0.77° difference (95% CI, −1.43 to −0.11; $p = .022$; $I^2 = 71.0\%$; Fig. 2). Moreover, there were more patients' postoperative alignment deviation with ± 3° in the individualized group than the control group (RR, 1.23; 95% CI, 1.09 to 1.38; $p = .00$; $I^2 = 36.4\%$; Fig. 3). After subgroup analysis, we found the source of heterogeneities in above results were from the Caucasian group ($I^2 = 82.1\%$, $p = .018$; $I^2 = 78.4\%$, $p = .031$, respectively; Figss. 2–3). Sensitivity analysis indicated that one independent study by Davis [13] was the main origin