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No effect of obesity on limb and component alignment after computer-assisted total knee arthroplasty☆

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ABSTRACT

Purpose: This retrospective study aimed to determine if computer navigation provides consistent accuracy for limb and component alignment during TKA irrespective of body mass index (BMI) by comparing limb and component alignment and the outlier rates in obese versus non-obese individuals undergoing computer-assisted TKA.

Methods: Six hundred and thirty-five computer assisted total knee arthroplasties (TKAs) performed in non-obese individuals (BMI < 30 kg/m^2) were compared with 520 computer-assisted TKAs in obese individuals (BMI ≥ 30 kg/m^2) for postoperative limb and component alignment using full length standing hip-to-ankle radiographs.

Results: No significant difference in postoperative limb alignment (179.7° ± 1.7° vs 179.6° ± 1.8°), coronal femoral (90.2° ± 1.6° vs 89.8° ± 1.9°) and tibial component (90.2° ± 1.6° vs 90.3° ± 1.7°) alignment and outlier rates (6.2% vs 7.5%) was found between non-obese and obese individuals. Similarly, alignment and the outlier rates were similar when non-obese individuals and a subgroup of morbidly obese individuals (BMI >40 kg/m^2) were compared.

Conclusions: Computer navigation can achieve excellent limb and component alignment irrespective of a patient's BMI. Although obesity may not be an indication per se for using computer navigation during TKA, it will help achieve consistently accurate limb and component alignment in obese patients.

Level of Evidence: Level II

1. Introduction

Risk of revision after total knee arthroplasty (TKA) is significantly higher when obesity is combined with malalignment of tibial component or the limb [1]. Reports have suggested that implant survival is significantly lower in obese patients (60–92%) in the long-term when compared to non-obese individuals (89–98.5%) [2–6] with loosening of tibial components and polyethylene wear being the major causes of revision [4,5]. Hence it is all the more important to ensure symmetric loading of implant and bone in the obese by accurate implant positioning and restoration of mechanical axis.

Conventional techniques have shown lower consistency in achieving accurate limb and component alignment when compared to navigation techniques during TKA [7–14]. Furthermore, recent studies have reported greater risk for limb malalignment with conventional TKAs when performed in the obese [15,16]. Computer navigation using the optical tracking system locates the centre of the femoral head, centre of the knee joint and the centre of the ankle to calculate the mechanical axis of the limb. However, during navigated TKA, obese patients may be prone to errors due to difficulty in exposing, palpating and registering important bony landmarks such as the malleoli and the femoral epicondyles. Although several studies have validated the accuracy and consistency of computer-assisted navigation and have reported significant improvement in component orientation and limb alignment in TKA with computer navigation [7–14], literature is lacking for limb and component alignment in computer-assisted TKA in the obese.

Accuracy of computer navigation during TKA in the obese has not been studied and whether computer navigation achieves the same degree of accurate limb and component alignment in the obese individuals vis-a-vis non-obese patients is not known. Hence, the purpose of the present study was to determine if computer navigation provides consistent accuracy for limb and component alignment during TKA irrespective of body mass index (BMI) by comparing limb and component alignment and the outlier rates in obese versus non-obese individuals undergoing computer-assisted TKA. Our hypothesis was that limb and component alignment will not be significantly different when obese and non-obese individuals were compared after computer-assisted TKA.

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2. Patients and methods

We retrospectively reviewed the clinical and radiographic records of 1500 computer-assisted TKAs (in 1250 patients) performed between 2005 and 2009. Non-obese individuals were defined as those having a BMI of <30 kg/m^2 (calculated by dividing the subject's weight in kilogrammes by their height in metres squared), obese individuals were defined as those having a BMI of ≥30 kg/m^2 and morbidly obese individuals were defined as those having BMI >40 kg/m^2. The inclusion criteria were primary computer-assisted total knee arthroplasties (TKAs) performed for knee arthritis in patients with a body mass index (BMI) of ≥30 for the obese group and <30 for the non-obese group at the time of surgery. The exclusion criteria was incomplete clinical or radiographic records where the height and weight data of a patient was unavailable to calculate BMI or full length hip-to-ankle or knee radiographs were incomplete or not available to determine limb and component alignment. Based on the above criteria, complete data of 635 computer-assisted TKAs performed in 484 non-obese patients and 520 computer-assisted TKAs performed in 390 obese patients was available for analysis. Amongst the 390 obese patients, a subgroup of 56 TKAs was performed in 43 morbidly obese patients.

Standing full length (hip to ankle) weight-bearing radiographs, weight-bearing anteroposterior knee radiographs and knee lateral radiographs were obtained in all patients pre- and postoperatively. The degree of knee deformity or hip–knee–ankle (HKA) angle was determined on the standing full-length radiographs as the angle between the mechanical axis of the femur (centre of the femoral head to the centre of the knee joint) and the mechanical axis of the tibia (centre of the knee joint to the centre of the ankle) [17]. Postoperatively, coronal alignment of femoral and tibial components was measured using their respective mechanical axes on full-length radiographs [17]. On lateral radiographs, the sagittal alignment of femoral component and tibial slope was measured using the distal femoral medullary axis and proximal tibial medullary axis [18]. Limbs with postoperative HKA angle outside the acceptable ±3° range from a neutral alignment of 180° were considered outliers for limb alignment [19]. Similarly, components outside the acceptable ±3° range from a neutral alignment of 90° in the coronal and sagittal plane were considered outliers for component alignment [19]. All radiographs were analysed by two surgeons blinded to the BMI of the patient. Radiographs taken preoperatively and at last follow-up (mean follow-up 4 years; range 2–6 years) were used to measure various parameters. Both height and weight were recorded by a ward nurse preoperatively on admission of the patient to the hospital. The height was measured using a wall mounted measuring scale and the weight was measured using a weighing scale. Height (m) and weight (kg) were then used to derive BMI (kg/m2) in each patient.

All TKAs were performed by a single surgeon using the computer-assisted technique. All procedures in the non-obese group were performed with the tourniquet inflated, which was deflated after the cement had hardened. However, in the obese group, tourniquet was inflated only for the duration of cementing and was deflated once the cement had set. An anterior longitudinal incision and a medial parapatellar arthrotomy were used in all cases. All patients underwent TKA using a cemented, posterior cruciate substituting design and all patients had resurfacing of the patella. The P.F.C. Sigma implant (DePuy Orthopaedics, Warsaw, Indiana) was used in all patients. The surgical aim in all patients of both groups was to align both femoral and tibial components perpendicular to the respective mechanical axes, femoral rotation aligned to the epicondylar axis, and to achieve a neutral lower limb mechanical axis. We used the Ci navigation system with its software (Version 2.1, Brainlab, Munich, Germany). Using 2 infra-red arrays affixed to the tibia and femur each, the centre of femoral head was computed by pivoting the femur without hindrance within the free range of motion of the hip joint and was accepted if the accuracy was within 3 mm. To minimise errors during registration of the femoral head centre, care was taken to ensure that the pelvis was properly stabilised at the anterior superior iliac spine by an assistant and the hip joint moved through a smooth, gradual circulatory movement mimicking the base of a cone. Following standard registration process, the mechanical axis of the limb was determined by the navigation software. Conventional cutting blocks were navigated into position to perform the appropriate bone cuts. The degree of soft tissue release was governed by the amount of soft tissue tightness assessed using a tensioning device and medial and lateral gap imbalance as quantified by the computer. The tensioning device used was a modified laminar spreader containing a fixed tibial base plate and two mobile, medial and lateral femoral plates which can be individually moved using a screw mechanism to assess gap tension (Protek, Bettlach, Switzerland). Medial release for varus knees and lateral release for valgus knees were performed to achieve rectangular balanced gaps and a fully restored mechanical axis.

Radiographic parameters in terms of limb (HKA angle) and component alignment (tibial and femoral sagittal and coronal alignment) of the non-obese TKA group were compared to those in the obese TKA group and of the non-obese and the morbidly obese groups using the *t* test. The percentage of outliers for limb and component alignment was compared between the groups using the Fisher's exact test. A p value of <0.05 was taken to be statistically significant.

3. Results

Demographic and radiographic parameters in the non-obese, obese and morbidly obese groups are summarised in Table 1. Postoperatively, the limb alignment (mean HKA angle) was not significantly different when the non-obese group was compared with the obese group (p = 0.33) and when the non-obese group was compared with the morbidly obese group (p = 0.20). Although the postoperative coronal alignment of the femoral component was not significantly different when the non-obese group was compared to the morbidly obese group (p = 0.66), the difference was statistically significant when non-obese and obese groups were compared (p = 0.0001). However this mean difference (0.4°) although statistically significant was very small to be of any clinical significance. Similarly, the postoperative coronal alignment of the tibial component was not significantly different when the non-obese group was compared with the obese group (p = 0.30) and when the non-obese group was compared with the morbidly obese group (p = 0.37).

In the sagittal plane, the alignment of the femoral component was not significantly different when the non-obese group was compared to the obese group (p = 0.42). However, the mean difference (1.7°) was statistically significant when non-obese and morbidly obese groups were compared (p = 0.002). The sagittal alignment of the tibial component was not significantly different when the non-obese group was compared with the obese group (p = 0.42) and when the non-obese group was compared with the morbidly obese group (p = 0.32).

Outlier rates for the postoperative limb and component alignment in non-obese, obese and morbidly obese groups is illustrated in Fig. 1. The outlier rates for postoperative HKA angle between the obese and non-obese groups were not significant (p = 0.48) and between the non-obese and morbidly obese groups, the rates were also not significant (p = 1.00). Similarly the outlier rates for coronal alignment of the femoral component were not significantly different when the non-obese group was compared to the obese group (p = 0.15) and when the non-obese group was compared to the morbidly obese group (p = 0.50). The outlier rates for coronal alignment of the tibial component were not significantly different when the non-obese group was compared to the obese group (p = 0.54) and when the non-obese group was compared to the morbidly obese group (p = 0.24).

4. Discussion

Despite showing superior and consistent results in the restoration of limb and component alignment, the technical challenges during computer-assisted TKA in obese individuals remain. Obese patients may be prone to errors due to difficulty in registering the femoral head centre because of substantial weight of the leg and difficulty in registering the ankle centre due to difficulty in palpating the malleoli. Furthermore, excessive fat makes effective exposure difficult in the obese and excessive pressure due to the subluxated or everted patella or due to the thick medial flap may cause difficulty in palpating and registering the femoral epicondyles. Also, in the surgeon's experience, the weight of the limb may adversely impact the computer software's algorithms to equalise flexion and extension gaps and thereby component size and position. Most studies of TKAs in the obese have focussed on functional outcome and survival of implant vis-a-vis these rates in the non-obese