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Prospective randomised trial comparing unlinked, modular bicompartmental knee arthroplasty and total knee arthroplasty: A five years follow-up

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ABSTRACT

Background: A significant proportion of patients with knee osteoarthritis have articular degeneration that is limited to the medial and patellofemoral compartments. The objective of this study was to compare clinical outcomes of unlinked bicompartmental knee arthroplasty (BCA) and total knee arthroplasty (TKA) at 5 years in this subset of patients.

Methods: 48 patients were randomised into two groups: unlinked, modular bicompartmental arthroplasty and total knee arthroplasty. Data on demographics and clinical outcomes were collected (Bartlett Knee Score, Oxford Knee Score, Knee Society Score). Data on intra-operative blood loss in both groups were also recorded.

Results: Out of the 48 patients, 26 underwent BCA and 22 had TKA. Both groups shared similar demographic profiles. At five years post surgery, there was significant improvement across all functional scores in both groups. However, there was no significant difference in outcome scores in the BCA group compared to the TKA group. The drop in serum haemoglobin levels postoperatively was 1.55 and 2.30 g/dl for the BCA and TKA groups respectively ($p < .001$). The total amount of blood loss was 397 and 647 ml respectively ($p = .001$).

Conclusions: Unlinked, modular BCA results in similar clinical and functional scores as TKA for medial and patellofemoral arthritis in the mid-term. Intra-operative blood loss was significantly lower in the BCA group compared to the TKA group. BCA is a viable option for a select group of young and active patients with the advantage of reduced intra-operative blood loss and equivalent functional outcomes as TKA.

1. Introduction

Osteoarthritis of the knee is a common disease in our population, whereby the medial, lateral and patellofemoral compartments are involved to varying degrees [1]. A large number of patients with debilitating osteoarthritis of the knee have articular degeneration that is limited to the medial and patellofemoral compartments with a relatively healthy lateral compartment. In addition, a significant subset of these patients has been found to have intact cruciate ligaments [2]. While the current standard of care is still total knee arthroplasty (TKA), there has been increasing interest in bicompartmental knee arthroplasty (BCA) as an alternative treatment option.

BCA can be performed using two philosophically different component designs, either with separate modular unlinked components or with a single monolithic design with a fixed relationship between the patello and tibiofemoral components [3]. The limited success of the bicompartmental prostheses has largely been associated with the monolithic designs, with several studies citing a relatively high incidence of patellofemoral complications and need for revision surgery [4–6]. This is likely related to challenges in sizing and orienting a linked femoral component, possibly resulting in a constrained articulation and abnormal stress transmission across the knee joint [7–9]. Conversely, a modular, unlinked trochlear and medial femoral condylar prosthesis allows for independent resurfacing of the medial and patellofemoral compartments. This allows for independent sizing and orientation of the separate components and avoids the problems faced when using the linked prostheses.

BCA provides a minimally invasive alternative to TKA that limits bony resection and spares the anterior and posterior cruciate ligaments, as well as the lateral compartment of the knee. These characteristics are essential to facilitating quicker postoperative recovery and increased stability with better restoration of normal knee kinematics and gait pattern [10,11]. However, there has been little in the literature comparing the mid-term functional outcomes of patients undergoing BCA and TKA [12].

The purpose of this study is to compare the functional outcomes of patients with advanced osteoarthritis limited to the medial and patellofemoral compartments treated with either a modular, unlinked BCA or TKA and the intra-operative blood loss during BCA and TKA.

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We hypothesized that due to the bicompartmental prosthesis being inherently tissue conserving and bicruciate-retaining in design, it can better restore knee kinematics and result in a superior functional outcome as opposed to TKA. In addition, we hypothesized that the blood loss during BCA is less due to limited surgical dissection and bone cuts as opposed to TKA.

2. Materials and methods

This study is a prospective, randomised, clinical trial comparing the functional outcomes and intra-operative blood loss of BCA and TKA in patients with advanced osteoarthritis limited to the medial and patellofemoral joints. Institutional Review Board approval was obtained prior to the commencement of this study in January 2007 (CIRB 2007/152/D). The patients were recruited from our specialist outpatient clinic from October 2007 to January 2009.

Patients diagnosed with primary knee osteoarthritis involving only the medial and patellofemoral compartments, and radiologically classified as Ahlback Grade 3 and above were eligible for the study. Exclusion criteria included patients with inflammatory arthritis, knee range of motion of less than 90°, flexion contracture of more than 15°, body mass index (BMI) greater than 30, coronal or sagittal plane knee instability and greater than 10° of varus or 15° of valgus malalignment.

Patients were prospectively recruited and informed consent was obtained before trial commencement. Each patient was randomly assigned to one of two study groups, with one group receiving BCA (Group 1) while the other receiving TKA (Group 2). Randomisation was based on a computer generated sequence. Sequentially numbered and sealed envelopes containing the treatment assignments were prepared and opened by the surgeon in the operating theatre prior to surgery. The patient, surgeon and all study personnel were not blinded to the randomization outcome.

A single fellowship trained senior surgeon, who is well versed in both techniques, performed all the procedures. A standard parapatellar approach was utilised in this study. Patients in Group 1 underwent bicompartmental knee arthroplasty with an independent medial unicompartment knee arthroplasty (DePuy Preservation™ Unicompartmental Knee, Warsaw, Indiana, United States) and patellofemoral arthroplasty (DePuy Sigma® High Performance Partial Knee, Warsaw, Indiana, United States). Patients in Group 2 underwent total knee arthroplasty with a posterior cruciate substituting prosthesis (DePuy Sigma®, Fixed Bearing Knee System, Warsaw, Indiana, United States). Patella resurfacing was performed in all the patients randomised to the total knee arthroplasty group.

For patients undergoing BCA, the distal femur and proximal tibia bone cuts for the medial unicompartmental arthroplasty were performed first with the aid of instrumented jigs. The tibia was cut perpendicular to the mechanical axis. Using spacer blocks for balancing, the aim was to achieve two degrees varus undercorrection in the mechanical axis. This is to minimise the risk of degeneration of the lateral compartment of the knee [13,14]. In addition, patella maltracking due to excessive valgus was avoided.

Patellofemoral replacement was then carried out using an inlay trochlear design with a right or left sided prosthesis and a built in Q-angle. All osteophytes are removed from the intercondylar notch and trochlear ridge so as to appreciate its true bony anatomy. A trial implant is selected such that the distal tip sits two to three millimetres from the apex of the intercondylar notch and the superior border of the trial lies just at the superior articular surface of the trochlear. The outline of the trial is then marked on the cartilage using a sterile marking pen. Trochlear preparation is then performed using a free-hand technique with a high-speed burr and rasp, taking care to maintain the anatomical Q angle and preserve the native lateral femoral condyle. The cavity is checked with the trial often to ensure proper fit and alignment. This is done until the trial fits into the trochlear cavity as desired. The aim was to place the trochlear prosthesis flush with the native bone and cartilage of the lateral femoral condyle and recreate the native anatomy of the pre-cut trochlear. The basis of this technique is to recreate ambient anatomy based on intra-operative topographic mapping. The patella was then prepared with the aid of instrumented jigs. We aimed to medialise the patella button as much as possible and precisely replicate the pre-cut thickness of the patella to achieve optimal patella tracking.

The unicompartmental and patellofemoral trial prostheses were then implanted and on-table trial assessment performed. The knee was moved through the full range of motion and patellar tracking was assessed. In particular, we looked for a smooth transition of the patella from the trochlea into the notch, smooth entrance of the patella into the trochlear component on extension and no abrupt medial or lateral movements of the patella.

All patients in both groups underwent a fixed physiotherapy regime postoperatively. Prophylaxis for deep vein thrombosis consisted of subcutaneous clexane. This was commenced on the first postoperative day and continued until the patient was discharged.

The patient's age, gender, BMI and length of hospital stay were recorded. Traditional postoperative complications of knee arthroplasty surgery including death, pulmonary embolism, deep vein thrombosis, cardiac events, cerebrovascular events, and wound complications including deep and superficial wound infection during the initial post-operative period of 30 days were recorded. Data pertaining to implant related complications and deep wound infections within five years of surgery were also collected.

Preoperative functional knee scores and knee range of motion were assessed to ascertain the baseline functional status of the patient. Postoperative general and disease-specific functional knee scores were measured include American Knee Society Score, Oxford Knee Score, Bartlett Patella Score and SF-36. We documented the outcomes at six months, 12 months, two years and five years post surgery. These outcome measures were recorded by a trained physiotherapist with more than five years of experience.

Post-operative radiographs were taken when the patients were able to fully weightbear. Coronal films were taken with the patient standing and the knee in full extension on a five centimetres riser to visualize the ankle joint. Both lateral malleoli were placed 20 cm apart with the toes pointing forward. The patella was placed in the direction of the X-ray source as a rotation guide, with its anterior surface perpendicular to the X-ray source. Evaluation of lower limb alignment was performed using Picture Archiving and Communication Systems (PACS), which has high inter and intra-rater reliability than using hard copy radiographs [15]. Two reviewers blinded to the surgical method performed the measurements on computer-based digital radiographic films on two separate occasions. Measurements were recorded to the nearest degree. The hip–knee–ankle (HKA) angle, the angle formed by the mechanical axis of the femur (the line between the centre of the femoral head and centre of the knee) and mechanical axis of the tibia (line between the centre of the talus and the centre of the knee) was recorded. The accepted values for normal alignment are 180° ± 3° varus/valgus for HKA.

In addition, preoperative and postoperative haemoglobin levels were obtained two weeks prior to surgery and on the morning following surgery respectively. Total blood loss was calculated using the haemoglobin balance method [16,17]. The patient's total blood volume (TBV) was first calculated using the formula of Nadler et al. as follows [18]:

$$\text{TBV (millilitres)} = \left(k1 \times \text{height}^3\right) + (k2 \times \text{weight}) + k3,$$

where k1 = 0.3669, k2 = 0.03219, and k3 = 0.6041 for men; k1 = 0.3561, k2 = 0.03308, and k3 = 0.1833 for women; and height is in metres and weight is in kilograms.