The Knee 22 (2015) 613–317

Contents lists available at ScienceDirect

The Knee

Total knee arthroplasty using patient-specific guides: Is there a learning curve?

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ARTICLE INFO

Article history:
Received 24 March 2014
Received in revised form 18 February 2015
Accepted 3 March 2015

Keywords:
Knee arthroplasty
Patient-specific guides
Learning curve
Surgery
Alignment

ABSTRACT

Background: Patient specific guides (PSG) have been reported to improve overall component alignment in total knee arthroplasty (TKA). With more surgeons likely to consider this method of TKA in the future, this study was performed to establish whether there is a learning curve with use of PSG in TKA.
Methods: Eighty-six consecutive PSG TKAs performed by one surgeon were retrospectively analyzed in two groups. The first 30 patients were compared to the second 56 patients with regards to their operative times and post-operative multi-planar alignments on computed tomography (CT) scan.
Results: Mean operative time was higher in the initial 30 cases compared to the second 56 cases (85 min vs. 78 min; $p = 0.001$). No statistically significant differences were found in post-operative TKA alignment between the two groups.
Conclusions: This study suggests that there is a minimal learning curve with operative time associated with use of PSG in TKA. This study was unable to detect a significant learning curve with regards to restoration of mechanical knee alignment with the use of PSG in TKA.
Level of Evidence: Level III, retrospective comparative study.

1. Introduction

Total knee arthroplasty (TKA) remains the gold standard treatment for end-stage knee arthritis [1]. Restoration of a neutral femoral–tibial mechanical axis has been thought to be associated with better long-term outcomes [2–4]. Whilst the long-term importance of a neutral mechanical axis has been questioned recently [5], it still remains an established goal in improving survivorship and outcomes.

Techniques that improve alignment accuracy and ease of surgery are garnering interest amongst orthopaedic surgeons. With reported better coronal alignment restoration compared to conventional knee arthroplasty surgery, and convenience in the form of less inventory and without the need for additional steps compared to computer navigation, patient-specific guides (PSG) is a technique that is likely to be utilized more in the coming years [1,6].

Introduction of new surgical techniques is commonly associated with a learning curve [7]. It is recognized that there is a significant learning curve associated with computer-navigated total knee arthroplasty and that initial cases are associated with increased operative time [8,9]. There is no corresponding literature for use of patient-specific guides. This paper aims to identify if there is a learning curve associated with patient-specific guides in total knee arthroplasty with respect to restoration of multi-planar limb alignment as well as operative times. We hypothesize that there will be no significant difference in post-operative alignment between the initial operations and later operations using this technique.

2. Materials and methods

2.1. Study design

A retrospective cohort analysis of the first 86 consecutive PSG total knee arthroplasty cases performed by a single knee arthroplasty surgeon (SJM) was undertaken as a convenience sample, with the aim to compare the alignment and operative times between the first 30 cases (Group 1) and the last 56 cases (Group 2) performed. A learning curve group of 30 patients was chosen based on the learning curve identified with use of computer navigated TKA surgery [10]. All the operations in this study were performed at one institution between July 2009 and July 2012. All patients who underwent PSG TKA during this time period were considered for inclusion in the study. Only one patient was excluded due to significant extra-articular deformity, as there were insufficient other patients with similar deformity to allow an accurate comparison. No patients were excluded based on their pre-operative knee pathology, demographics or medical comorbidities.

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http://dx.doi.org/10.1016/j.knee.2015.03.002
0968-0160/

Approval to conduct the review was granted by a research ethics committee.

2.2. Pre-operative planning

All patients underwent pre-operative magnetic resonance (MR) imaging of the relevant knee that was used to create individualized cutting blocks (Zimmer PSI, Warsaw, IN). The blocks were created to achieve a resection perpendicular to the mechanical axis in the coronal plane for the distal femur and proximal tibia. In the sagittal plane, neutral femoral flexion angle and posterior tibial slope of seven degrees was planned. Femoral component rotation was programmed to be parallel to the surgical transepicondylar axis.

2.3. Surgical details

On average, the operating surgeon performed 200 TKA surgeries each per year and was experienced in conventional knee arthroplasty surgery as well as computer-navigated surgery but had not performed PSG TKA previously. All surgeries were performed under spinal anaesthesia using a medial parapatellar approach. The aim was to restore a neutral femoro-tibial coronal axis followed by appropriate ligament balancing. The distal femoral and proximal tibial cuts were carried out though placement of metal cutting guides from the PSG positioning. The remaining femoral preparation was also undertaken with standard metal cutting blocks through corresponding pin holes from the PSG. The same cemented posterior-stabilized prosthesis was used in all cases (NexGen LPS Flex, Zimmer, Warsaw, IN). Initial incision to skin closure operative time was recorded in all cases.

2.4. Post-operative radiographic analysis and outcome measures

All patients had a post-operative CT scan of the operated knee within one week of surgery following the Perth protocol [11]. All scans were performed at a single radiology centre using low dose two to three millisieverts radiation to create two millimeters slice helical scan from acetabulum to ankle joint. A single experienced CT radiographer analyzed all scans.

The femoral coronal mechanical axis was measured as a line from the centre of rotation of the femoral head to the centre of the knee at the distal femur. The tibial coronal mechanical axis was defined as a line from the centre of the proximal tibia to the centre of the tibial plafond. The hip–knee angle (HKA) was measured in the coronal plane as the angle between the femoral coronal mechanical axis and the tibial coronal mechanical axis (Fig. 1). A valgus alignment was given a positive (+) value, a varus alignment was given a negative (−) value, and zero degrees was the value considered as neutral alignment.

Femoral coronal angle (FCA) was calculated in the coronal plane as the angle between the femoral coronal mechanical axis and a line through the most distal aspect of the femoral component of the knee replacement, measured on the medial aspect (Fig. 2). Ninety degrees was considered to be neutral alignment.

Tibial coronal angle (TCA) was calculated in the coronal plane as the angle between the tibial coronal mechanical axis and a line level through the most proximal aspect of the tibial component of the knee replacement, measured on the medial aspect (Fig. 3). Ninety degrees was considered the neutral alignment value.

Femoral sagittal angle (FSA) was measured as the angle between the femoral sagittal mechanical axis and a line level with the posterior flange of the femoral component of the knee replacement (Fig. 4). A flexed component was designated a positive value (+) and an extended component was given a negative value (−). Zero was the neutral alignment value.

Tibial sagittal angle (TSA) was measured in the sagittal plane as the angle between the tibial sagittal mechanical axis and a line level with the proximal aspect of the tibial component (Fig. 5). Seven degrees was the target TSA as per the manufacturer's guidelines.

Fig. 1. Hip–knee angle (HKA).

Femoral rotation alignment (FRA) was calculated in axial sections as the angle between a line through the posterior flange of the component and the surgical transepicondylar axis. FRA was considered neutral when the two lines were parallel (Fig. 6). A positive value (+) was assigned to indicate an externally rotated component, a negative value (−) was assigned to an internally rotated component and zero was considered the neutral value.

Greater than three degrees off the neutral alignment in any plane was considered to be the cut-off for outliers, based on historical alignment goals of TKA [2,3].

A recent study by our group looking at radiographic outcomes of PSG TKA included an inter-observer reliability assessment and found strong inter-observer agreement on CT alignment of prostheses for this study's group of patients [12].

Fig. 2. Femoral coronal angle (FCA).