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Optimization of sagittal and coronal planes with robotic-assisted unicompartmental knee arthroplasty

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ABSTRACT

Background: One of the anatomic goals of total knee arthroplasty (TKA) is optimizing in the coronal and sagittal plane. Accurate alignments of both planes have been correlated to functional outcome and range of motion. There is a paucity of evidence on the accuracy of unicompartmental knee arthroplasty (UKA) in balancing biplanar knee alignment – specifically sagittal plane alignment. Because robotic assisted UKA has an advantage of more accurately manipulating sagittal plane for optimal alignment and kinematics based on pre-operative and intraoperative CT planning we assessed the accuracy.

Methods: We reviewed the clinical and radiographic information of 94 robotic assisted UKA surgeries for balancing of sagittal and coronal knee anatomy using radiographic parameters, such as posterior condylar offset ratio (PCOR), posterior tibial slope (PTS), femoral-tibial angle, and joint line.

Results: In the sagittal plane, we found no significant difference between pre and postoperative PCOR values. As planned, PTS was significantly lower after UKA compared to the native knee (4.91° vs 2.28°; $p < 0.0001$). In the coronal plane, there was no significant difference in the joint line however pre and post-operative mechanical axis were significantly different (5.43°± 2.58 of varus vs. 2.76°± 2.14 of varus; $p < 0.0001$).

Conclusion: This study attempts to quantify sagittal and coronal plane alignment after robotic assisted UKA. More attention should be paid to the role of sagittal plane alignment after UKA. We believe modifying posterior tibial slope, while maintaining PCOR is fundamental in achieving native kinematics and optimizing range of motion in the sagittal plane. This may be best-accomplished using robotic techniques for UKA.

1. Introduction

There has been a dramatic increase in the number of unicompartmental knee arthroplasty (UKA) cases performed in comparison with total knee arthroplasty (TKA). The advantages of UKA include reduced blood loss, faster recovery, and minimal surgical invasiveness [1,2]. In properly selected patients, UKA has been shown to have good clinical and long-term outcomes [3,4].

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However, UKA has a generally shorter implant lifespan and a higher revision rate when compared with TKA [5,6]. UKA failures have been attributed to two major factors: aseptic loosening and osteoarthritis progression [7]. Improper component placement caused by under or over correction of alignment is posited in leading to altered knee kinematics, with accelerated polyethylene wear and disease progression in other compartments [8–11].

In order to assess component placement, radiographic parameters were analyzed to determine proper alignment in the sagittal and coronal planes. While coronal plane alignment after UKA has been well described, there is a relative paucity of literature regarding maintenance and optimization of sagittal plane alignment [12,13]. Sagittal plane alignment has been better described for TKA. Specifically: posterior femoral condylar offset (PCO) and posterior femoral condylar offset ratio (PCOR) have been found to be important determinants of postoperative range of motion (ROM); an increase in the latter has been correlated with knee flexion contracture [14–16]. In addition, another sagittal plane parameter – posterior tibial slope (PTS) – has been significantly related to postoperative knee flexion ROM [17]. In the coronal plane, joint line height and femoral-tibial angle are the traditional parameters for evaluating alignment after TKA. Prior published UKA literature evaluating postoperative kinematics and joint alignment has focused on ligament balancing and coronal plane alignment; it is believed that no prior study, to date, has reported both coronal and sagittal alignment [8,13,18–23].

Robotic-assisted UKA has demonstrated significant promise for providing a high level of accuracy in restoring joint alignment and kinematics [8,21]. In order to more accurately position components in the sagittal and coronal planes, surgeons have turned to robotic-assisted UKA, which allows for improved positioning with the ability of real-time dynamic intraoperative ligament balancing [8,18,24]. The purpose of the present study was to analyze the ability and accuracy of robotic-assisted UKA in balancing sagittal and coronal knee alignment using radiographic parameters.

2. Materials and methods

This study retrospectively reviewed prospectively collected data for 94 knees in 85 patients who underwent medial UKA by the senior author (ASR) from September 2008 to July 2015. Patients were deemed to be candidates for unicompartmental knee arthroplasty rather than total knee replacement on the basis of: diagnosis of unicompartmental osteoarthritis or osteonecrosis; radiographic evidence of preservation of the opposite compartment; and mild radiographic signs of deterioration of the patellofemoral joint. Other surgical inclusion criteria were: ROM of at least 90° with a flexion contracture of <5°, minimal pain at rest, a relatively sedentary lifestyle, a weight of <275 lb. (124.7 kg), and an age of >50 years. Surgical exclusion criteria were inflammatory arthritis, hemochromatosis, chondrocalcinosis, hemophilia, patellofemoral joint symptoms, a positive patellar grind test, symptomatic knee instability, and valgus knee alignment. Surgery was performed using the MAKOplasty robotic-assisted unicompartmental device and a Restoris implant was used (Mako Surgical Corporation, Kalamazoo, MI). The surgical

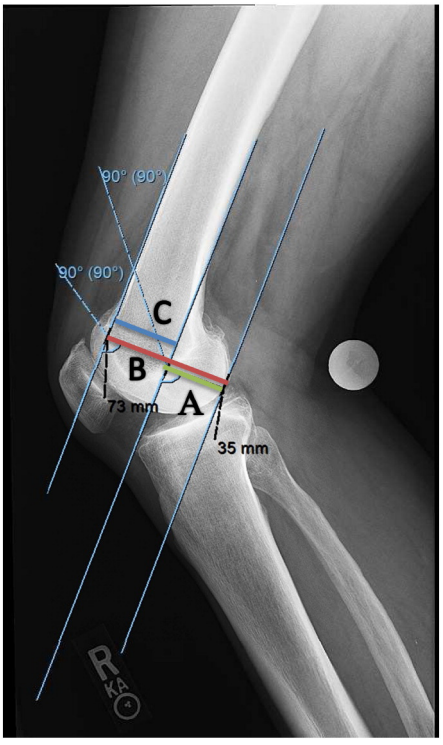

Figure 1. Posterior condylar offset ratio: A is divided by B (A/B).

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