Robotic unicondylar knee arthroplasty: a commentary on a recently published level 1 study

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Total knee arthroplasty (TKA) is predicted to increase at a rate of 673% between 2005 and 2030, with an estimated 3 million procedures being performed annually by 2030 (1). Approximately 8–10% of all knee arthroplasty procedures are unicompartmental knee arthroplasties (UKA), which are predicted to grow at a similar rate or potentially greater (2). With the advent of improved technology and instrumentation, UKA has seen a resurgence and the incidence of UKA has grown at a rate three times that of TKA procedures from 1998 to 2005 (2). UKA is used for end-stage osteoarthritis restricted to the medial, lateral, or patellofemoral compartment (3). The potential advantages compared with TKA are lower perioperative morbidity and earlier functional recovery (3).

Despite the advantages seen with UKA, higher revision rates have been reported than with TKA (2). The causes leading to revision of UKA can be convoluted and multifaceted (4). These can include patient age, indications, ligamentous imbalance, properties of the implant, and alignment of the prosthesis (5). Component alignment is influenced by the surgeon with the goal to achieve restoration of the pre-arthritic compartment height with proper ligament-balancing, thereby minimizing wear and stress on the implant (6,7). UKA is a technically challenging procedure and component malalignment may lead to decreased implant survival and increased revision rates to TKA (7,8).

The introduction of robotics in surgery has primarily been beneficial by augmenting technical improvements (9). Robotics has become significantly more prominent in orthopaedics in the last 3 decades since robotic-assisted systems started providing precision in bone resection (10). This can be achieved by haptic guidance provided to the operating surgeon through a robotic arm equipped with surgical tools (10). Robotic-assisted systems like the MAKO Robotic Interactive Orthopedic (RIO) Arm (Stryker, Mahwah, NJ, USA) have been shown to provide accurate positioning and alignment with real-time ligament balancing (7,10). More precise alignment and configuration between the implant and bone avoids impingement and has been shown to improve functional outcome and in turn may increase the longevity of the implant (8,9).

In a recent therapeutic level 1 study by Bell *et al*. (11), the accuracy of component positioning with robotic-assisted UKA in comparison to conventional UKA was investigated. This was the first level 1 study to assess UKA component placement accuracy based on robotic-assisted (MAKO) versus conventional surgical technique (Oxford). This has produced new insights to the existing controversy of performing UKA. It is well accepted that survivorship in UKA is lower than that seen in TKA; however, several authors believe this is due to inaccurate component positioning in UKA (5,12-14). Robotic assisted devices have been developed to improve the accuracy for implant positioning with the use of preoperative computerized tomography (CT) scans to create a 3D model of the patient's native anatomy, allowing the surgeon to program the robot with the exact dimensions of each cut to be made, as well as the planned position of the prosthetic components (9). A small level 1 study was conducted in 2004 comparing component positioning of the Acrobot robotic system to a conventional Oxford UKA system and found there to be an improvement in coronal alignment with the Acrobot (7). This is in accordance with the existing literature that has investigated the benefits of robotic assisted UKAs (14,15). The investigation by Bell *et al*. (11) is the first to examine 3 planes of alignment. The alignment was assessed via CT scan 3 months following the procedure and compared to the initial preoperative planning CT scan. The authors found that in all 3 planes the tibial and femoral components had alignment closer to the preoperative plan with robotic assistance.

The results seen in the study by Bell *et al*. (11) confirm that component positioning for UKA is more accurate with the use of a robotic-assisted system than the conventional manual technique. This is in accordance with investigations assessing a previous version of the robotic system used (16). Furthermore, a more recent study investigated the accuracy of component placement using robotic-assisted UKA (17). Accuracy was evaluated in the sagittal and coronal planes comparing the intra-operative plan and post-operative radiographs. The authors found an average difference of 2.2°±1.7° to 3.6°±3.3° depending on component and radiographic plane assessed, thus concluded that robotic assisted UKA results in accurate prosthetic position.

However, the question that still remains is if the degree of alignment does in fact lead to increased survivorship. An alternate theory is that the patient selection criteria introduced by Kozinn and Scott (18) in 1989 has led to a decrease in the revision rate seen in UKAs, and if not strictly followed will not improve outcomes. Before the introduction of these guidelines revision rates were as high as 30% at 6-year follow-up, and have since decreased to about 10% at 15-year follow up (19). However, a recent review concluded that adherence to all the original criteria did not lead to improved outcomes (19). Correspondingly, several authors have found there to be no difference in outcomes for one of the selection criteria, obesity, in UKA (15,20). It is believed that the drastic increase in UKA survivorship is a combination of advancement in component design and surgeon skill, thus better implant position. However; the range of component alignment deviates considerably, even in the hands of a skilled surgeon (16).

Furthermore, Whiteside demonstrated that successful knee surgery heavily relies on proper soft tissue balancing in UKA (21). Accordingly, the robotic-assisted UKA system allows the surgeon to fine-tune the prosthesis and bone resection during virtual surgery for any required changes in soft tissue balancing (9). This was demonstrated in a case series of 52 consecutive UKAs using a robotic-assisted system (22). The authors evaluated the accuracy of ligament balancing by comparing the actual ligament balance after implantation of the final components to the intraoperative balance plan at 0°, 30°, 60°, 90°, and 110° of flexion and found the variation in ligament tensioning was less than 1 mm in 83% of cases.

Despite improved accuracy in component position and soft tissue tensioning with robotic assisted UKAs, the survival of the implant is still the most important outcome that must be assessed. Conditt *et al*. (23) reported on 620 patients who underwent robotic assisted UKA using the MAKO RIO system and found a survivorship of 98.9% at an average of 2-year follow-up. The authors concluded that this promising survivorship seen at 2 years indicated that improved accuracy in implant position leads to improved implant survivorship and patient outcomes. Conversely, the 3-year revision rate for UKAs to TKA performed using the robotic-assisted system, with a predominantly all polyethylene component, has been reported as 5.8% by Plate *et al*. (15). This is comparable to the 3-year revision rate of manual UKAs seen in national registries (15). Thus, without the presence of long-term follow-up data we cannot conclude that the increased accuracy demonstrated with robotic-assisted UKA leads to increased implant survivorship. However; the lack of large level 1 studies investigating the accuracy of robotic assisted UKAs makes the addition of the investigation by Bell *et al*. (11) indispensable. Further level 1 studies with long-term follow up must be conducted in the future to evaluate the relationship between survivorship and accuracy of implant position. This will allow us to define the clinical implications of component malalignment in UKA.

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Footnote

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