Computer Navigation and Robotics for Total Knee Arthroplasty

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Total knee arthroplasty (TKA) is a good surgical option to relieve pain and improve function in patients with osteoarthritis. The goal of surgery is to achieve a well-aligned prosthesis with well-balanced ligaments in order to minimize wear and improve implant survival. Overall, 82% to 89% of patients are satisfied with their outcomes after TKA, with good 10- to 15-year implant survivorship; however, there is still a subset of patients that are unsatisfied. In many cases, patient dissatisfaction is attributed to improper component alignment.[1-3] Over the past decade, computer navigation and robotics have been introduced to control surgical variables so as to gain greater consistency in implant placement and postoperative component alignment.

Computer-assisted navigation tools were introduced not only to improve implant alignment but, more importantly, to optimize clinical outcomes. Most studies have demonstrated that the use of navigation is associated with fewer radiographic outliers after TKA.[4] Various studies have compared radiographic results of navigated TKA with results of TKA using standard instrumentation.[4-7] While long-term studies are necessary, short-term follow-up has shown that computer-assisted TKA can improve alignment, especially in patients with severe deformity.[8-10] Currently, there is no definitive consensus that computer-assisted TKA leads to significantly better component alignment or postoperative outcomes due to the fact that many studies are limited by study design or small cohorts. However, the currently published articles support better component alignment and clinical outcomes with computer-assisted TKA. While some argue that the use of computer-assisted surgery is dependent on the user's experience, computer-assisted surgery can assist less-experienced surgeons to reliably achieve good midterm outcomes with a low complication rate.[8,11] Various studies have looked at computer-assisted TKA at midterm

follow-up, with no significant differences in clinical outcome between navigated and traditional techniques. However, long-term studies showing the benefits of computer navigation are beginning to emerge. For example, de Steiger and colleagues[12] recently found that computer-assisted TKA reduced the overall revision rate for loosening after TKA in patients less than 65 years of age.

While surgical navigation helps improve implant planning, robotic tools have emerged as a tool to help refine surgical execution. Coupled with surgical navigation tools, robotic control of surgical gestures may further enhance precision in implant placement and/or enable novel implant

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design features. At present, robotic techniques are increasingly used in unicompartmental knee arthroplasty (UKA) and TKA.[13] Studies have demonstrated that the robotic tool is 3 times more accurate with 3 times less variability than conventional techniques in UKA.[14] The utility of robotic tools for TKA remains unclear. Robotic-driven automatic cutting guides have been shown to reduce time and improve accuracy compared with navigation guides in femoral TKA cutting procedures in a cadaveric model.[15] However, robotic-enabled TKA procedures are poorly described at present, and the clinical implications of their proposed improved precision remain unclear.

Computer navigation and robotic tools in TKA hold the promise of enhanced control of surgical variables that influence clinical outcome. The variables that may be impacted by these advanced tools include implant positioning, lower limb alignment, soft-tissue balance, and, potentially, implant design and fixation. At present, these tools have primarily been shown to improve lower limb alignment in TKA. The

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clinical impact of the enhanced control of this single surgical variable (lower limb alignment) has been muted in short-term and midterm studies. Future studies should be directed at understanding which surgical variable, or combination of variables, it is most essential to precisely control so as to positively impact clinical outcomes. ∎

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