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EDITORIAL

Minimum reporting criteria for robotic assisted total knee arthroplasty studies

ALIGNMENT AND BALANCING TECHNIQUES SHOULD BOTH BE DEFINED

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There is a growing body of evidence assessing the outcome of robotic assisted total knee arthroplasty (rTKA), however it is not clear whether there is any functional benefit when compared to conventional manual TKA.[1-4] Robotic assisted TKA allows the surgeon to position the implant accurately, joint gap to be balanced, and results in less soft tissue damage compared to manual TKA.[5-7] However, there remain numerous techniques of aligning the implant and how the joint space/pressure should be balanced.[8-11] Alignment and balance are likely to be directly related to one another, as balance may not be maintained throughout a range of movement (ROM) if the implant is not positioned along the kinematic axis for that knee due to differential change in the ligament tension.[12] However, there are numerous methods for alignment of the prothesis and it is not clear which is optimal.[8] Even when alignment has been defined/achieved the method and definition of balancing the knee throughout a ROM is also variable with numerous techniques being described, and numerous definitions of 'balance'.[11] It is not always clearly stated in rTKA studies how the implant was aligned or how balance was achieved or defined.[1,3] The authors suggest there should be a minimum reporting criterion for future rTKA studies to clearly define these methods to allow the results to be interpreted in context. Currently all data from rTKA studies are being amalgamated on the assumption of a homogeneous group of patients and this may not be the case.[5,13] The authors propose that implant alignment and method of balancing the knee should be defined in all future rTKA studies.

Riviere et al[8] defined five different methods of implant alignment: mechanical, adjusted mechanical, anatomical, kinematic, and restricted kinematic alignment. More recently Oussedik et al[14] have also defined functional alignment.

Mechanical alignment was described by Insall.[15] The bone cuts are made perpendicular to the mechanical axis of the lower limb. Using manual techniques, the mechanical axis is generally taken to be the same as the anatomical axis of the tibia and the distal femoral cut is made in 4° to 6° of valgus relative to the anatomical axis of the femur using an intramedullary alignment jig. Navigation and robotic assisted surgery allow the surgeon to position the implants perpendicular to the true mechanical axis of the lower limb, which may vary when compared to manual techniques using jigs and assumed mechanical axis of the femur and tibia.[16] Changing the joint line to be perpendicular to the mechanical axis, compared to the mean 3° of varus, there needs to be compensatory external rotation of the femoral component to balance the knee in flexion.[9]

Anatomical alignment is similar to the mechanical alignment method but the joint line is made in 3° of valgus relative to the mechanical axis of the lower limb.[17] The aim here is to reproduce the mean 3° of varus of the tibia and 3° of valgus on the femur relative to the mechanical axis. Therefore, no adaptive external rotation of the femur is required to balance the knee in flexion. Riviere et al[8] also define an anatomical alignment-like technique where mechanical alignment cuts are made but the prosthesis has 3° valgus joint line built into the design.

In the acceptance that some patients have a naturally varus or valgus knee joint alignment, adjusted mechanical alignment is used to restore the constitutional varus/valgus to within a maximum tolerance of 3°.[18,19]

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Kinematically aligned TKA aims to reproduce the patient's normal anatomy and align the implant to their own unique kinematic axis (tibiofemoral and patellofemoral joints), and can be thought of as a resurfacing of the knee.[20] After accounting for cartilage thickness of approximately 2 mm, measured resection of the femur and tibia are performed. For example, an 8 mm bone resection would be performed for a component that is 10 mm thick. The slope of tibial is also replicated but may be reduced slightly to protect the integrity of the posterior cruciate ligament.[20] This technique does not require any ligamentous release other than the surgical approach.

In the knowledge that implant malalignment can potentially lead to an increased risk of failure and revision of TKA, some authors have described restricted kinematic alignment where the implant is aligned with a 'safe range' thought to replicate the patient's normal knee but not predispose them to early failure. However, these definitions do vary according to author group,[21,22] and the parameters used should be stated in the methods section of a manuscript. Oussedik et al[14] described functional alignment as being similar to restrictive kinematic alignment, using intraoperative image navigation to assess joint gaps in flexion and extension and adjusting the implant position to equalize these joint gaps.

The definition of a balanced knee joint is not clear.[11] Four commonly employed methods are measured resection, gap balancing, intracompartmental pressure, and natural.

The principle of measured resection is to remove the same amount of bone/cartilage that is to be replaced by the prosthesis.[9] However, this is not true measured resection when the alignment is anything other than kinematic. The rotation of the femoral component can be assessed using Whiteside's line and the posterior condylar axis.[9,11] Again, this bone cut is often differential to accommodate the 3° of external rotation of the femoral component commonly employed. The tibial cut is also often not true measured resection with a decreased slope often being used and the varus/valgus position being adapted according to the alignment technique used. Once measured resection has been performed, balance is assessed by the surgeon and ligament releases performed as needed.

Gap balancing traditionally starts with the tibial cut first, the aim being to make this perpendicular to the mechanical axis.[9] The femoral component is then positioned parallel to the tibial bone cut in extension and at 90° of flexion, the aim being to create equal rectangular extension and flexion gaps the same as the thickness of the component to be used. The gap can be assessed using distraction devices and spacer blocks intraoperatively. More recently intraoperative computer navigation enables the surgeon to define their flexion and extension gaps.[16] No ligamentous releases are thought to be needed, but these are sometimes required.[23]

The VeraSense knee system (Orthosensor, Dania Beach, Florida, USA) is a device that can be used to measure intraoperative pressures in the medial and lateral compartment of the prosthetic knee joint and can be used as part of measured resection or gap balancing.[24] The current aim is to equalize the pressures in the compartments to within 15 lbs either by further bone resection or soft tissue releases.[25]

It is recognized that in the normal knee the medial compartment works more like a ball and socket, whereas the less constrained lateral compartment allows for femoral roll back in flexion resulting in internal rotation of tibia.[26] The native joint space is thought to be trapezoidal and a recent kinematic alignment study found better outcomes with increased laxity in the lateral flexion gap.[27]

Robotic-arm assisted unicompartmental knee arthroplasty has been shown to be associated with improved early pain scores and function when compared with manual unicompartmental knee arthroplasty,[28] and better functional outcome when compared with manual TKA,[29] however whether such a benefit is also associated with rTKA relative to manual TKA remains to be affirmed. The technique that is used to align and balance the rTKA is an essential element of any published study assessing the outcome, so this can also be assessed as an influencing factor.

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