Novel Algorithm for Gap Balancing and Bone Cuts in Robotic Total Knee Replacements significantly improves Accuracy and Surgical Duration

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Introduction / Objective

Robotic Total Knee Replacements (rTKR) have become increasingly popular. However, intra-operative manual planning of the positions of the femur and tibia implants in all possible degrees of freedom to achieve the surgeon's ideal targets and limits of bone cuts, gaps and alignment is challenging. The final manually defined solution may not be optimal, and surgical duration becomes extended significantly. We aim to demonstrate the clinical effectiveness of utilising our novel algorithm.

Materials & Methods

We have developed a novel computational algorithm to achieve optimal positioning of rTKR implants. The initial set of parameters determining the 3D positioning of the implants and the surgeon-defined target gaps and bone cuts are first defined. The algorithm then determines various permutations that give the ideal 3D positioning of the implants, to fulfil the targets with an accuracy of ±0.5mm, while also ranking them by surgeon-preference and evidence-based criteria. We compared the accuracy and duration in achieving surgeon-defined target gaps between both groups. Power analysis based on a pilot study showed 44 patients were required.

Results / Discussion

A prospective study of 67 consecutive rTKR patients at a tertiary institution from November 2021 to December 2023 was performed. 25 utilised the algorithm intra-operatively while 42 did not. 92% of rTKRs that used our algorithm achieved surgeon-defined target gaps ±1.5mm, compared to 52% of rTKRs that were done manually (P=0.003). With algorithm use, average difference between surgeon-defined target gaps and final achieved gaps was significantly lower (1.08±0.51mm vs 1.81±1.04mm, P=0.003), gap-balancing duration was significantly shorter (1.16min±0.11 vs 14.49min±8.31, P<0.0001), and total surgical duration was significantly lower (38.4min±14.94 vs 73.66min±19.61, P=0.0002).

Conclusion

Our novel algorithm significantly improves both accuracy of achieving the surgeon's target extension and flexion gaps, along with gap-balancing and overall surgical duration. This is highly promising for achieving both reproducibility and efficiency in rTKRs.