MEDIA RELEASE

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Alexandra Hospital develops world's novel A.I. algorithm (with international patent) that enhances accuracy and efficiency of robotic total knee replacement

Newspoints:

- An A.I. algorithm for robotic total knee replacement (rTKR) has secured an international Patent Cooperation Treaty (PCT) patent[1], that protects this algorithm for robotic total knee replacement for its uniqueness, exclusivity, novelty and proprietary rights. Filed since August 2024 in over 150 member countries to seek patent protection, to-date, there are no other similar concepts or technologies found through rigorous examination and vast data searching by independent patent authorities. Singapore's patent was obtained earlier in October 2023.
- More than 200 patients have benefited from this novel approach since 2023.
- The algorithm has an implant planning accuracy of within ±0.5mm, and has shown an accuracy of 92% for rTKRs, compared to 52% in the manually planned group, in achieving the surgeon-defined target gaps within ±1.5mm. This enhanced precision in surgical planning helps with final implant placement.
- By replacing manual intraoperative adjustments with AI-driven optimization, the technology reduces surgical duration by approximately 15 minutes, potentially leading to improved patient outcomes and satisfaction.

[1] This PCT application itself does not automatically confer this novel solution as the "world's first".

Alexandra Hospital's Orthopaedic surgery consultant, Dr Glen Liau flanked by Matthew Ng and Ryan Loke (far right) who developed this novel AI-based algorithm to enhance accuracy and efficiency of robotic total knee replacement.

Singapore, 11 February 2025 – A team at Alexandra Hospital (AH) Orthopaedic Surgery has obtained an international Patent Cooperation Treaty (PCT), which is administered by the World Intellectual Property Organization, and that protects this algorithm for robotic total knee replacement for its uniqueness, exclusivity, novelty and proprietary rights. Filed since August 2024 in over 150 member countries to seek patent protection, to-date, there are no other similar concepts or technologies found through rigorous examination and vast data searching by independent patent authorities. Singapore's patent was filed in October 2023 earlier, and had established that as a computational algorithm designed to improve the accuracy and efficiency of robotic total knee replacements (rTKR), it is one of a kind.

The algorithm was developed by Dr Glen Liau Zi Qiang, Orthopaedic Surgery Consultant at Alexandra Hospital (AH) and National University Hospital (NUH), in collaboration with Dr Matthew Ng Song Peng, and Mr Ryan Loke Wai Keong, who were both medical students when they embarked on this project with Dr Liau. This AI-powered innovation optimizes personalised implant positioning in rTKR surgeries by integrating patient-specific unique anatomical characteristics with the surgeon's preferred surgical philosophy.

Since 2023, more than 150 patients have successfully undergone this innovative approach, which addresses the challenges of manual planning during surgery. It has been shown to both significantly improve accuracy in surgical planned positioning of the knee components, and reduce surgical duration, with the potential to improve postoperative outcomes and implant longevity.

Addressing Challenges in rTKR Procedures

Total knee replacement (TKR) surgeries are among the most commonly performed orthopaedic procedures, particularly for patients suffering from severe knee pain due to degenerative conditions such as osteoarthritis. The prevalence of these surgeries has risen by 2.7 times, increasing from 187 per 100,000 individuals aged 65 and above in 1999, to 499 per 100,000 in 2019[2].

Robotic-assisted TKR surgeries have gained popularity over the past five years due to their potential to improve surgical precision and patient outcomes. However, challenges remain: achieving optimal implant positioning that accounts for both the patient's unique bony and ligamentous anatomy, and the surgeon's objectives. Accurate positioning of the implants is critical for the post-operative biomechanical function of the knee, patient's comfort, and success of the operation.

Currently, rTKR surgeons manually plan and adjust the positioning of femur and tibia implants intraoperatively. This can be a complex process, as it requires 3-dimensional space consideration of the two implants in at least 8 axes of movement / degrees of freedom. As each degree of freedom influences the others, it can be challenging to achieve the most ideal position of implants for each patient. This may require a surgeon to take into consideration thousands of possibilities, with a possibility of needing to redo bone saw cuts and soft tissue releases multiple times, or to utilise planning simplifications that could impact surgical precision. The decision-making process is further complicated by time constraints in the operating room, often limiting the number of possible solutions a surgeon can explore. As a result, manual planning can be time-consuming and may introduce variability in surgical outcomes.

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[2] Managing Healthcare Cost Increases (https://www.moh.gov.sg/newsroom/managing-healthcare-cost-increases

Features of the new AI-algorithm Solution

The novel developed AI algorithm addresses these challenges by streamlining and automating implant positioning within the rTKR workflow. By considering at least eight degrees of freedom and their interdependencies, the algorithm computes thousands of permutations to determine the optimal implant placement.

Key features of the algorithm include:

- **Enhanced Accuracy:** Achieves an implant planned positioning accuracy of ±0.5mm that is personalised for both the patient's unique anatomy, and individual surgeon's philosophy.
- **Computational Efficiency:** Within 0.1 seconds, the algorithm solves for a hyperplane of thousands of solutions and ranks optimal solutions effectively.
- **Reduced Surgical Duration:** Minimizes time spent on intraoperative planning, reducing overall surgical duration.

Clinical Benefits and Future Prospects

This algorithm has been shown to significantly increase the accuracy of planning for TKR implants and saves valuable time during surgery, which potentially translates into reduced blood loss and shorter anaesthesia duration. Further long-term studies are being conducted to investigate the degree that this innovation may improve patient outcomes and safety by decreasing rates of suboptimal implant positions, unnecessary operative time, blood loss, infection rate. By improving planning accuracy, this may also lower the risk of postoperative complications such as loosening, wear, and instability, reducing the number of revision surgeries needed, and contributing to better long-term implant function and longevity, and lead to cost savings over time.

A prospective study involving 67 rTKR patients between 2021 and 2023 demonstrated the algorithm's effectiveness:

- **Accuracy:** 92% of rTKRs using the algorithm achieved the surgeon-defined target gaps within ±1.5mm, compared to 52% in the manual planning group.
- **Time Efficiency:** The AI-assisted group achieved optimal gap balancing in under 0.1 seconds, compared to 15 minutes in the manual planning group, which included redo bone saw cuts and soft tissue releases.
- **Consistency:** The algorithm's performance was unaffected by variables such as patient age, gender, height, or severity of knee degeneration.
- **Surgical Productivity:** Procedures utilizing the algorithm were completed approximately 48% faster than those relying on manual planning[3].

The research underpinning this innovation has been recognized at major scientific forums, including the 2024 Singapore Orthopaedic Association Annual Scientific Meeting, where it received the P Balasubramaniam Award as the best research paper. It has also been selected for presentation at the 2024 International Society for Technology in Arthroplasty (ISTA) Scientific Congress in the USA and the 2025 International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine (ISAKOS) Congress in Germany.

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[3] From an average duration of an hour plus to under 40 minutes.

Looking Ahead

“I am passionate about incorporating innovative solutions to enhance my patient outcomes.” said Dr Glen Liau who practices and operates at both AH and NUH. "It brings me great joy and satisfaction to see my patients enjoy a significantly improved quality of life following surgery," he added. With ongoing studies to validate its long-term impact, this AI-driven approach has the potential to set new standards in robotic-assisted orthopaedic surgery, ultimately benefiting both patients and surgeons worldwide.

Click to see AH’s video on this new approach (Source: AH)