From Guesswork to Certainty: Predicting Spinal Fractures in Cancer Patients

Alkaios Lamprakis - University College London

Every year, thousands of cancer patients develop spinal metastases, leaving surgeons facing a challenging decision: operate now to prevent catastrophic fractures, or avoid risky surgeries that may be unnecessary?

Wrong decisions mean patients either suffer preventable paralysis or undergo needless operations with serious complications, decreasing their quality of life. This research uses advanced mathematical modeling to give surgeons precise, patient-specific data.

By analyzing medical scans and running computational simulations, the goal is to predict how much force a diseased vertebra can withstand before fracturing, transforming guesswork into data-driven decisions. Current clinical tools treat bone as a simple solid material. However, tumors fundamentally change how vertebrae behave. This approach uses poroelasticity to capture how solids and fluids interact within living tissues. This accounts for how cancer cells weaken the bone structure at a fundamental level, delivering increased precision in fracture prediction.

This framework can also be extended to model tumor growth and nutrient transport, enabling even better clinical insights. Built on Firedrake, an open-source Python framework, it is scalable and cost-effective for hospital implementation. In the UK, unnecessary spinal surgeries cost the NHS around £20,000 per procedure, with additional costs from complications and extended recovery. On the other hand, missed interventions lead to emergency surgeries costing significantly more, and have poor patient outcomes.

Ultimately, our goal is to help clinicians make the best decision for the patients, reduce hospital costs and give cancer patients personalized care that maximizes their quality of life.