JTO Subspecialty Section

The Future of Orthopaedic Surgery

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As the 21st century comes of age and the global burden of disease shifts increasingly towards musculoskeletal conditions, orthopaedic surgeons will be called upon to rise to the challenge.

Orthopaedic surgery is on a path towards less invasive and more precise operations, with a greater proportion of outpatient and overnight procedures[1]. This trajectory is likely to continue and will be further facilitated by new technologies, making surgery more selective and the orthopaedic surgeon an increasingly proactive specialist in the management of injuries and conditions.

As the saying goes: "Predictions are difficult, especially about the future." It would be remiss

to presume too much about how orthopaedic surgery will look tomorrow, but there are a few key trends that are becoming apparent. This is occurring against a backdrop of increasing demand for orthopaedic services worldwide and the rising threat of antibiotic resistance[2,3,4]. Clinical expertise and experience will be needed to inform appropriate responses.

Technology is reshaping the world and, with it, orthopaedic surgery. Whilst many recent advances have occurred inside the operating theatre, much of what is set to change will take place outside of the hospital, beyond the clinic room, in the time before and after surgery.

Measuring quality: Tomorrow's questions

As new tools and techniques enter orthopaedic practice, accurate and comparable approaches to assess quality of care and outcomes will be paramount. The future success of orthopaedic surgery will be assessed using digitally-enhanced Patient-Reported Outcome Measures (PROMs). By applying Item Response Theory and Computer Adaptive Testing

(CAT), which shapes remaining survey questions based on those already answered, patients can be asked more relevant questions whilst giving fewer responses.

CAT can make patients' survey responses more efficient, of higher quality and more easily comparable. Cambridge University's open-source adaptive testing platform Concerto (*concertoplatform.com*) and the Patient-Reported Outcomes Measurement Information System (PROMIS) (*www.healthmeasures. net*) are leading exponents of this approach, with the latter comprising the world's largest item bank of CAT measures currently being translated, implemented and validated across the word. PROMIS surveys measure generic, commonly relevant outcomes such as pain and physical function that can be used and correlated across and within different patient populations. Increasingly, orthopaedic patients have more than one condition and combining generic scores with disease or procedure-specific measures provides opportunities for more comprehensive assessments with relevance across different groups[5]. PROMIS CAT surveys can also avoid the ceiling effects seen with other musculoskeletal function scores[6].

Beyond surveys: Smartphones and sensors

As existing models of measuring pre-intervention function, treatment progress and outcomes are being refined, smartphones, wearables and sensors are adding new layers of objective, real-world data, informing a deeper and more nuanced understanding of musculoskeletal treatments and results. Specialised sensors able to provide continuous, real-time information will increasingly enhance decision-making before, during and after surgery.

Smartphones are rapidly becoming ubiquitous across the world and, with their in-built recording of steps and activity, offer a convenient and scalable means of measuring the physical activity of both individuals and large populations[7]. Automatically collected patient-specific data will reveal new insights into recovery patterns and enhance pre- and post-intervention planning. Research using smartphone data in orthopaedics is in its infancy, yet its use has been demonstrated

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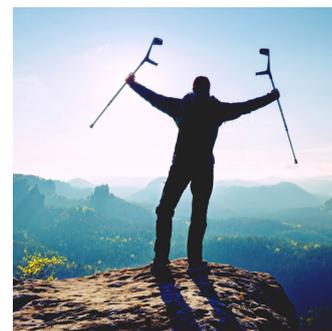
in predicting outcomes including Parkinson's-related gait progression and recovery from shoulder injuries[8,9]. Improved tools to estimate recovery progress against activity-related baselines and procedure-specific points of reference may also aid conversations with patients about treatment goals and expectations.

Remote support and day-case surgery

Improved capabilities for accurate remote monitoring and self-care will further enable day-case surgery. Retrospective activity data with clear baselines and tools to estimate outcomes will help to identify patients appropriate for outpatient procedures. Patients will be able to take more active roles in their treatment and improved capabilities for remote support can help to ensure that the potential savings of shorter hospital stays are not offset by increased follow-up appointments or readmissions[10].

Machine Learning and Artificial Intelligence: Making sense of more information

Arguably, the uptake of robotic surgery may not have been as rapid as expected, yet its transformative potential is clear. Robotic surgery and Artificial Intelligence, as with any powerful force, must be handled with respect. As costs fall and evidence builds, robotic-assisted approaches will become increasingly common across the orthopaedic subspecialties. Rather than replacing clinical skills, however, these new technologies will assist and enhance decision-making intra-operatively, as they will do too in the planning and recovery stages. In time, computer-assistance is likely to also enable new techniques and procedures[11].

Currently recognised as the best-in-class approach within AI, Machine Learning techniques combine computer science and mathematics to improve predictive accuracy and translate large datasets into useful insights[12]. Long before autonomously operating robots become credible competitors, AI systems will revolutionise orthopaedics by working in partnership with surgeons, applying their superior capacity of drawing conclusions from large datasets, to enable surgeons to do more, better. Recent successful examples include algorithms helping to organise operation lists, prioritise workflow and predict in-hospital mortality, unplanned readmissions and prolonged length of stay[13,14]. Indeed, an appealing vision of the future is one where emerging technologies increasingly shoulder administrative duties, meaning healthcare becomes safer and more efficient, whilst surgeons are freed up to spend more time on clinical work.

New tools of the trade

Biologic treatments comprise a wide field of techniques, including stem cell therapies and platelet-rich plasma injections, which aim to encourage regeneration and repair. Whilst the current evidence for these techniques is variable, biologic approaches hold great potential and will likely play a role in the future evolution of the orthopaedic surgeon as injected therapies become more common.[15,16]

3D imaging, navigation and printing will enable surgeons to be increasingly precise and personalised. Implants themselves will become increasingly 'smart' with person-specific design, dynamic materials and incorporated sensors providing further data and direct feedback on progress and performance. Smart implants will be able to highlight the need for further review and may even be self-protective by automatically responding to changes in the local environment[17].

Virtual and augmented reality will enhance pre-operative planning, training and procedural precision, further supporting safer surgery[18]. Telemedicine tools are enabling surgeons to share expertise in real-time during cases, adding a new dimension of collaboration to surgical practice, which may evolve further as surgeons become increasingly able to virtually 'scrub in' and join cases remotely[19].

Coming together

As orthopaedic practice is changing, so too is the fabric of the profession, increasingly matching the diversity of its patients. The current and widely acclaimed online campaign #ILookLikeASurgeon is challenging the white, male surgeon stereotype and helping to redefine ideas about who surgeons are[20].

The ability to share ideas and experience is a core promise of a more interconnected and informed world. As highlighted by The Lancet Commission on Global Surgery, five billion people are currently unable to benefit from surgical care and, whilst many new technologies are vying for a place in the orthopaedic toolkit, perhaps the most significant achievements of tomorrow will lie in replicating current successes and increasing access to high quality surgery.[21] To echo the author William Gibson: "The future is already here – it's just not evenly distributed"[22].

Communities of orthopaedic surgeons are forming to discuss and define the changing landscape. To find out more and join these conversations, see the links below to Stefano Bini's Digital Orthopaedic Conference in San Francisco; the upcoming Digital Orthopaedics meeting at The Royal Society of Medicine and, for more general discourse on the impact of AI in medicine, AIMed Europe. ■

Find out more:

AIMed Europe
Shoreditch Town Hall,
11-13th Sep 2018
aimed.events/aimed-europe

Digital Orthopaedics: Measuring quality in orthopaedic healthcare
The Royal Society of Medicine,
Monday 17th Sep 2018
tinyurl.com/rsmortho

Digital Orthopaedics Conference San Francisco
InterContinental San Francisco,
Jan 5-6th 2019
www.docsf.health

Axel Sylvan trained in surgery before co-founding the London-based orthopaedic start-up myrecovery.ai with fellow surgical trainee and patient Tom Harte. Aiming to improve patient experience and clinical insight, www.myrecovery.ai enables surgeons to create tailor-made treatment companion Apps and, with a growing team of software engineers and PhDs, is developing the next generation of AI-enabled digital tools for musculoskeletal care.

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References can be found online at *www.boa.ac.uk/publications/JTO* or by scanning the QR Code.

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