Wearable sensor technology in spine care

As in all fields of medicine, outcomes in spine surgery are important by reflecting a patient's clinical status, with continuous data monitoring delivering significant potential benefit to both patient and health care provider. In spine surgery, outcomes are measured in terms of pain, functional disability (focussing on impairments to activities of daily living), radiological features, and physical performance. These outcomes may be quantified by various outcome measures – instruments which measure outcomes. This allows for the measurement of disease severity, the assessment of intervention effectiveness (measuring outcomes before and after an intervention), and the tracking of rehabilitation processes (comparing changes in outcomes over time).

Patient-reported outcome measures (PROMs) are commonly used in spine surgery for the assessment of clinical outcomes. These include the Visual Analogue Scale, and the Oswestry Disability Index, which are validated questionnaires that allow patients to communicate their perspective of their disease (1). However, by being inherently subjective, these measurement tools are highly variable depending on patient psychology at the timepoint of measurement (2), potential secondary gain, and reporter bias if the information is being collected by a third party. Furthermore, these tools are used at discrete timepoints (for example, after surgery, patients may be typically assessed at the 2-week, 6-week, and 3-month timepoints depending on the preferences of the clinical team, providing no information about the changes in health status that occur between these timepoints). Hence, although PROMs are useful in the evaluation of the spine patient, they have significant disadvantages.

To overcome the drawbacks of subjective outcome measures in spine surgery, clinicians may also use objective outcome measures. Objective outcome measures in spine surgery include, but are not limited to, radiological and physical assessments. However, the radiological assessment of spinal pathologies may poorly correlate with clinical symptoms, affecting their relevance as a marker of clinical health status (3). Physical assessment traditionally involves clinician-observed single time-point tests such as the six-minute walk test (4). However, these tests are susceptible to the "white-coat effect" of greater conscious control of walking when observed (5). Fortunately, with technological advancements, wearable technologies (including smartphones, smartwatches, and activity trackers, which many patients already use) have emerged as a more sophisticated method of physical assessment using gait and walking analysis. Commercial devices such as smartwatches can measure basic metrics (step count and walking speed), however questions regarding accuracy remain, and these devices may not yet be suitable for medical grade monitoring.

Wearable devices are small, lightweight, and unobtrusive in daily life. Therefore, they can collect objective data as people participate in day-to-day activities. This paints a detailed continuous portrait of a person's health status, as opposed to the "snapshot" assessment that PROMs provide. In spinal patients, wearable devices can be used to measure gait and walking metrics relating to physical activity (typically daily step count), spatiotemporal gait metrics (such as walking speed, step length, and step time), and derived asymmetry and variability metrics. These metrics are relevant in the assessment of spine patients. Daily step count is representative of general health, with higher daily step count values being significantly associated with lower all-cause mortality (6). Meanwhile, spatiotemporal metrics and their derived asymmetry and variability metrics are particularly relevant in gait-altering pathologies, such as lumbar spine pathologies (including lumbar spinal stenosis, lumbar disc herniation, and mechanical low back pain) (5,7-9), cervical myelopathy, and in the identification of complications following spinal surgery (10). Objective gait and walking metrics have future possibilities of being combined with artificial intelligence to form predictive algorithms and assist in the diagnosis of disease (5).

Another benefit of such devices within the spinal arena is to compare technique, intervention and medical device performance from a patient outcomes perspective. For lumbar spine fusion, there are many reported approaches to achieve spinal arthrodesis (11), however there remains conjecture as to the 'best' or most efficacious technique depending on a particular pathology. These devices may add insights to recovery kinetics so that the clinician can use objective data to assist in decision making. Ultimately, a combination of PROMs and objective metrics may provide a more comprehensive evaluation of the spine patient. The authors encourage the use of wearable devices amongst spine care providers. On that note, the authors are proud to present this special edition to highlight and contribute to the rapidly expanding literature base on the use of wearable devices for the spine patient.

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Footnote

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References

1. Finkelstein JA, Schwartz CE. Patient-reported outcomes in spine surgery: past, current, and future directions. J Neurosurg Spine 2019;31:155-64.
2. Stienen MN, Smoll NR, Joswig H, et al. Influence of the mental health status on a new measure of objective functional impairment in lumbar degenerative disc disease. Spine J 2017;17:807-13.
3. Babińska A, Wawrzynek W, Czech E, et al. No association between MRI changes in the lumbar spine and intensity of pain, quality of life, depressive and anxiety symptoms in patients with low back pain. Neurol Neurochir Pol 2019;53:74-82.
4. Stienen MN, Ho AL, Staartjes VE, et al. Objective measures of functional impairment for degenerative diseases of the lumbar spine: a systematic review of the literature. Spine J 2019;19:1276-93.
5. Betteridge C, Mobbs RJ, Fonseka RD, et al. Objectifying clinical gait assessment: using a single-point wearable sensor to quantify the spatiotemporal gait metrics of people with lumbar spinal stenosis. J Spine Surg 2021;7:254-68.
6. Saint-Maurice PF, Troiano RP, Bassett DR Jr, et al. Association of Daily Step Count and Step Intensity With Mortality Among US Adults. JAMA 2020;323:1151-60.
7. Chakravorty A, Mobbs RJ, Anderson DB, et al. The role of wearable devices and objective gait analysis for the assessment and monitoring of patients with lumbar spinal stenosis: systematic review. BMC Musculoskelet Disord 2019;20:288.
8. Ghent F, Mobbs RJ, Mobbs RR, et al. Assessment and Post-Intervention Recovery After Surgery for Lumbar Disk Herniation Based on Objective Gait Metrics from Wearable Devices Using the Gait Posture Index. World Neurosurg 2020;142:e111-6.
9. Mobbs RJ, Mobbs RR, Choy WJ. Proposed objective scoring algorithm for assessment and intervention recovery following surgery for lumbar spinal stenosis based on relevant gait metrics from wearable devices: the Gait Posture index (GPi). J Spine Surg 2019;5:300-9.
10. Mobbs RJ, Katsinas CJ, Choy WJ, et al. Objective monitoring of activity and Gait Velocity using wearable accelerometer

following lumbar microdiscectomy to detect recurrent disc herniation. J Spine Surg 2018;4:792-7.
11. Mobbs RJ, Phan K, Malham G, et al. Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. J Spine Surg 2015;1:2-18.

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