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Wide awake surgery as an opportunity to enhance clinical research

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By now we are becoming more familiarized with the Wide Awake Local Anesthesia No Tourniquet or the WALANT technique, and its accompanying advantages. From a clinical perspective, the limitations as a result of general anesthesia are lifted, relieving patients from strict pre-surgical instructions and assessments, possible accompanying side effects, an intravenous line and a hospital stay. But the advantages of WALANT are not limited to the clinical experience alone. In this article, we will describe potential new areas and opportunities for research by using different research related aspects and placing them within the context of the WALANT approach to hand surgery.

Extension of operation time and intra-operative motion assessment

Depending on the location and extent of the surgical procedure, different total volumes and concentrations of injectate can be used to acquire the desired effect, varying from 1% lidocaine and 1:100,000 epinephrine to 0.25% lidocaine and 1:400,000 epinephrine¹. This results in up to 2.5 hours of effective local anesthesia without the need for a tourniquet; even for longer procedures the main limitation is patient fatigue and difficulty in remaining still for extended periods of time, as dosing can be repeated, even if longer acting anesthetics are not used. This elongated window of opportunity allows for the clinical researcher to make full use of another beneficial feature of WALANT versus general anesthesia: the ability to have the patient actively move their wrist, hand or fingers allows for direct physiological measurements that would otherwise have been either obtained indirectly by imaging

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modalities or not possible at all. Since hand anatomical dimensions are highly individualistic, any non-individual estimates are hard to generalize, which emphasizes the added value for research outcomes of intraoperative patient specific assessments.

Wide awake hand surgery by itself is not new, and research studies have used the advantages of wide awake surgery for years, albeit through a much shorter time window due to the historical avoidance of the use of epinephrine in the hand, for reasons now discredited¹, with the need to complete studies before tourniquet pain and tourniquet induced paralysis drawing the investigation to a conclusion. Within these restrictions, researchers in the past were able to quantify tendon forces in order to better understand normal digit function. One such study for example measured flexor tendon forces during carpal tunnel release surgery². Using an S-shaped buckle transducer, tendon forces were measured during a set of different active motions, and correlated with fingertip load. This required the patient's full cooperation during surgery, but could be accomplished within a 10–15 minute window. Similar studies could, for example, correlate tendon, nerve and synovial motion after carpal tunnel release, as a novel way to quantitate the effect of adhesions on motion, and to validate non-invasive ultrasound measurements.

Wide awake surgery has also been described as a means to test surgical repair success, the need for adjustment of tendon tension before closure of the skin, and to test the patient's cognitive adaptation to tendon transfers³. One study observed that all patients (n=7) could extend their thumb immediately after the commonly performed extensor indicis proprius to extensor pollicis longus tendon transfer, without any special education. Based on these results, the authors concluded that the concept of formal reeducation after tendon transfer in the hand may require re-evaluation, and that it is more likely that a preexistent neural system is recruited to cope with the new alignment. This opens an exciting new field of research where other procedures and the ability of the patient's adjustment to a new "wiring" construction can be assessed within a very short time frame through the use of WALANT.

Intra-operative measurement of muscle properties has been described by Lieber et al. Sarcomere length has a significant impact on force generation in a muscle and should therefore affect surgical results. However it is extremely difficult to measure sarcomere length in living humans for research purposes, for one due to the need of tissue exposure⁴. Additionally, results of tendon transfer in particular can be very surgeon and clinical situation dependent, making generalization and the design of specific guidelines challenging⁵. WALANT allows for intra-operative measurements with laser diffraction techniques^{6,7} to quantify sarcomere overlap indicating the achievement of a stage of muscle resting length at the end of the surgical procedure. Simultaneous comparison of these measurements with theoretical modelling have already been shown to be a powerful tool to help the surgeon better predict functional outcomes⁸. With WALANT, due to the increased operating time permitted, further refinements are also possible. A hypothesized model combining tension of the transfer, intraoperative force during pinch or grip and sarcomere length and all of their correlations could now, for example, be measured to address scientific questions related to optimal functioning of the tendon transfer. Research questions concerning the presence of, if any, a functional disadvantage of setting the transfer slightly tighter than physiological length of the muscle, could also be tested. With physiological

length accurately assessed by sarcomere length, and with the ability under WALANT to measure many aspects of hand function in the operating room, and even to change them, such questions can be answered empirically.

Imaging validation

Part of developing novel imaging techniques or data analysis protocols is the necessity to establish both the repeatability as well as the validity of the technique. The first meaning that similar results are acquired when performing the same type of measurement on the same subject multiple times, and the latter indicating that any quantitative measurements provided by the imaging modality adequately reflect physiological truth. Validation is more than often done using either cadaveric samples or phantom models, which in their own respect can approximate the clinical situation but also have intrinsic limitations. For example, in the context of carpal tunnel syndrome (CTS), many studies have used B-mode ultrasound imaging in order to improve the accuracy of diagnosis or to help predict treatment outcome^{9,10}. More recently, dynamic imaging of tendon and nerve motion, as well as movement of the surrounding synovium (which is thickened in CTS and also distinctly visible ultrasonographically) has been added to the repertoire^{11–13}. WALANT-based research can, for example, explore the hypothesis that stiffening of the connective tissue around the carpal tunnel structures might underlie part of the CTS pathophysiology¹⁴. Although part of the validation work for a particular displacement analysis technique called speckle tracking has been done in cadavers¹⁵ and phantoms¹⁶, a real-time validation could also be done using a wide awake approach during live surgery¹⁷. The latter off course best representing the clinical situation in which the clinician would later incorporate the imaging method. Dissociation between the movement of flexor tendons and the covering visceral synovium has also been documented *in vivo* during carpal tunnel release surgery¹⁸.

Separating the effect on function of a surgical procedure versus healing

During any type of anatomy altering procedures (as compared to fixation type surgeries), the hand surgeon can utilize the patient's ability to actively move to assess the effect of the procedure based on the mechanical properties of the subjected structures and those that surround them. Although this type of immediate feedback is indispensable for surgeons to review their work, it has the limitation of only providing the expected result if mechanics were the only influencing factors. However, after surgery, patient activity postoperatively and wound healing also impact the result noted in follow up. The WALANT approach allows for a baseline assessment of the patient's strength, range of motion and other functions first before, and then after, all surgical interventions have been completed, while the patient is pain free but fully awake and with strength unimpeded by sedation or paralysis. These measurements in turn serve as the true baselines against which any subsequent measurements can be made, before any postoperative changes have occurred. This in turn allows the researcher as well as the clinician to distinguish the immediate mechanical change of the procedure from the subsequent biological effects on functionality. In addition, the intraoperative measurements can be correlated with final outcome, to determine whether factors such as strength or excursion predict the final outcome.

Logistical advantages in research

Not having the necessity to have to do the surgery under general or regional anesthesia not only allows more logistical freedom in terms of planning and staffing, it also increases the total time available for research and opens up opportunities to add elements that could not have been utilized otherwise. This is particularly true if WALANT is done in the office setting. Examples of the logistical advantages would be the assessment of the desired outcomes (e.g. function, patient survey, MRI) immediately before the surgery or the opportunity to more easily bring in medical imaging devices for intraoperative correlations. The surgical procedure will still need to be done within a sterile field but the addition of, for instance, a sterilized ultrasound probe is much easier to achieve, especially with imaging modalities becoming increasingly more mobile and smaller.

From a research perspective, it is always important to respect and minimize the impact and burden on the patient/research subject. Decreasing the patient's logistical load could help lowering the participation threshold without a negative effect on data acquisition. Additionally, it comes with a decreased risk involved with the procedure, due to the safer form of anesthesia, allowing for a complementary expression of beneficent action. Clinical research is almost fully done on a voluntary basis and thus depends on the willingness of subjects to spend their time and energy by getting involved in studies. Any changes that lower the threshold for participation would therefore directly benefit the course of a study. Being able to communicate with a patient throughout the procedure adds another helpful element: Getting patients to successfully engage in research is highly dependent on their personal interest and emotional link to the research topic and potential outcomes¹⁹ and an extra moment of conversation could go a long way in achieving that level of involvement, just as it does in helping the patient better understand the procedure and the postoperative care. Additionally, potential costs associated with a study can be minimized by simplifying the surgical environment, providing not only more opportunities in developed countries but also in less developed low, and middle income countries.

Decreased costs will also be helpful in any type of research in which trainees play a role. Training surgical residents is an investment in time, effort, and monetary expense²⁰ which can be particularly challenging when working within a research budget. Expanding the repertoire of office based procedures through the use of WALANT can be very helpful in this context. Not having to use a full operating room and being less limited in time due to the absence of a tourniquet means that residents can be more actively involved in the surgical procedure if allowed in the research context. Secondarily, using training aspects as a main topic of investigation (e.g. comparison of different teaching strategies) are possible, not only to study resident education, but also intraoperative patient education strategies that might positively affect outcome.

Research about WALANT itself

Of course, WALANT can not only facilitate physiological and other clinical research based on the procedures that can be performed using WALANT. WALANT can itself be the subject of research. WALANT dramatically reduces intraoperative bleeding- does this result

in less postoperative inflammation, less pain, and better healing? Such hypotheses can be tested. And, as noted above, intraoperative education can also be studied, to identify the features most likely to improve patient outcomes.

Conclusion

To conclude, the combination of advantages provided by the WALANT technique is valuable, not only from a clinical point of view but also when viewed from a research perspective. WALANT facilitated and WALANT focused research both open new horizons for study, not possible previously. As WALANT becomes more widely adopted at academic centers, such opportunities will be more often grasped. Indeed, the scholarly opportunities offered by WALANT represent themselves a strong argument for the adoption and dissemination of WALANT.

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KEY POINTS

- Wide awake surgery allows the clinician-scientist to observe and measure active function of muscle tendon units before, during and after surgical intervention. In addition to improving clinical results empirically, this capability allows novel expansions of physiological research previously not possible in humans.
- Wide awake-enhanced research can improve our ability to correlate muscle function and physiology with clinical outcome after procedures such as tendon transfers, and correlate muscle and tendon forces with clinical activities such as pinch and grip.
- Wide awake enhanced research has the potential to improve our understanding of the correlation between nerve physiology and motor and sensory function.

SYNOPSIS

Wide Awake surgery under Local Anesthesia with No Tourniquet (WALANT) has revolutionized clinical hand surgery, improving clinical outcomes and reducing postoperative pain and morbidity. It can also be used to deepen scientific knowledge, because the unsedated patient, with sensation intact and without the adverse effects of tourniquet neurapraxia or paralysis, can follow commands and actively move the limb after tendon and nerve surgery. These movements can be correlated with fingertip force, tendon tension, nerve conduction and amplitude, and muscle sarcomere length measurements to develop new insights into the effectiveness of many different tendon and nerve procedures in the hand.