Reply to the Letter to the Editor

Reply to the Letter to the Editor: The Chitranjan Ranawat Award: Running Subcuticular Closure Enables the Most Robust Perfusion After TKA: A Randomized Clinical Trial

Cody C. Wyles MD, Steven R. Jacobson MD, Matthew T. Houdek MD,
Dirk R. Larson MS, Michael J. Taunton MD, Franklin H. Sim MD,
Rafael J. Sierra MD, Robert T. Trousdale MD

To the Editor,

We thank Drs. Fourman and Phillips for their thoughtful critique of our randomized clinical trial. They rightly point out that plastic surgeons have led the pioneering efforts using the SPY-

Elite (Novadaq, Bonita Springs, FL, USA) system as a powerful tool for soft-tissue management. Indeed, orthopaedic surgeons remain grateful to these surgeon-scientists as we become more familiar with this technology in our own practices. Although plastic surgeons have recently advanced the application of indocyanine green angiography for soft-tissue surgery, it must not be forgotten that this technology existed for several

decades prior to that, with roots in cardiac surgery [6].

While the authors address a variety of issues they believe to be imperfections in our methodology, we caution that a more-careful read would reveal that our execution was quite-often synchronous with their suggestions. They note previously published work from their respective institutions [1–4] has demonstrated that measuring the maximum quantitative perfusion is the most-reliable method for normalizing a variety of potentially confounding host variables. Furthermore, they assert any effort to the contrary would represent an unnecessary “reinventing of the wheel.” However, our trial documented perfusion both at the measured peak (in accordance with their methodology) as well as at baseline once the arterial and venous phases have reached stable equilibrium. The results were strikingly similar with both measured time points and, in our opinion, more robust given the consistency throughout the perfusion cycle.

(RE: Wyles CC, Jacobson SR, Houdek MT, Larson DR, Taunton MJ, Sim FH, Sierra RJ, Trousdale RT. The Chitranjan Ranawat Award: Running Subcuticular Closure Enables the Most Robust Perfusion After TKA: A Randomized Clinical Trial. *Clin Orthop Relat Res*. 2016;474:47–56.)

The authors certify that neither they, nor any members of their immediate families, have any commercial associations (such as consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article. All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research*® editors and board members are on file with the publication and can be viewed on request.

The opinions expressed are those of the writers, and do not reflect the opinion or policy of CORR® or The Association of Bone and Joint Surgeons®.

C. C. Wyles MD, M. T. Houdek MD,
M. J. Taunton MD, F. H. Sim MD,
R. J. Sierra MD,
R. T. Trousdale MD (✉)
Department of Orthopedic Surgery,
Mayo Clinic, 200 1st Street SW,
Rochester, MN 55905, USA
e-mail: Trousdale.Robert@mayo.edu

S. R. Jacobson MD
Jacobson Plastic Surgery, Rochester,
MN, USA

D. R. Larson MS
Division of Biomedical Statistics and
Informatics, Mayo Clinic, Rochester,
MN, USA

Reply to the Letter to the Editor

The authors also affirm that perfusion away from the incision bears considerable prognostic implications for wound viability given that is where blood flow to the wound originates. Certainly, we agree. In fact, we created an outcome metric to specifically account for this, which we labeled the “mean perfusion impairment.” As described in our manuscript, this value accounts for global differences in perfusion about the wound by comparing perfusion along the incision to twice as many points away from the incision where the skin remains undisturbed at the surface. The authors also fairly affirm that staples and sutures can create signal artifact during measurement. The SPY-Elite is quite sensitive to small changes in the location being measured. We adjusted the points between sutures or staples until the maximum value along the incision was identified, which was nearly always halfway between sutures and staples. In addition, our consistency of results between mean incision perfusion and mean perfusion impairment mitigates any potential influence from signal artifact.

Another critique relates to the timing of perfusion evaluation immediately following closure. The authors propose that measurements taken at later time points may be more helpful as the process of closure can provide a “second hit” phenomenon to

the tissue. We agree that serial measurements over time would be preferable, but this was a logistical challenge that we could not overcome, since our institution currently has only one SPY-Elite per hospital, and clinical demand for the device is extremely high. However, we maintain that measurement of perfusion immediately after closure is most critical specifically because it does account for the “second hit” phenomenon of closure. Respectful soft-tissue management principles are based on inducing minimal iatrogenic trauma throughout all phases of a procedure from incision through closure. If a specific closure technique is more injurious to peri-incisional soft tissue that would be an argument against its use for maintaining ideal perfusion.

The authors do point out their own work in defining quantitative cutoffs for breast tissue at risk with a threshold of 23.8 arbitrary perfusion units for partial thickness necrosis [5]. This is vital information that will need to be validated in tissues with different soft tissue and vascular composition such as the anterior knee. Raised mastectomy flap tissue certainly provides a different environment than previously uninterrupted skin about a joint. The treatment arm receiving staple closure in our trial had a mean incision perfusion of 19 arbitrary perfusion units with no partial thickness necrosis;

however, it must be reasserted that these were patients with no identifiable wound healing comorbidities.

We thank Drs. Fourman and Phillips for their immense contributions to the science of soft-tissue management, specifically with the SPY-Elite system. Indeed, it will be critical for both orthopaedic surgeons and plastic surgeons to remain collaborative in this effort and continue to learn and improve from the respective experiences of these closely related disciplines.

References

1. Fourman MS, Gersch RP, Levites HA, Phillips BT, Bui DT. Is there a right way to interpret SPY? Normalization of indocyanine green angiography readings in a burn model. *Plast Reconstr Surg*. 2015;136:128e–130e.
2. Fourman MS, Phillips BT, Crawford L, McClain SA, Lin F, Thode HC, Jr., Dagum AB, Singer AJ, Clark RA. Indocyanine green dye angiography accurately predicts survival in the zone of ischemia in a burn comb model. *Burns*. 2014;40:940–946.
3. Fourman MS, Phillips BT, Fritz JR, Conkling N, McClain SA, Simon M, Dagum AB. Laser-assisted indocyanine green dye angiography accurately predicts the split-thickness graft timing of integra artificial dermis. *Ann Plast Surg*. 2014;73:150–155.
4. Nasser A, Fourman MS, Gersch RP, Phillips BT, Hsi HK, Khan SU,

Reply to the Letter to the Editor

- Gelfand MA, Dagum AB, Bui DT. Utilizing indocyanine green dye angiography to detect simulated flap venous congestion in a novel experimental rat model. *J Reconstr Microsurg*. 2015;31:590–596.
5. Phillips BT, Fourman MS, Rivara A, Dagum AB, Huston TL, Ganz JC, Bui DT, Khan SU. Comparing quantitative values of two generations of laser-assisted indocyanine green dye angiography systems: Can we predict necrosis? *Eplasty*. 2014;14:e44.
6. Rubens FD, Ruel M, Fremes SE. A new and simplified method for coronary and graft imaging during CABG. *Heart Surg Forum*. 2002;5:141–144.