Comment on the Effect of Working Length, Fracture and Screw Configuration on Plate Strain in a 3.5mm LCP Bone Model of Comminuted Fractures

Mark Glyde, BVSc MANZCVSc MVS HDipUTL DECVS[1] Michael Kowaleski, DVM DACVS DECVS[2]

[1] School of Veterinary Medicine, Murdoch University, Murdoch, Australia
[2] Cummings School of Veterinary Medicine at Tufts University, North Grafton, Massachusetts, United States

Address for correspondence Mark Glyde, BVSc MANZCVSc MVS HDipUTL DECVS, School of Veterinary Medicine, Murdoch University, Murdoch 6150, Australia (e-mail: m.glyde@murdoch.edu.au).

VCOT Open 2024;7:e114–e116.

We want to comment on the study by Wainberg and colleagues 2023.[1] Consistent with other work[2–6] evaluating the effect of working length (WL) on plate strain in a fracture gap model, the authors concluded that reducing plate WL decreased plate strain, and that elevation of the locking compression plate (LCP) from the bone increased plate strain, which is broadly consistent with published studies.[2,4,7]

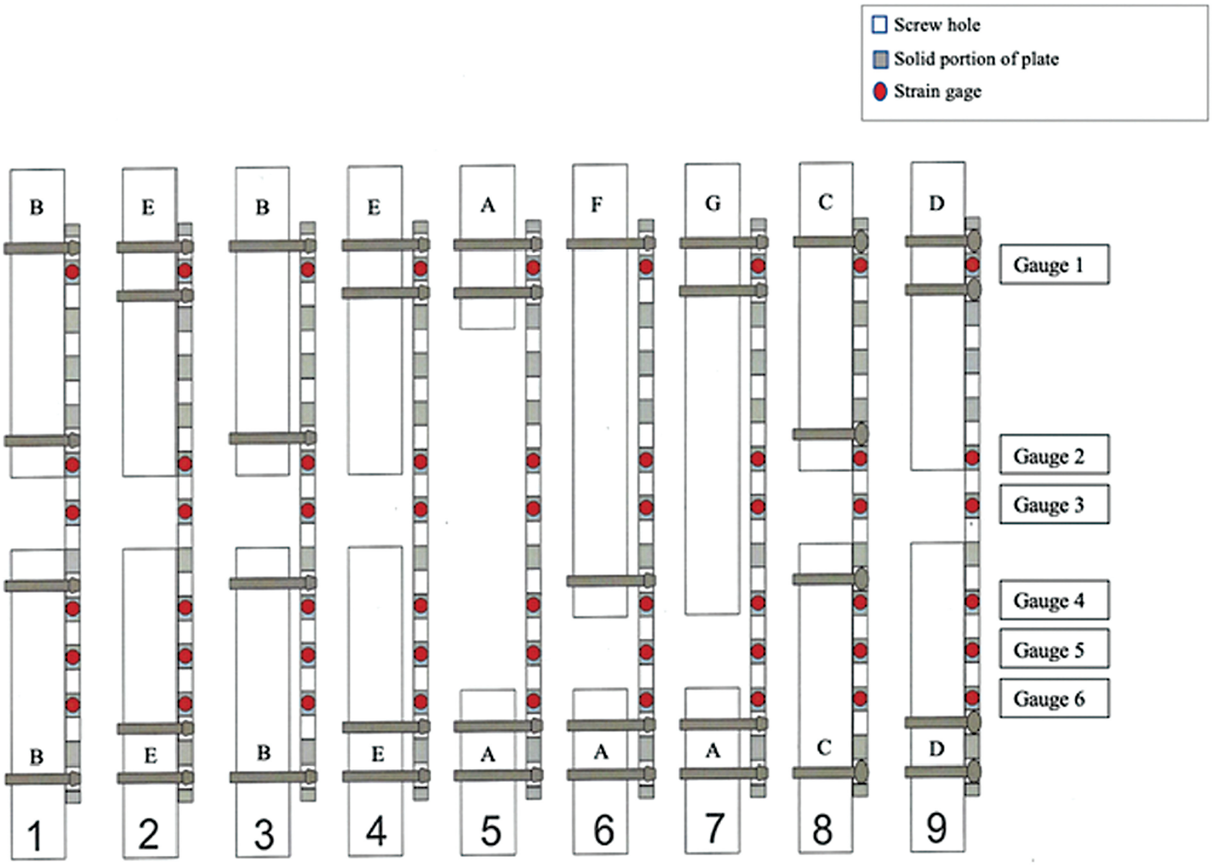

Fig. 1 A copy of Fig. 1 from Wainberg and colleagues 2023[1] showing configurations of drilled bone models. For configurations 1, 2, 8 and 9, the plate is in direct contact with the bone model.

received
February 25, 2024
accepted
February 26, 2024

DOI https://doi.org/10.1055/s-0044-1787574.
ISSN 2625-2325.

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

While we agree that increasing plate WL in a fracture gap model, where plate–bone contact does not occur, reduces construct stiffness and increases plate strain and that increasing plate standoff tends to reduce construct stiffness and increase plate strain, we do not agree that the conclusions of this study are valid based on the methodology used.

On evaluation of methodology, we consider the authors' interpretation of results should be reviewed regarding findings on WL in all models with plate–bone contact. Regarding the conclusion on the effect of plate standoff on plate strain, we consider the results are confounded by a simultaneous change in effective WL which accounts for most of the increased plate strain.

►**Fig. 1** copied from the original article shows nine constructs. In constructs 1, 2, 8 and 9 the plate directly contacts the bone with no standoff, whereas the other 5 constructs have a 1.5mm standoff. For constructs 1 and 2, plates were fixed with locking screws, while in 8 and 9 the plate was fixed with cortical screws. Screw number was maintained at two screws per fragment. Screw position, however, was varied with the specific intention of creating a short WL construct, with screws adjacent to the fracture gap, and a long WL construct, with screws at the plate ends.

Axial compression loads were applied coaxially to the tested constructs, creating tension bending of the eccentrically positioned plate. Plate WL is the distance between screws closest to the fracture, provided plate–bone contact does not occur. Effective WL is the distance between any area of plate–bone contact on either side of the fracture gap. Under the load conditions in this study, the effective WL of constructs 1, 2, 8 and 9 is the fracture gap under tension bending, as the plate directly contacts the bone. So, despite the variation in screw position with the intention of changing WL, the effective WL in constructs 1, 2, 8 and 9 is the width of the fracture gap, and so is identical in the four tested constructs.

We question the validity of the findings comparing models 1 and 2 and models 8 and 9. In the section on 'Effect of Plate Working Length with Symmetric Fracture Gap', the authors state comparing constructs 8 and 9 'a shorter plate working length resulted in lower plate strain over the fracture gap (gauges 4 and 5)'. As the effective WL for each was identical, the finding of significantly lower

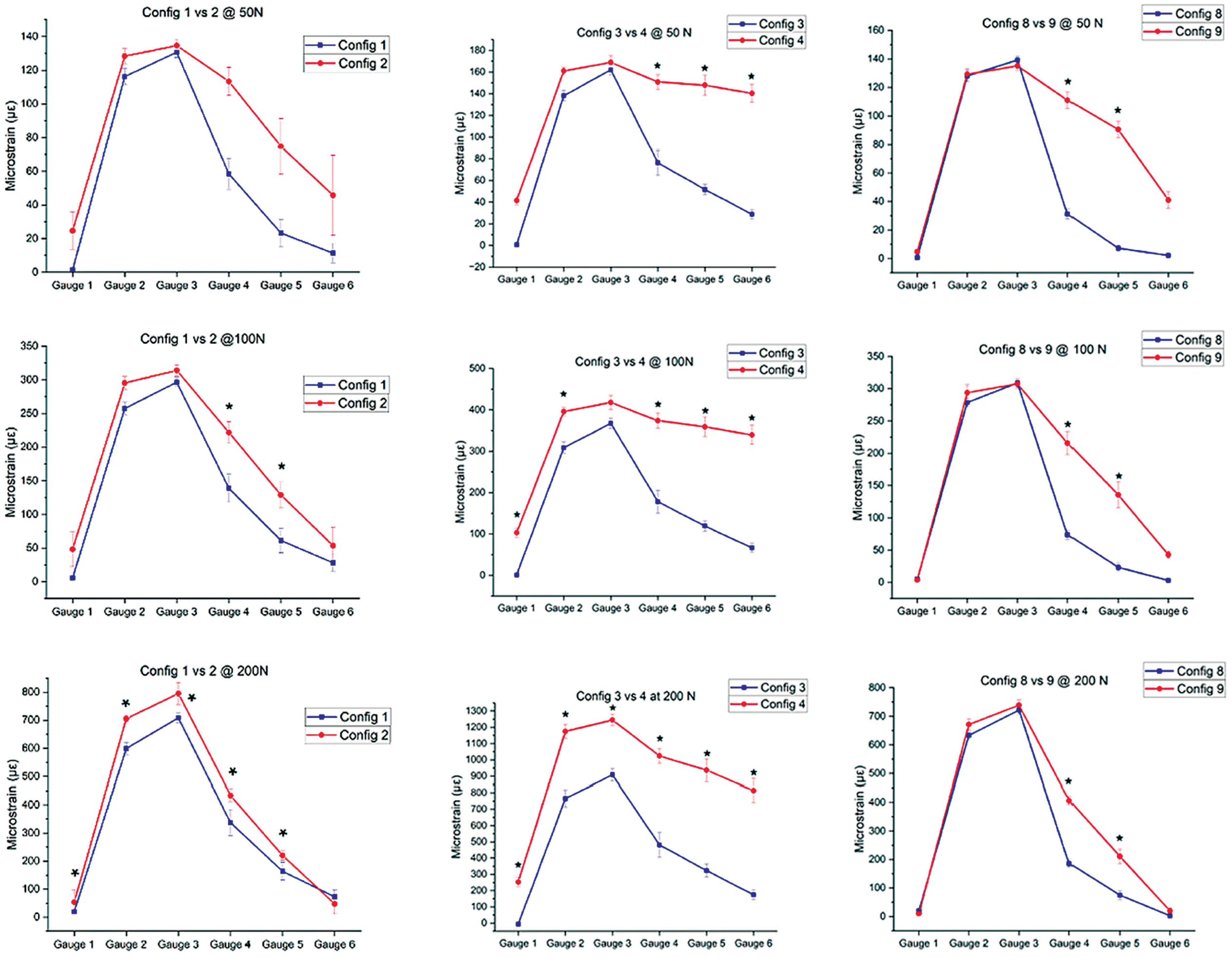

Fig. 2 A copy of Fig. 2 from Wainberg and colleagues 2023[1] showing that microstrain at gauge 3 is no different between constructs 8 and 9 at any of the three tested loads, consistent with the same effective working length.

plate strain with a shorter WL, while consistent with published literature, is difficult to explain given the identical effective WLs tested. Also, the identification of gauges 4 and 5 being 'over the fracture gap' is not consistent with ►**Fig. 1** which shows gauge 3 positioned over the gap in constructs 8 and 9. Inspection of ►**Fig. 2** shows microstrain at gauge 3 is no different between constructs 8 and 9 at any of the three tested loads, consistent with the same effective WL.

The second main conclusion that 'elevation of the plate from the bone resulted in increased strain in all configurations' is not valid. In the section titled 'Effect of Plate Position on the Bone', the authors state comparing constructs 1, 3 and 8, all of which had the short WL with screws immediately adjacent to the fracture gap, that elevation of the plate 1.5mm resulted in higher strain. In constructs 1 and 8, the LCP was in contact with the bone meaning that under axial compression the effective WL was the fracture gap of 22mm. In model 3, however, the plate standoff meant that WL was the distance between innermost screws of approximately 30mm, an increase of 36% compared to constructs 1 and 8.[8,9] The increase in plate strain noted between constructs 3 and 8 in gauges 2 and 3 is a result of an increase in plate WL in combination with an increased bending moment and not increased bending moment alone as suggested by the authors in the discussion.

Working length is a key determinant of construct stiffness and plate strain in fracture gap models with a shorter WL increasing construct stiffness and decreasing plate strain.[2–6] For this reason, the interpretation of the significant increase in plate strain of construct 3 with 1.5mm standoff compared to construct 8 with no standoff is confounded by a concurrent major change in effective WL despite the intent to compare identical short WLs and so is not a valid conclusion. The increase in plate strain shown in construct 3 is highly likely to be caused by the 36% increase in WL rather than a small increase in standoff distance.

Similarly in comparing the intended long WL constructs 2, 4 and 9, the results are confounded, and the interpretation is, therefore, not valid. Considering that the effective WL of constructs 2 and 9 is the 22mm fracture gap, and in construct 4 with 1.5mm standoff the WL is 107mm between screws, there is a 486% increase in WL between short effective WL constructs 2 and 9 and the long WL construct 4, at least until the 'bone segment contacted the plate during bending' at 'high loads'. The substantial difference in effective WL confounds the finding of increased plate strain and the conclusion of the study that increasing standoff from 0mm to 1.5mm resulted in increased plate strain.

Unfortunately, the methodology in this study confounds interpretation of the results, and with respect to the mentioned model comparisons, invalidates the conclusions made from these confounded results.

Conflict of Interest
None declared.

References

1 Wainberg SH, Moens MNN, Ouyang Z, Runciman J. The effect of working length, fracture, and screw configuration on plate strain in a 3.5-mm LCP bone model of comminuted fractures. VCOT Open 2023;6:e122–e135

2 Evans A, Glyde M, Day R, Hosgood G. Effect of plate-bone distance and working length on 2.0-mm locking construct stiffness and plate strain in a diaphyseal fracture gap model: a biomechanical study. Vet Comp Orthop Traumatol 2024;37(01):1–7

3 Bird G, Glyde M, Hosgood G, Hayes A, Day R. Effect of plate type and working length on a synthetic compressed juxta-articular fracture model. VCOT Open 2020;03(02):e119–e128

4 Bird G, Glyde M, Hosgood G, Hayes A, Day R. Biomechanical comparison of a notched head locking T-plate and a straight locking compression plate in a juxta-articular fracture model. Vet Comp Orthop Traumatol 2021;34(03):161–170

5 Stoffel K, Dieter U, Stachowiak G, Gächter A, Kuster MS. Biomechanical testing of the LCP–how can stability in locked internal fixators be controlled? Injury 2003;34(Suppl 2):B11–B19

6 Pearson T, Glyde M, Hosgood G, Day R. The effect of intramedullary pin size and monocortical screw configuration on locking compression plate-rod constructs in an in vitro fracture gap model. Vet Comp Orthop Traumatol 2015;28(02):95–103

7 Ahmad M, Nanda R, Bajwa AS, Candal-Couto J, Green S, Hui AC. Biomechanical testing of the locking compression plate: when does the distance between bone and implant significantly reduce construct stability? Injury 2007;38(03):358–364

8 Zderic I, Varga P, Styger U, et al. Mechanical evaluation of two hybrid locking plate designs for canine pancarpal arthrodesis. BioMed Res Int 2021;2021:2526879

9 Zderic I, Varga P, Styger U, et al. Mechanical assessment of two hybrid plate designs for pancarpal canine arthrodesis under cyclic loading. Front Bioeng Biotechnol 2023;11:1170977