The Effect of Working Length, Fracture, and Screw Configuration on Plate Strain in a 3.5 2-mm LCP Bone Model of Comminuted Fractures

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We would like to thank Dr. Mark Glyde for his thoughtful comments in their letter regarding our publication entitled: "The Effect of Working Length, Fracture, and Screw Configuration on Plate Strain in a 3.5-mm LCP Bone Model of Comminuted Fractures."

Working length of a plate has been defined as the two nearest points where the bone is fixed to the plate and is generally the distance between the two screws closest to the fracture.[1] We do recognize that the true definition of the working length in its purest form probably applies only to locking plates that are elevated from the bone and therefore where there is no friction or contact between the bone and the plate. However, others have used the notion of working length with cortical screws, hybrid fixation, or in tension bending where the plate would contact the bone during loading.[2] In our experiment, we tried to represent several clinical situations which are frequently encountered in practice. Repair of mildly comminuted, severely comminuted and asymmetrical fractures, such as distal radial fractures incorporate frequently used methods of plate fixation (locking plate away from the bone, in contact with the bone or compression). Although locking plates do not require contact with the bone, there is no question that they often are in contact with the bone, at least partially, or they will contact the bone at some point during loading. That was the reason for us to include long or asymmetric segments of bone surrogate, despite having the fixation at the extremities of the plate. Incorporation of the last two groups of fractures with the cortical screws, therefore resulting in compression of the plate, was for us an attempt to reconcile some of the previous literature which used cortical screws. We are aware that friction between the plate and the bone, whether is generated by screw compression or contact between the plate and the bone during loading, skews the notion of working length. The effect is clearly seen as a deflection in the strain curve that occurs as soon as contact occurs. We chose tension-bending as a loading method as it is the one closest to a clinical situation where the plate is placed on the tension side of the bone. In clinical situations contact between the bone and the plate does occur, regardless of the type of plate (locking vs. nonlocking). Although we did use the proper definition of the working length for locking lates, we recognize that the definition becomes open to interpretation for compression screws or for plates that are in contact with the bone. We do address the effect of plate contact or compression by discussing the "effective" working length of the construct which is shorter than the working length defined by the location of the screws closest to the fracture gap. We did not define "effective" working length as the distance between any area of plate bone contact because we believe that this distance varies with the degree of compression and friction between the bone and the plate. For compression plates where screws are placed close to the fracture, the effective working length is likely very close to the length of the fracture gap; however, for locking plates merely in contact with the bone, we do not believe that a proper definition of plate working length exists. This is why we included models with long fracture gaps and short fracture gaps as the degree of friction and thus load sharing between the plate and the bone would undoubtedly be different. It is true that the differences between construct 1, 2, 8, and 9 are less obvious than for other constructs; however, they are not identical. For the models 1 and 2, a difference in strain is observed at gauge 4 and 5 @ 100 N and gauges 1, 2, 3, 4, and 5 @ 200 N. This may be that the friction of plate and bone makes the difference less evident and it takes higher loads to reach significance; however, significance was achieved at gauge 3 @ 200 N for the longer working length.

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The absence of difference at gauge 3 in models 8 and 9 was expected as it has been previously reported in the literature.[3] The increase in strain observed at gauges 4 and 5 in construct 9 can be explained by the fact that the degree of compression between the bone and plate likely dissipates as we move away from the screws. Therefore, we once again disagree with Glyde that the plate working length between group 8 and 9 are truly identical. Furthermore, in group 8, gauges 4 and 5 being located in a segment of the plate surrounded by two compression screws, we would not expect significant bending. In the result section entitled "effect of plate working length with symmetric fracture gap," we erroneously mentioned that gauges 4 and 5 were located "over the fracture gap" when if fact we should have said "located in the non-supported portion of the plate." We do apologize for the confusion.

For the second point raised in the letter, regarding the effect of plate elevation from the bone, our methodology and discussion are somewhat similar to those of Ahmad et al.[4] There is no question that in our model, and theirs, effective working length and plate elevation did play a combined role in the increased plate strain. This would also be the case in any clinical situation where bone would, or could, contact the plate. We recognize that the "working distance" variable could have been eliminated by testing our constructs in compression bending.[5] However, we elected not to test this way as it would mean testing in ways that are not directly clinically relevant. Although we did not claim that all differences were due to plate elevation rather than a combination of elevation and change in effective working length, I believe we could have been more explicit to this fact. Biomechanically, there is no question that moving the fixation away from the bone increases the bending moment on the implant. However, whether that increase would have been significant without the unavoidable increase in effective working length remains unanswered in our article. Once again, the argument stems from the definition of plate working length and whether the plate working length is equal to the fracture gap in all constructs where the bone touches the plate, regardless of the degree of screw compression. We have shown that bone contact does modify the degree of bending observed in the plate; however, we do disagree with the statement that the plate working length is equal to the fracture gap in constructs where the plate is touching the bone. The increase in plate strain at gauges 4 and 5 in constructs 2, 4, and 9 (compared with constructs 1, 3, and 8) and gauges 2 and 3 in construct 7 clearly indicates that the entire, unsupported portion of the plate is subjected to increase bending, therefore rejecting the notion that, in these groups, the working length is limited to the length of the fracture gap.

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Conflict of Interest
None declared.

References

1 Hak DJ, Toker S, Yi C, Toreson J. The influence of fracture fixation biomechanics on fracture healing. Orthopedics 2010;33(10):752–755
2 Chao P, Conrad BP, Lewis DD, Horodyski M, Pozzi A. Effect of plate working length on plate stiffness and cyclic fatigue life in a cadaveric femoral fracture gap model stabilized with a 12-hole 2.4 mm locking compression plate. BMC Vet Res 2013;9(01):125–132
3 Maxwell M, Horstman CL, Crawford RL, Vaughn T, Elder S, McLaughlin R. The effects of screw placement on plate strain in 3.5 mm dynamic compression plates and limited-contact dynamic compression plates. Vet Comp Orthop Traumatol 2009;22(02):125–131
4 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
5 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