Comments on torsional testing

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Dear Editor-in-Chief,

I am writing as an engineer and orthopaedic surgeon to express a few concerns about methodology for mechanical testing appearing in your journal over the years. The latest example is that by Hutcheson, et al., “Comparison of double locking plate constructs with single non-locking plate constructs in single cycle to failure in bending and torsion”, that appeared in VCOT issue 4/2015 (1). My apologies to the authors for choosing this paper to elicit a Letter to the Editor. Please know that my intent is to improve the quality of biomechanical data in future publications.

The purpose of mechanical testing is to apply simple and uniform loading modalities (in this case pure bending and pure torsion) to test specimens so as to compare strength and stiffness characteristics of bone/fixation constructs, in this example. Uniformity in testing facilitates direct comparisons of results with other studies. This approach has been developed to help predict and compare the performance of internal fracture fixation in vivo, among other questions commonly asked. Testing in bending was performed following ASTM standards and was therefore fairly straightforward. This study assumed rigid body kinematics and calculated flexural strain of the construct from crosshead displacement. My preference is to measure strain locally (deflection) and represent bending stiffness in units of Nm/degree (from beam theory) to avoid strain artefacts but both representations appear in the literature.

Torsional testing, however, is more complicated than bending and is often applied inappropriately, as in this paper. For torsional testing to provide clinically accurate information, the location of the inherent torsional axis of the bone/fixation construct must be taken into account. The inherent torsional axis of the bone/fixation construct is not necessarily the torsional axis imposed by the instrument when the specimen is clamped in position in the testing jig. Rather the location of the unconstrained torsional axis is determined by the distribution and mechanical properties of the mass that surrounds it, the so-called polar moment of inertia. In this study the torsional axis was fixed or constrained instrumentally to the centre of the synthetic bone rods on which the fixation devices were asymmetrically applied. In this configuration the plate/bone constructs were not tested in torsion but rather in a complex, indeterminate state of stress consisting of shear, bending, and minimal torsion on the plates and screws. This mode of loading and the induced failure mechanisms are not likely relevant to clinical trauma and therefore the results are not necessarily valid for the fixation systems tested and compared. From first principles, the inherent torsional axis was likely within the substance of the plate for the dynamic compression plate and between the fixation bars for the String-of-Pearls (SOP).

The first paper in this same issue of VCOT (by Tyagi, et al.) also constrained the torsional axis of the test specimens (2). However, because the fixation materials of the external fixators were more symmetrically distributed about the constrained torsional axis of the mechanical testing instrumentation, the inherent torsional axis approximated the artificial, instrument-imposed torsional axis, a more acceptable assumption, I suppose. For asymmetrical fixation such as a plate or SOP, it would have been preferable to use methodology in which the torsional axis was unconstrained, permitting it to self-centre or shift when the test specimens are loaded in torsion, as well as during the failure process. This is more complicated to set up but it can be accomplished by using gimbals or paired universal joints at either end of the construct (3). With standardized testing methods, consistent results can be achieved permitting valid comparisons of construct strength, stiffness, and energy to failure. I welcome these studies and commend the authors for their work and care for dogs.

Sincerely,

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Conflict of interest

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References


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