The Effect of Locking Inserts and Overtorque on the Fatigue Behavior of Locking Compression Plates

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Introduction

A recent trend toward ‘‘biological fixation’’ focuses on bridge plating techniques using longer plates and fewer fixed angle screws to restore bone length and alignment, with indirect reduction and minimal periosteal stripping. This approach may be facilitated by new implant designs, such as the locking compression plate (LCP; Synthes), which uses screw heads that are conically threaded on the undersurface and create an angular stable plate-screw device. This type of plate fixation relies on the threaded plate-screw interface to lock the bone fragments in position and does not require friction between the plate and bone or preloading of the bone.1

To help augment the strength and stability of locking plates in a fracture gap model, the idea of locking inserts has arisen. Locking inserts are threaded conical screw heads without shafts. The theory is that using these locking inserts will help prevent plate failure at the screw holes left intentionally vacant while bridging fracture gaps.

The most important factor contributing to construct stability is working length (distance between the first two screws on each side of the fracture site). The longer the working length, the fewer cycles to failure.3 In a clinical setting, a large fracture gap is sometimes encountered due to comminution, bone loss, or periosteal stripping.

Overtightening of screw locking inserts so as to permanently deform the material around screw hole, thereby increasing the strength of the construct has been used in the aviation industry. Over-tightening locking inserts should also improve the mechanical properties of an LCP.

The purpose of this study was to determine: 1) the amount of torque typically applied to locking screws in a clinical scenario; 2) if the cycles to failure of an LCP with Combi holes can be improved by filling unused holes with locking inserts with two- and four-hole working lengths; and 3) the effect of insert over-torque on fatigue of these plates.

Methods

Torque level: The average peak torque measurement of 7 different surgeons was calculated (AWS-QC Torque Tester).

Testing: Standard narrow 4.5-mm 12-hole LCP with Combi holes were used. Plates were divided into 3 groups (N=7/group) for both the 2-hole and 4-hole constructs; defects unfilled (control group) or filled with locking inserts tightened to either 4 or 8 Nm. Each construct was tested using 3-point bending under cyclic loading at 5 Hz. Three 2-hole and three 6-holes plates without inserts were ramped to failure to determine the yield strength of the plates. All plates for fatigue testing were cycled to 80% of this yield strength: 2-hole constructs from 10 to 3360 cycles and 4-hole constructs; defects unfilled (control group) or filled with locking inserts tightened to either 4 or 8 Nm. Each construct was tested.

Number of Cycles

Discussion

We have shown that the cycles to failure under cyclic loading of an LCP can be increased by using locking inserts in unused holes. This may have clinical applications where bridge plating has left holes open and the potential for hardware failure exists.

The Locking Compression Plate has recently gained widespread appeal among orthopaedic surgeons. However, while usage of the plate has increased, so have complications. A known mechanism of treatment failure is plate breakage, typically the result of repeated bending loads. We have shown that by using locking inserts in what would otherwise be empty holes, the bending stiffness of an LCP can be increased. Furthermore, by tightening the inserts to twice the recommended insertion torque, the bending stiffness can be further increased in a longer working length. This may have clinical applications where bridge plating has left several threaded holes open and an even greater potential for hardware failure exists.

Sommer et al reported on four cases of LCP loosening and breakage in a series of 169 fractures.5 They attributed two cases of plate breakage to inappropriate fixation technique rather than intrinsic properties of the LCP itself. However, they state that a stronger plate may have withstood the load sharing for a longer period, potentially preventing breakage and treatment failure.

We have shown that the bending stiffness of an LCP construct can be increased. However, while this may improve the longevity of the implant prior to failure, it may not be advantageous to achieving fracture union. If the construct is ultimately too stiff, this may also lead to nonunion.

We do not know clinical implications of overtightening the locking inserts. Attempting to remove locking screws or inserts that have been over tightened (“cold-welded”) can be a technical challenge for the orthopaedic surgeon while in the operating room. If screws that have been cold-welded to the plate must be removed, the most common way is by drilling the screw head with a carbide drill tip. We plan to measure removal torque of the inserts to evaluate this potential problem.

References

(1) Gardner et al J Orthop Trauma Volume 19, Number 9, October 2005
(2) Stoffel et al. Injury Vol. 34, Suppl. 2, 2003 (3) Sommer et al

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