Citation for published version:
Avis, D, Wright, S, Forder, J, Miles, AW & Holsgrove, TP 2014, 'Volar Locking Plates for Distal Radius Fractures: A Biomechanical Study Investigating Optimal Locking Screw Trajectory' Paper presented at British Orthopaedic Research Society Annual Meeting, Bath, UK United Kingdom, 23/06/14 - 24/06/14, .

Publication date:
2014

Document Version
Early version, also known as pre-print

Link to publication

Volar Locking Plates for Distal Radius Fractures A Biomechanical Study Investigating Optimum Locking Screw Trajectory

D Avis*, S Wright, J Forder**, I Pallister*, AW Miles**, TP Holsgrove****

***University of Swansea, Swansea UK., **University of Bath, Bath UK**

centre for orthopaedic biomechanics

Introduction

The use of volar locking plates for distal radius fractures is widespread and a multitude of designs exist. Previous generic research has demonstrated that screw trajectory influences locking plate construct strength and resistance to failure. In osteoporotic bone a divergent trajectory is considered to provide a mechanical advantage compared with parallel or convergent trajectories[1,2,3].

In recent years there has been an increase in volar locking plate designs incorporating and advocating a crossed, convergent trajectory of distal locking screws. However, there is a paucity of experimental evidence investigating volar locking plate screw trajectory.

It was hypothesised that there would be a difference in construct stiffness, strength and resistance to screw pull-out between parallel, convergent and divergent distal locking screw trajectories.

Materials and Methods

Two sets of tests were completed: physiological cyclic and ramp compression testing; and screw pull-out testing. Stryker VariAx distal radius volar locking plates were applied to Sawbones artificial osteoporotic radii (17 pcf). These plates have a 30º polyaxial capability thus the same plate deisgn could be used to test different trajectories.

Bicortical distal locking screws were applied in three trajectories (Figure1): convergent (n=5); divergent (n=5); and parallel (n=5). A standardised 1 cm osteotomy was created to simulate an unstable fracture. Cyclic loading was applied in three blocks of 2000 sine-waves at a frequency of 1Hz (30-100N, 30-200N, and 30-300N). 30N was chosen as a preload with the end loads and number of cycles representing likely encountered loads through the distal radius in the first 6 weeks of rehabilitation following fracture fixation. Following this, a ramp load to failure was applied. Test endpoints were set as fracture point on load/displacement curve, screw pullout, or closure of the osteotomy gap.

The pull-out testing consisted of fixing each screw-plate construct (n=6 for each group) in Sawbones synthetic bone foam block (15 pcf), and loading the plate in tension at a rate of 5mm/min (ASTM F543-13) until failure of the screw-foam construct.

Statistical analyses were completed using Kruskal-Wallis tests, with Mann-Whitney post-hoc tests ($p<0.05$ for significance).

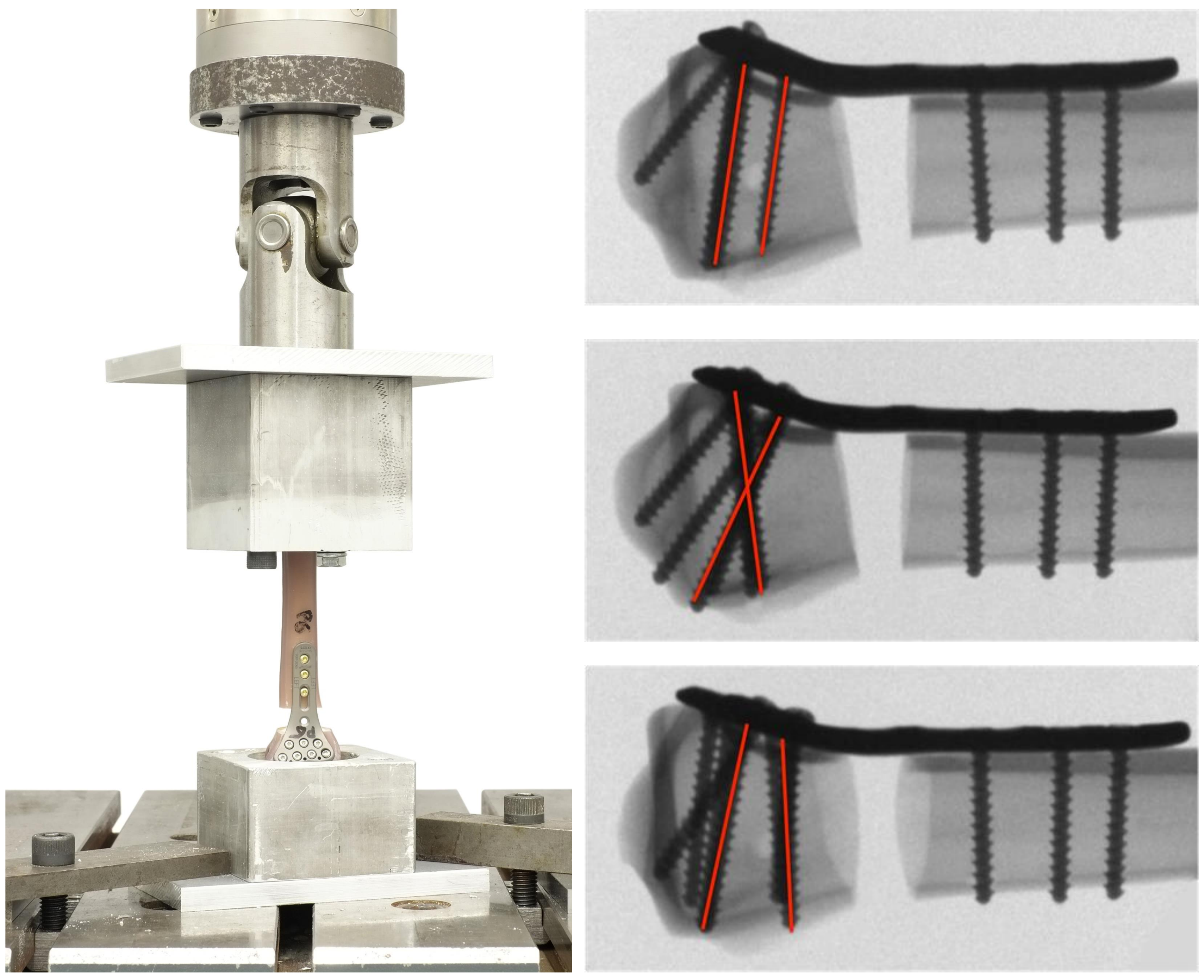

Figure 1: The physiological test set-up (left), and fluoroscopic images (right) of the locking plates applied to the Sawbones with an osteotomy using the three trajectories: Parallel (top), Convergent (middle), Divergent (bottom)

Results

The maximum ramp load of divergent screws was significantly higher than parallel screws ($p=0.009$). There were no significant differences between any other groups ($p=0.347$ and $p=0.175$ for convergent-parallel and convergent-divergent respectively). The mean maximum ramp loads were 2581.3, 2415.8, and 2138.6N for the divergent, convergent, and parallel groups respectively (Figure 2).

There was no statistical difference in construct stiffness ($p=0.432$) or maximal pull-out force ($p=0.085$) between any of the groups.

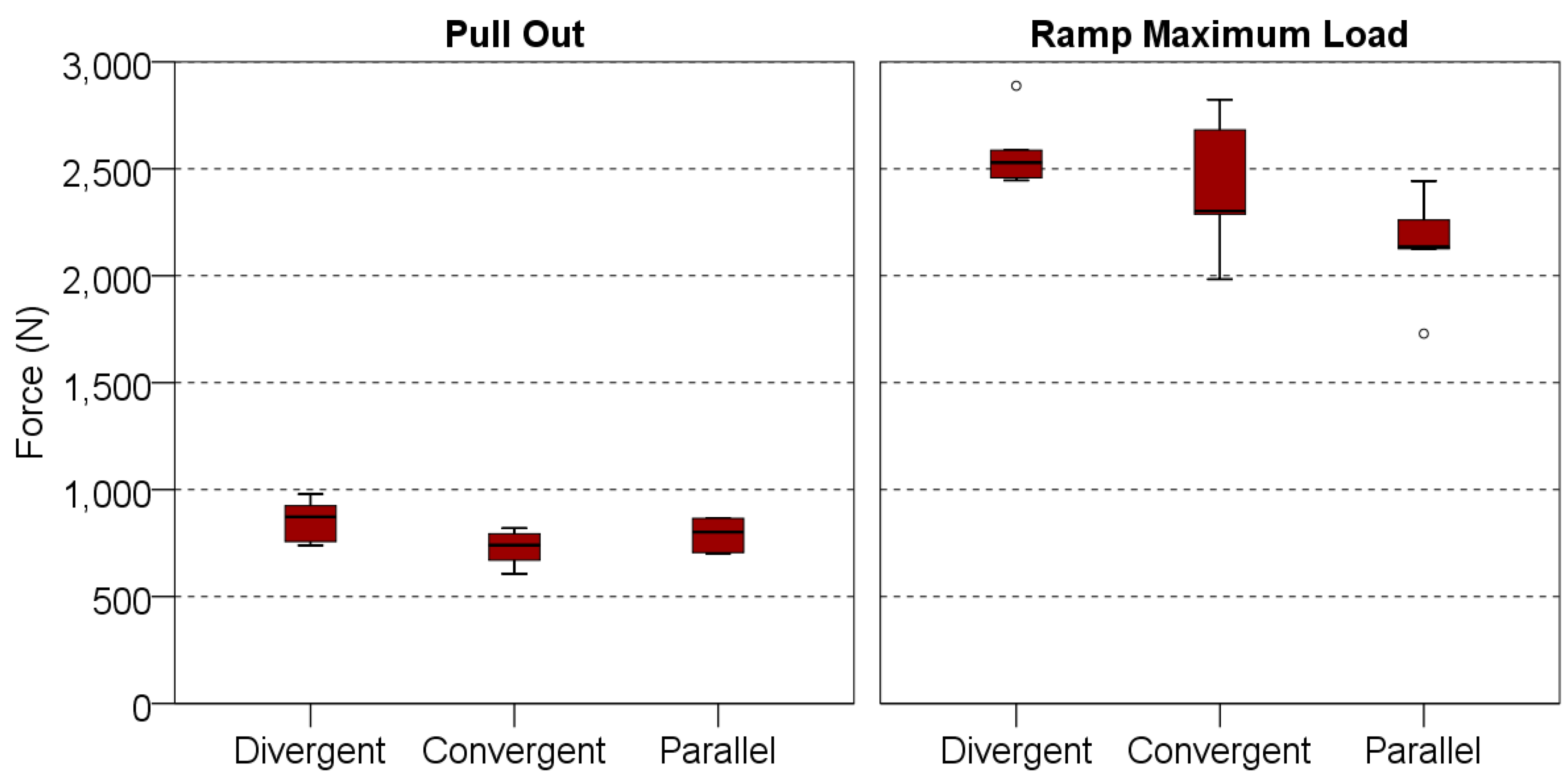

Figure 2: Boxplots of maximum load during pullout testing and ramp loading

Two modes of failure were observed during pull-out tests (Figure 3). The parallel and divergent screws pulled away from the bone due to failure of the screw-bone interface. The convergent screws created a weakness at the point of screw intersection with subsequent bone failure above this.

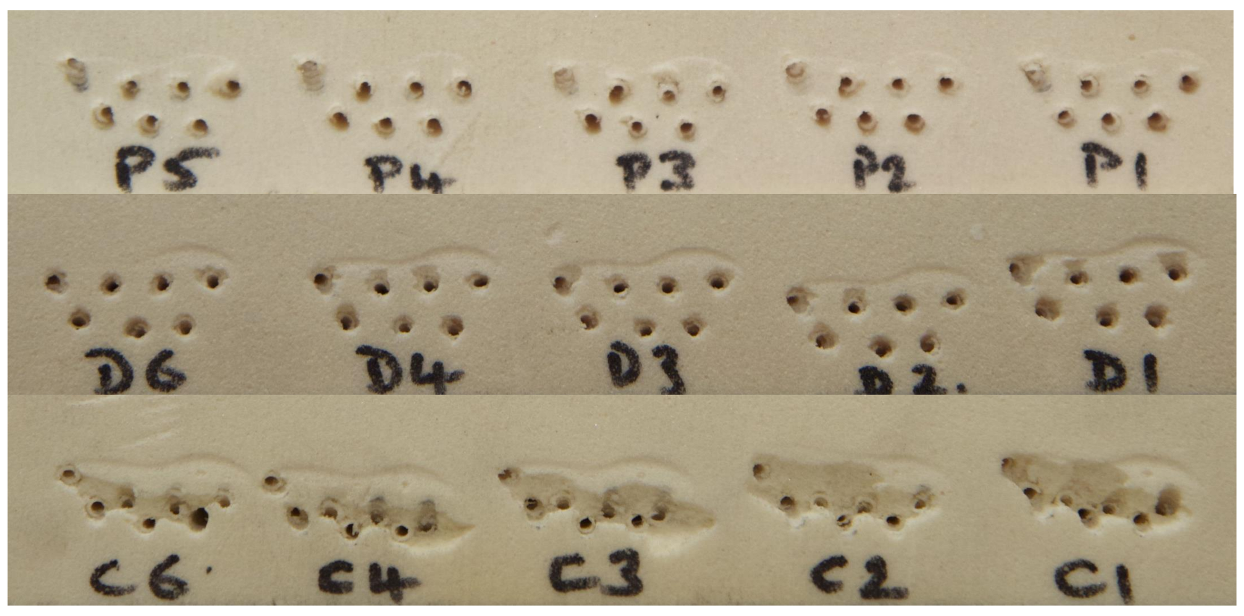

Figure 3: Different methods of failure in the foam test material during pull-out testing, with bone loss evident in the convergent constructs (C)

Discussion and Conclusions

The results support earlier more generic work, which suggests that in osteoporotic bone a divergent screw pattern imparts greater construct strength. The present study has provided new data on the biomechanical performance of fixation plates using different locking screw trajectories under physiological loading conditions.

All specimens remained stable during the simulated recovery period, and the yield loads measured during the ramp to failure tests were supraphysiological for all constructs. Hence each locking screw trajectory is likely to achieve fracture stability, and be able to tolerate the physiological loads associated with recovery after such an operative procedure.

A concern resulting from the present study was the differential mode of failure of the convergent trajectory. This configuration resulted in the failure of a substantial volume of bone. It is therefore recommended that this configuration is not used in osteoporotic bone, which is already mechanically compromised.

Divergent screw trajectories may transfer the load over a greater area than alternative configurations, thus providing greater construct strength. Therefore, in an unstable osteoporotic fractured distal radius, divergent screws are recommended for the optimal distal locking trajectory.

UNIVERSITY OF BATH

References: **1. DiPaula** Spine J 2008 8, 717-22. **2. Wahnert** JBJS Br 2011 93, 1259-64 **3. Rios** Spine 2012 37, E942-8 **4. Putnam** J Hand Surg Am 25(3) 469-75

Acknowledgements: Many thanks to Stryker for supplying the implants and funding the laboratory costs required for this study.

Corresponding Author: duncanavis@hotmail.com

Swansea University
Prifysgol Abertawe