Double locking plate, surgical trauma and construct stiffness improved by the helical plate

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Problem: In comminuted or defect fractures e.g. of the distal femur, a single plate may fail due to fatigue under load exceeding the strength of the plate. A second plate added parallel to the initial plate improves the stiffness and strength *(1-4)* but such procedure was condemned early on because of the increased risk of refracture especially when both plate were remove simultaneously *(5)*.

Solution: The locked plates as accepted today solve this problem. Locked plates do not produce relevant bone loss although they protect similarly stresses but do not damage the blood supply like contacting plates *(6)*. Still, the application of any type of second parallel plate requires additional surgical exposure at the fracture site. Therefore, Alberto Fernandez has developed the helical plate *(7,8)*. It consists of a plate that is inserted remote to the fracture site and requires only a small additional medial approach distally. Proximally the same approach as for the main lateral plate is used allowing combined or separate coupling. The question is how much stiffness and with-it strength does the helical plate contribute?

Tests: Two tests were done using the Synbone™ plastic bone (used for comparative tests):

1. A quick and dirty test applying a bending load and measuring the opening of the fracture gap. The test was performed in Montevideo and demonstrated an important improvement of the stiffness contributed by the helical plate under bending with of an open fracture gap (Fig. 1 and Fig. 2).

2. An extensive testing of the stiffness and its change under axial load was performed at the AO Research Institute by Mark Lenz et al. A significant and relevant improvement of the stiffness contributed by the helical plate was demonstrated for fractures in contact and fractures with open gap (Fig. 3 and Fig. 4).

Today's situation: The helical plate contributes relevant stiffness and with-it strength; the application is simple and atraumatic. At present time the helical plate needs to be shaped around a cylindrical rod. The procedure would gain better acceptance with pre-shaped helical plates.

Conclusion: The helical plate improves safety of double plate fixation of comminuted or defect fractures for instance of the distal femur. The application is simple, the effect efficient and the biology is maintained intact. The procedure requires the surgeon to accustom to a new practise that is simple and straight forward.

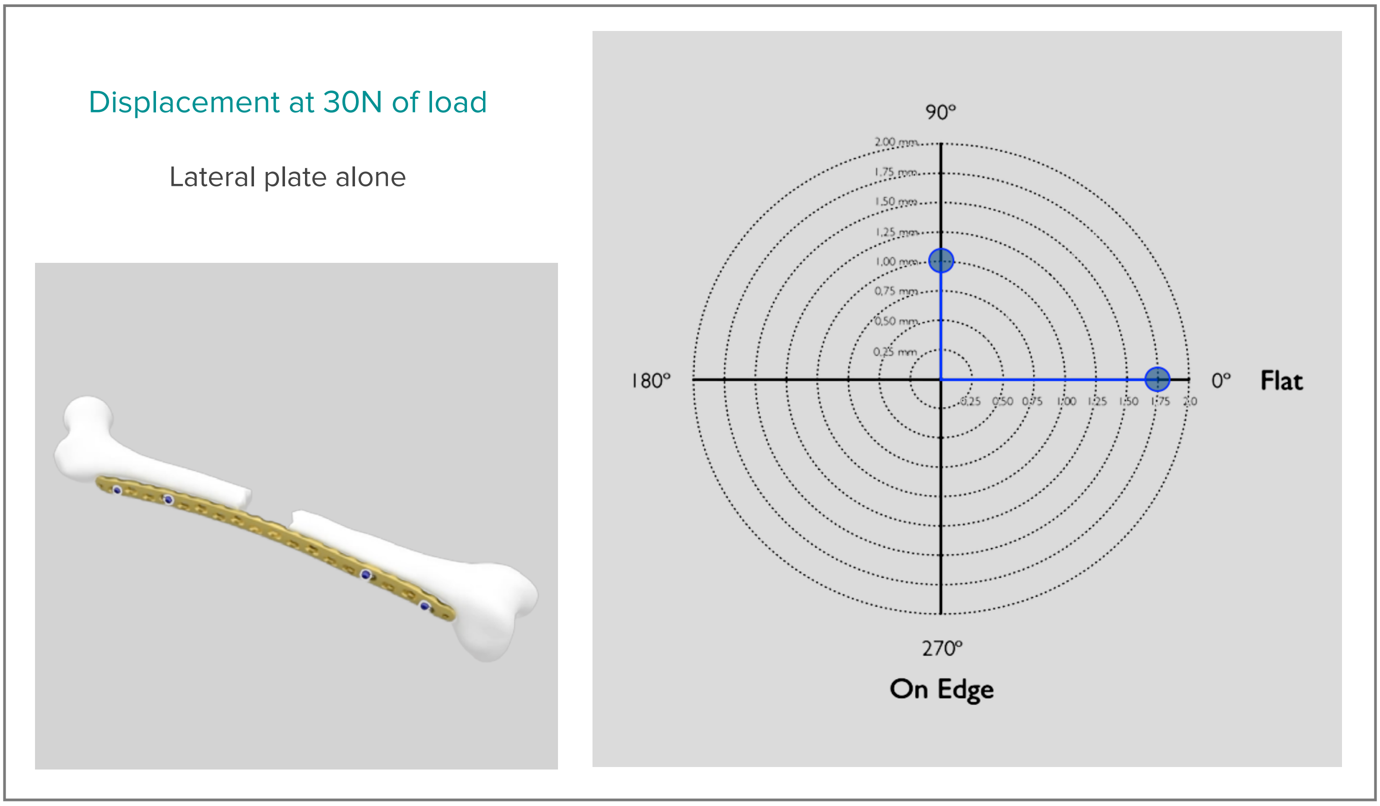

Fig. 1: Quick and dirty bending test measuring the change of the width of the open fracture gap. Testing a single lateral plate spanning the gap. The diagram shows a large *stiffness* when the bending is applied around an axis at 90° offset from the flat surface *("On Edge")* of the plate and show less stiffness when bending is applied around an axis parallel to the flat surface of the plate *("Flat")*.

Fig. 2: Quick and dirty testing of the contribution of the helical plate to stiffness as tested in Fig. 1. The helical plate improves stiffness when tested around an axis parallel to the flat surface of the plate *("Flat")* while when tested around an axis perpendicular to the flat surface *("On Edge")*, where the initial stiffness is large no additional effect is observed.

Testing axial stiffness under gap conditions:

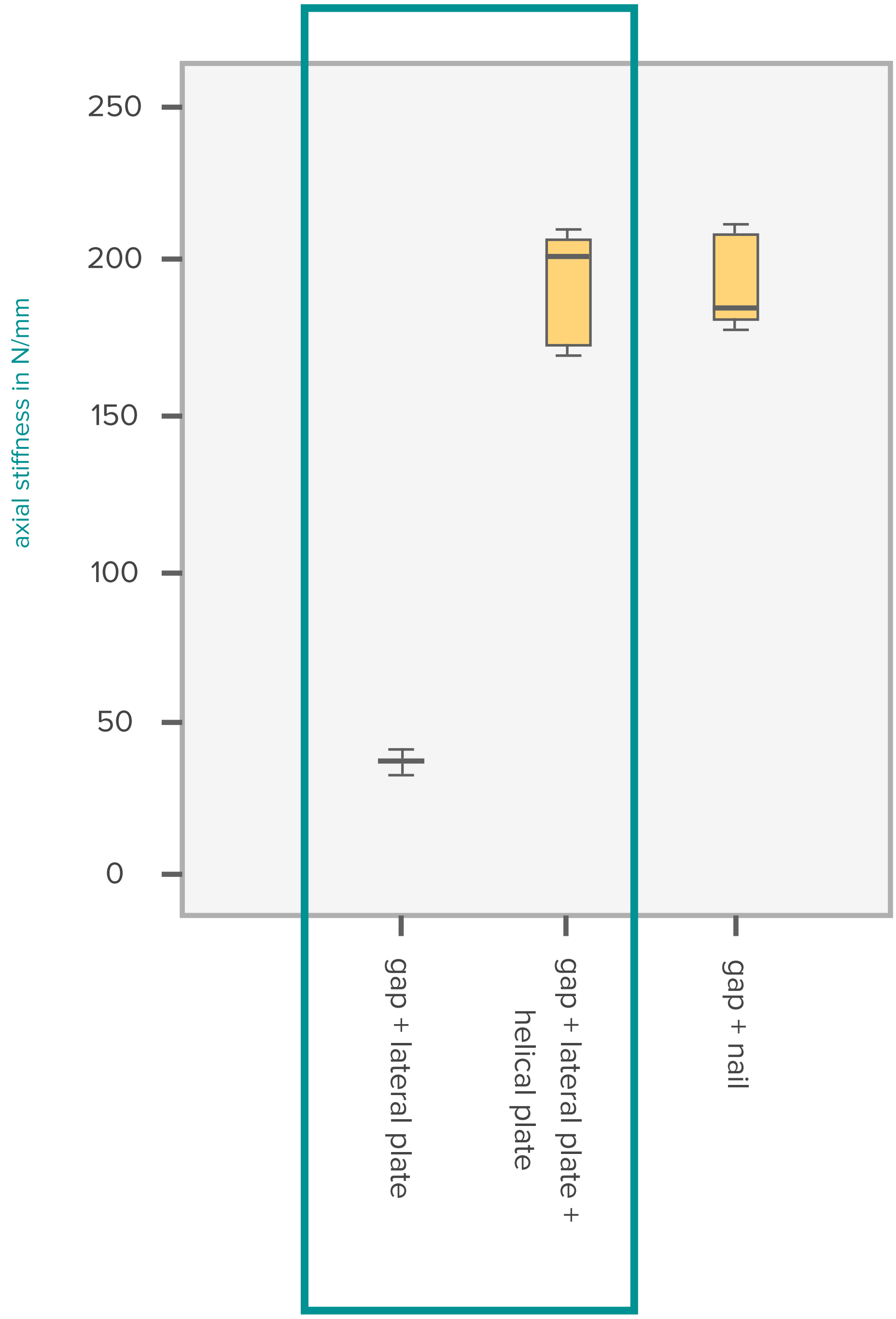

Fig. 3: Testing axial stiffness under gap conditions: An eccentric axial load of 100 N was applied. A significant improvement of axial stiffness from lateral plate alone from 36 N/mm to 193 N/mm with additional helical plate was achieved (Mark Lenz et al. AO Research Institute).

Testing torsional stiffness under gap conditions:

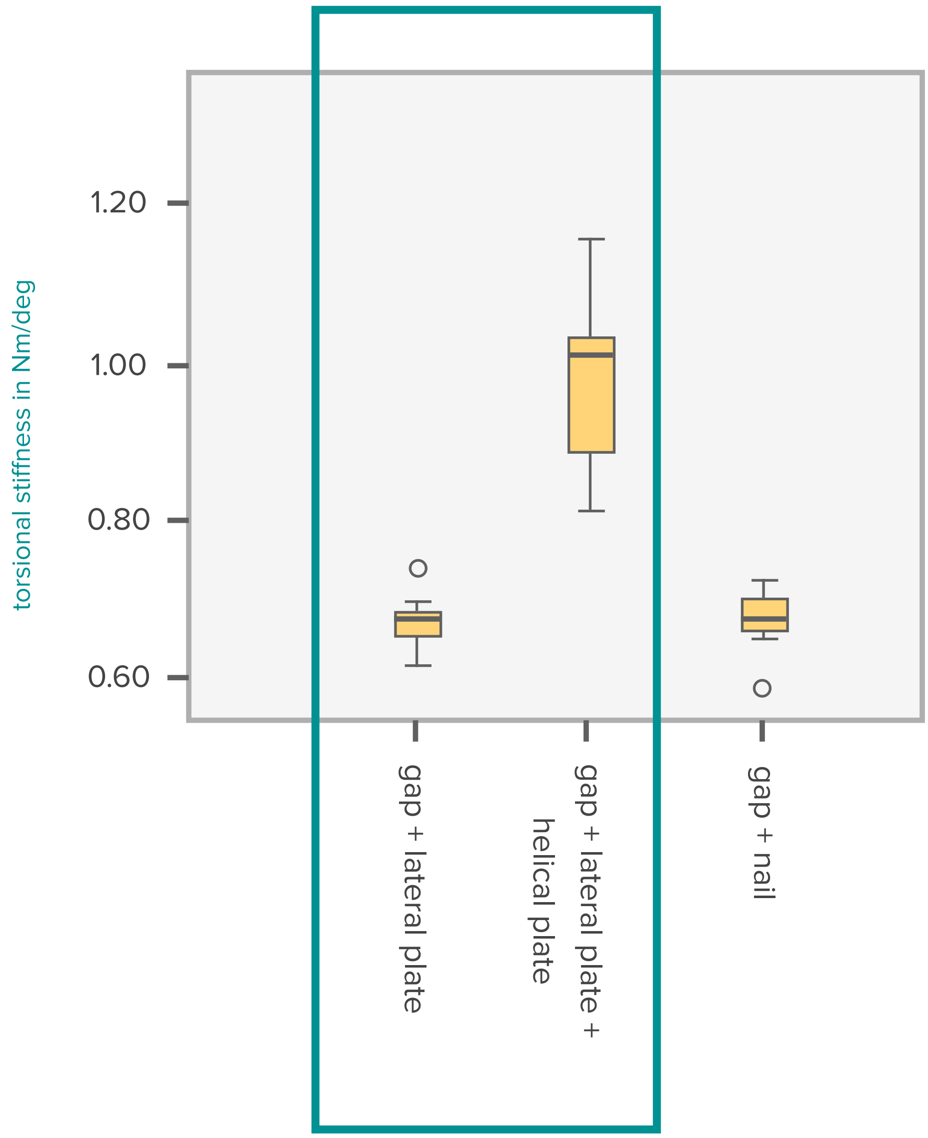

Fig. 4: Testing torsional stiffness under gap conditions: A torque of 2 Nm was applied. A significant improvement of torsional stiffness of lateral plate alone from 0.71 Nm/deg. to 0.91 Nm/deg. with additional helical plate was achieved (Mark Lenz et al. AO Research Institute).

References

1. Holzman MA, Hanus BD, Munz JW, O'Connor DP, Brinker MR. Addition of a medial locking plate to an in situ lateral locking plate results in healing of distal femoral nonunions. Clin Orthop RELAT RES. 2016; 474 (6):1498-1505. DOI: 10.1007/ S11999-016-4709-3.

2. Jiamton C, Apivatthakakul T. The safety and feasibility of minimally invasive plate osteosynthesis (MIPO) on the medial side of the femur: A cadaveric injection study. Injury. 2015; 46 (11):2170-2176. doi:10.1016/j.injury.2015.08.032.

3. Sanders R, Swiontkowski M, Rosen H, Helfet D. Double-plating of comminuted, unstable fractures of the distal part of the femur. J Bone Joint Surg Am. 1991; 73 (3):341-346.

4. Todorov D, Zderic I, Richards RG, Lenz M, Knobe M, Enchev D, Baltov A, Gueorguiev B, Stoffel K. Is augmented LISS plating biomechanically advantageous over conventional LISS plating in unstable osteoporotic distal femoral fractures? J Orthop Res. 2018. doi:10.1002/jor.24047.

5. Müller ME, Allgöwer M., Schneider R , Willenegger H. Manual of Internal Fixation, Springer 1977 , p 153.

6. Perren, Stephan M. Evolution of the internal fixation of long bone fractures. The scientific basis of biological internal fixation, JBJs 2002; 84: 1093 - 1110.

7. Fernandez Dell'Oca AA. The principle of helical implants. Unusual ideas worth considering. Injury. 2002; 33 Suppl 1:SA1-27.

8. Perren SM, Regazzoni P, Fernandez AA. Biomechanical and biological aspects of defect treatment in fractures using helical plates. Acta Chir Orthop Traumatol Cech. 2014; 81 (4):267-271.

Further Readings

ICUC newsletter Fatigue resistance P. Regazzoni, SM. Perren, AA. Fernández April 2016.

ICUC Newsletter: Biomechanical and biological aspects of defect treatment in fractures using helical plates. AA. Fernández, P. Regazzoni, SM. Perren March 2016.