Dynamics of Screw and Plate Interaction

Several papers in this issue of the Journal address topics in the theme of plate and screw fixation (1–4). A critical element of this form of internal fixation is that the maintenance of stability provided by the plate relies heavily on the integrity of the screw fixation. Bone screws can perform their work in several ways. In conventional plate fixation, the head of a tightened screw compresses the under-surface of the plate onto the underlying bone, creating friction between these three elements. The stability of the plate fixation relies on the maintenance of friction between the plate and bone. By contrast, locking plates do not rely on this plate-bone contact because the screw heads are locked into the plate hole. Indeed there may be a space of several millimetres under a locking plate, and the size of this space does not change unless implant failure occurs. These are two fundamentally different mechanisms of action for bone screws used with bone plates.

During a surgical osteosynthesis, at the time when a bone plate is being applied to the bone, a potentially dynamic relationship exists between the screws, the plate and the bone. Each of the steps leading up to final insertion and tightening of the screws can have either planned or unintended consequences on the final resting position of the bone plate. Moreover, a change in plate position can affect the relationship between the bone fragments that are being stabilized, either in a favourable or undesirable manner. The best known example of this dynamic relationship is with the use of a compression bone plate to produce interfragmentary compression. Another example observed by Woodbridge and colleagues is the unplanned translation of tibial plateau levelling osteotomies with application of locking plates (4).

The principle of the self-compressive bone plate was refined by the AO Foundation in Switzerland, resulting in the development of the dynamic compression plate, with each plate hole precisely machined with an internal glide path for the load or compression screw (5). Perren and colleagues showed in the transverse diaphyseal osteotomy ovine model that the application of a compression plate produced over 100 kg of interfragmentary compression, and that this did not result in bone necrosis but rather primary bone healing (5).

There are many factors that can alter the magnitude of this interfragmentary compression, such as for example the angle of the screw axis with respect to the longitudinal axis of the bone plate. One of the design features of the dynamic compression plate hole is that it allows up to 25 degrees of angulation of the screw in a longitudinal plane, on either side of the perpendicular position. However, if the load screw in a dynamic compression plate is angled by 10 degrees or more in the longitudinal plane, such that the tip of the screw is directed away from the fracture gap, then the amount of interfragmentary compression is more than double that achieved by a perpendicular load screw (6). By contrast, if the load screw is directed by 10 degrees or more towards the fracture gap, then the amount of interfragmentary compression achieved drops to zero, with full tightening of the load screw (6). Furthermore the study reported by Jermyn and Roe found that prior application of a neutral screw in another more distal plate hole significantly diminished the magnitude of compression achieved by subsequent application of the load screw, even if the initial neutral screw had not been completely tightened initially (1). Therefore there are many potential technical pitfalls to consider during the execution of load screw insertion with bone plate osteosynthesis.

The introduction of locking plates has been an important advance for fracture stabilization, especially in comminuted diaphyseal fractures. However the use of plates that allow for the generation of interfragmentary compression of reducible transverse fractures and osteotomies is still much preferred over locking plates that do not have this feature because of the reduced

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risk of implant failure. In my opinion, the widespread acceptance of locking plates certainly does not mean that plates that allow load screw insertion should be abandoned; the ideal situation seems to be plates that allow for insertion of both conventional load and locking screws.

References


